Programme **Beta2**

Office of the Government of the Czech Republic

Analysis of the Development Potential of Artificial Intelligence in the Czech Republic

Summary Report

December 20, 2018

TECHNOLOGY CENTRE CAS

CTU CZECH TECHNICAL UNIVERSITY IN PRAGUE

INSTITUTE OF STATE AND LAW of the Czech Academy of Sciences

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Summary Report

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The study was written for the Office of the Government of the Czech Republic by a team of authors from the Technology Centre CAS, the Czech Technical University in Prague and the Institute of State and Law of the Czech Academy of Sciences, on the basis of the minitender no. 15 "Research on the Potential of Artificial Intelligence Development in the Czech Republic" under the framework contract TI00UVCR001: Design of research perspectives responding to the consequences of the so-called Fourth Industrial Revolution (Society 4.0) - Stage 2 within the BETA 2 program of the Technology Agency of the Czech Republic, which is the provider of the financial resources. However, the views and attitudes of the research team reflected in the study are based on the performed analyses and investigations and they express neither the position of the Office of the Government nor the position of the Government of the Czech Republic as such.

All data contained are actual to the closing date of the publication, unless otherwise stated.

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1 Management summary

Artificial Intelligence (AI)[1] is no longer a science fiction, but has become a part of our everyday life. Due to the increase in computing capacity, data availability, and progress in algorithm development, AI has become one of the strategic technologies of the 21st century. In April 2018, the European Commission launched the "Artificial Intelligence for Europe" initiative [23] to ensure a coordinated EU approach making the most of the opportunities offered by AI and addressing the related challenges. The aim of this initiative is to strengthen significantly the EU's technical and industrial capacities and to support the use of AI throughout the economy, to prepare for the wide-ranging socio-economic changes caused by the development of AI and to provide an appropriate legal and ethical framework for all the related processes. The total public and private AI R&D investment in the EU, estimated between EUR 4 to 5 billion in 2017, should rise to at least EUR 20 billion by the end of 2020, according to the European Commission. The activities took a concrete form in the Coordinated Plan on Artificial Intelligence issued in December 2018 [24]. The aim of this plan is to maximize investment at European and national level, to strengthen cooperation between Member States in the field of AI and to identify the main directions of the development of AI in the EU.

The need for an active engagement in the deployment of AI technologies stems from the assumption that the economic growth in the following period will heavily rely on the use of new technologies. Digital technologies and AI have a leading role in this respect. According to the economic model developed by Deloitte for the Czech Republic [14], automation will lead to productivity gains in the production factors, GDP and wages. Assuming full realisation of the technological potential for automation and full workforce adaptation, the average growth rate of the economy could reach 3.9% per year over the next 16 years. Thus, the potential of the economy would increase by 78% by 2033, which is more than double in comparison to the baseline scenario without the use of automation. National studies of other countries, e.g. the Finnish analysis [25] have come to similar conclusions.

Another reason why this topic has been addressed with high urgency in a number of countries is the expected disruptive impact of AI technologies on the labour market. This will impact not only low and mid-level qualification jobs, but practically all types of employment, including high paying jobs that require a high level of qualification. Considering the workforce structure in the Czech Republic and the way the country is involved in global value chains, it is expected that it will be among the countries significantly impacted by AI in its employment structure (see e.g. [35] and [47]). This will require adaptation not only of the social security and retraining system but also of the whole process of education.

The transformation of the education system at all levels is a key task that will have a crucial role both for providing top scientists and researchers and for delivering a quality and adaptable workforce. The importance of specific knowledge is decreasing in favour of the importance of complex skills, especially so-called 21st century skills[2], along with the computational thinking.

As a first step in the systematic approach to AI in the Czech Republic in the forthcoming period, we can identify the need for a national strategy involving the priorities in the AI area, following the Digital Czechia government program [17]. The formulation of this strategy should provide answers to the following questions:

(1) How can the public and private sectors ensure that businesses and research institutions receive the necessary support for the development and deployment of AI-based innovations so that the AI potential is fully exploited in terms of competitiveness and economic growth?

[1] The term AI is defined in the technological study, Chap. 3.

[2] Sometimes also referred as so-called soft skills, i.e. skills aimed at developing creativity, critical thinking, collaboration and communication with people as well as machines, presentation, project management and problem solving.

(2) How can the public sector exploit the potential offered by AI in its own activities to provide high quality public services effectively? How can data-oriented businesses benefit from the secondary use of public sector information sources?

(3) How will AI influence us as individuals and what impact will it have on the labour market? What will be its wider impact on society and how to prepare for it? How can we ensure that our social structures adapt to the changes brought by AI and that we continue to be a well-functioning, prosperous society?

(4) What new ethical and legal issues does AI cause and how should society and the legal system be prepared for their implementation? What regulatory measures should be addressed by the public sector at the time of the rise of AI?

This summary report sums up the key findings of three more elaborated studies that analysed the situation in the Czech Republic and offered answers to the aforementioned questions. More precisely, these studies dealt with (i) the analysis of the research, technological, and business background for AI development in the Czech Republic (in the following text as the "technological study"), (ii) the analysis of the expected socioeconomic impacts of AI development (the "impact study"), and (iii) the analysis of the necessary legal instruments and other regulations in relation to the AI development (the "legal and ethical study"). These detailed studies are available only in the Czech language on the website of the Office of the Government of the Czech Republic[3]. A complete set of recommendations for public administration from all three sub-studies is contained in Chapter 5 of this summary report.

In the final stage of the completion of these studies, a workshop was organised at the Office of the Government of the Czech Republic that delivered expert feedback from the public, private and academic sector participants. The main conclusions reached during this workshop were subsequently incorporated in the final studies.

1.1 Key findings

Research and innovation ecosystem

The wide range of research required by AI implementation represents a major challenge. Efficient and targeted support to R&D and education may be thus considered as a key factor for underpinning the AI development. The conclusion reached in our study is that public R&D in the Czech Republic is strong and doing fine in comparison with other countries, while covering all the essential technological topics of AI.

Its greatest weakness, however, is its inability to retain capable domestic researchers, who are massively switching to the private sector, coupled with its low ability to attract foreign researchers with good results and reputation to work in the Czech public research organizations (see Chapter 2.1 of the summary report).

The key findings of the analysis are summarised as follows:

- **R&D in AI is implemented by the entire spectrum of public research institutions,** particularly by major technical universities but also by some institutes of the Czech Academy of Sciences and other institutions that are involved in R&D in the AI field. The research covers the full spectrum of the AI technology topics, the institutions carry out both fundamental and applied R&D.

[3] The website of the Office of the Government of the Czech Republic focused on the potential of AI (English version): http://www.vlada.cz/en/evropske-zalezitosti/aktualne/what-is-the-potential-of-artificial-intelligence-in-the-czech-republic--170961/

- **A supportive infrastructure for AI research and AI research centres have been established making use of the European Structural and Investment Funds (ESIF) and additional public resources.** These centres have a top-quality research infrastructure allowing carrying out excellent fundamental research in an international comparison (for example, the national Supercomputing Centre IT4Innovations). In the Operational Programmes (OP) framework such as the RDI OP, RDE OP[4] and a number of complementary national programmes, a number of new application-focused centres were created, which carry out R&D in the field of AI and transfer the research results into the application sphere (centres focusing on AI were newly established making use financing by these programmes, such as Czech Technical University (CTU) Research Centre for Informatics (RCI) in Prague, the Czech Institute of Computer Science, Robotics and Cybernetics (CIIRC) at the CTU, and New Technologies for the Information Society (NTIS) in Pilsen, West Bohemia). Instrumentation innovation due to the RDI OP, RDE OP was also implemented at a number of other research institutions that are ready to carry out cutting-edge AI research. There are research labs (Research Centres) at universities and other research institutions specifically focused on R&D in the field of AI. A detailed overview of these important institutions is given in section 6.1 of the technology study. In recent years, Technology Transfer Centres were established in most of the institutions that assist the commercialization of the R&D results and support the cooperation with the application sector.
- **R&D in AI is also implemented by a number of Czech businesses, including the small and medium enterprises (SMEs).** Large companies operating in the field of AI are mostly under foreign control and the R&D results are often used by parent companies abroad. An important part of the research and innovation ecosystem in the field of AI is the start-up companies (start-ups). Currently there are almost 40 start-ups in the Czech Republic operating in the field of AI. These start-ups are focused on the development of products and services with a particular focus on the area of information and communication technologies and the development of support tools for various areas of deployment (for example text search, computer vision, etc.). Some of the start-ups in the AI field have been active in the cyber security, marketing, business management and other sectors. In the Czech Republic, there is a relatively strongly developed network of venture capital investors. However, it seems that there is a lack of projects suitable for financing through venture capital.

PUBLIC SUPPORT FOR R&D

A major source for R&D funding in the field of AI are the programs of Research and Development Operation Programme targeted research. Targeted support has grown in the long term and between 2007 and 2017 it almost doubled (reaching CZK 260 million in 2017), with a large increase which occurred especially in the period 2016 - 2018. The public support for R&D of AI will grow in the coming years and should exceed CZK 400 million in 2018 (according to the national R&D Information system and budgets planned for ongoing projects). (See Chapter 2.1 of the Summary Report.)

- **In the period 2015-2017 the AI R&D focused projects have been supported by the programs of eight providers, especially by the Grant Agency of the Czech Republic (GA CR), the Ministry of Education, and the Technology Agency of the Czech Republic (TA CR)**. None of these programs, however, was specifically focused on R&D in AI and the technology using it. The closest to the AI topic are specific calls for tenders addressed to the TA CR, favouring sectoral projects in the field of Industry 4.0.

[4] RDI OP – Framework Programme Research Development and Innovation, RDE OP – Framework programme Research, Development and Education.

- **Targeted support for R&D is used mainly by universities** which received almost 80% of targeted support granted to AI-related projects in the years 2015-2017. R&D is primarily implemented at major universities such as the Czech Technical University in Prague, the Brno University of Technology, the Technical University Ostrava and Charles University in Prague. Some start-ups received public support as well. Approximately 20% of the targeted support has been used by the commercial sphere, including micro-enterprises and SMEs. Other research institutions are involved in AI-focused R&D at a smaller extent.
- **Businesses and research institutions often work together on the projects supported by public funds**. Some university faculties play the key role in R&D in the field of AI and cooperate quite intensively with other entities of the research and innovation ecosystem. On the other hand, businesses cooperate in AI–focused projects at a lesser extent. Research institutions and businesses, including SMEs, are also internationally involved in AI-focused R&D projects that are supported by the EU Framework Programmes. The involvement of the Czech Republic, however is somewhat lower in comparison to the EU-15 countries[5].

ORIENTATION OF THE TECHNOLOGICAL DEVELOPMENT

The Czech Republic belongs among the countries with the greatest expected impact of automation and technology using AI, particularly in areas such as manufacturing, retail trade, wholesale trade, health care and social services, education and construction. It can be further expected that automation will have a great impact in the Czech Republic on employment and jobs (which comes together with the high proportion of manual work suitable for the automation), while in other countries the automation will have a great impact on productivity, safety and quality. It can be assessed that the starting conditions for the implementation of AI technology in the Czech Republic are not optimal. The majority of domestic businesses stands at the lower end of the global value chains (GVC) or is controlled from abroad. Therefore, their foreign headquarters will exert decisive control over the implementation of innovations. For home research institutions and especially for companies providing the AI solutions, this means a strong orientation towards partners abroad where these solutions are supplied. (See Chapter 2.1 and 2.2 of the summary report.)

- **The technological focus of the Czech projects is diverse.** R&D projects focus particularly on cognitive skills such as gathering information and logical decision-making. A relatively high number of projects deals with speech processing. The contemporary technologies in these areas have advanced so much that they are comparable with the human performance, and therefore suitable for their application. R&D in these areas should be implemented primarily by businesses. Some projects have also been focused on creativity, logical thinking, and intelligent systems. In these areas, the current AI systems fall short in comparison with humans, which gives opportunities especially for R&D carried out by research institutions. It is very positive that the supported projects also address some up-to-date issues such as robotics, cyber security and transport technologies.
- **Orientation of the projects supported by the programs of the targeted applied R&D support is - in terms of expected AI impacts in the Czech Republic – not optimal**. As revealed by the analysis, a relatively high number of supported projects has displayed a general focus (i.e., without connection to the application sector) or has dealt with the use of AI methods only as a supporting tool for solving tasks in some of the engineering sectors. Some of the projects offered solutions for the manufacturing sector, finance, insurance and health and social care sectors, which, except for the manufacturing, have the lowest risk level

[5] The EU-15 comprises 15 member countries in the European Union before its enlargement in May 2004, i.e. Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and United Kingdom.

of societal AI impact. A minimum of the projects was in the area of administrative and support activities, mining and extraction, trading, which, in turn, are areas with the highest risk level of the AI impact. Some sectors which will be affected by the deployment of AI and automation to a considerable extent are in the Czech Republic not yet adequately covered by the applied R&D.

- **Strategic application sectors, technological areas and their support**. In Chapter 2.2 of the summary report and, in more detail, in chapters 6 and 8 of the technology study, implementation fields and technologies are listed which are of strategic importance for the Czech Republic from the perspective of AI impact and development. These are the sectors in which the SMEs are currently involved, applied research is implemented, and in which the largest AI impact is expected.
- **An important prerequisite for the successful implementation of R&D in relation to the current needs of the Czech Republic is the inclusion of the AI into all relevant strategic-policy documents.** The AI topic, however, is not yet sufficiently taken into account in the strategic-policy documents, especially in relation to the disruptive nature of the involved technologies. The current National Research and Innovation Strategy for Smart Specialisation of the Czech Republic (RIS3) specifies only the general areas which offer opportunities for domestic enterprises to strengthen international competitiveness through the adoption of the AI technology. The Digital Czechia strategy [17] also partially addresses these issues.

SOCIOECONOMIC IMPACTS AND THEIR SOLUTIONS

Based on the current technological level in the field of AI, it can be expected that on the five-year horizon the technology will be able to replace more than 50% of the required skills in the occupation performance in 11% of the occupations (see the outputs of the economic model in Chapter 3.1 of the summary report). On the thirty-year horizon, automation can replace over 50% of skills in the vast majority of the current professions. At the same time, new professions will continuously emerge, though they will place different demands on their performers and will require different skills and abilities in comparison to current professions.

- **The benefit of automation lies primarily in taking over of routine and repeatable, as well as strenuous work activities by machines** and in freeing human resources for more creative work activities with a higher value added. At the same time, automation increases efficiency, quality, and effectivity of work activities, where machines can perform better than humans. Automation is also a way to replace the human workforce missing due to the unfavourable demographic development in developed countries.
- **Occupations with a high proportion of routine skills** in the manual area (machine operators, packaging and palletizing, dosing) as well as knowledge area (accounting, data collection and processing, text and data proofing, measurement of physical quantities, quality control) **are among the professions where the most significant changes in the nature of work due to automation and AI can be expected.** The lower risk of human work replacement is in professions with a higher proportion of non-routine and creative skills in the manual area (repair and renovation, services and personal care) as well as knowledge area (research, analysis, planning, design, rules and procedures, negotiation and training, leadership, entertainment and presentation).
- **Especially professions with middle qualifications and income level are facing a higher risk of replacement.** In low-skilled, low-income manual professions, automation is not worthwhile in many cases. In high-skilled and high-income professions, however, the automation potential is reduced by the limited availability of the necessary technologies to automate the non-routine and the creative activities associated with these professions. The

drop-in occupations in the middle-income category caused by automation can therefore lead to a deepening of the economic inequality in society.

- **It is necessary to adapt the whole system of education, lifelong learning and retraining to the changing demands on the skills of the human workforce.** The microeconomic data show the increasing importance of the technical expertise (STEM - Science, Technology, Engineering and Mathematics) and the multidisciplinarity. The weight of specialized knowledge is decreasing in favour of the importance of complex skills, especially so-called 21st century skills[6], along with the computational thinking.
- **Strengthening social security and developing social safety nets**. The speed of retraining and finding new jobs is different for different employments and employers, which can lead to an increase in the structural and the frictional unemployment. The social safety nets must be adapted to this situation in order to offer an effective support of the vulnerable employees seeking retraining and knowledge broadening, skills, and abilities for the prospective professions. It will be necessary to verify experimentally which forms of support will work best (e.g. the right to the educational leave tested in France, or the recently negatively evaluated experiment with the basic unconditional income in Finland).
- **Automation will change the nature of work and will cause organisational changes in companies**. Considering the changes in the nature of work, tasks in production and services will be more outsourced to non-core employees. This implies a new demand for the state to ensure social security for a growing number of self-employed people. Instead of a hierarchical structure, companies will prefer a direct and a flexible networking. Greater expectations will be placed on employees in terms of both time and space flexibility of the jobs, which will require a greater flexibility of the wages system. A need will arise to adjust the protection of employees by the labour law. It will include the need to modernize the Labour Code.

Development of the Regulatory Framework

The development of the regulatory framework is **one of the key conditions for successful development of AI in the Czech Republic**. It has a potential to significantly contribute to increase the competitiveness of the Czech Republic by providing legal certainty and removing regulatory barriers to the development and use of AI. However, **the Czech law is limited up to a certain degree by its dependence on developments in the field of international and European law**, and by the **unpredictability** of the use of AI and its real social consequences. In the European context, AI has already been widely discussed at the EU level and is also highlighted in the European Commission's work program for 2019.

In the field of **ethics**, the legal and ethical study of the aspects of AI development focuses in particular on the general description of current trends in approaching ethical problems associated with AI, identifies key ethical problems and suggests recommendations that may also affect legal regulation. In the field of **Czech law**, the study assesses its readiness for new AI applications, especially with regard to enabling and protecting innovation while ensuring the effectiveness of law in society.

New ethical problems emerge in connection with the development and use of AI. These are addressed in particular in the field of roboethics, i.e. the area of ethical problems faced by people designing, developing and using intelligent machines, as well as in the field of machine ethics, i.e. the area dealing with situations where machines decide on ethical issues.

[6] Sometimes also referred as so-called soft skills, i.e. skills aimed at developing creativity, critical thinking, collaboration and communication with people as well as machines, presentation, project management and problem solving.

- **Ethical problems associated with AI**. These problems are related especially to algorithmic bias, classification of people, limitation of their autonomy, interference with privacy, etc. These problems are in general addressed by formation of ethical codes of conduct that promote leaving control over fundamental decisions in hands of humans ("human-in-command" approach), reject the possibility of ethical decision-making of machines and transfer of liability to machines, warn against possible discrimination, and demand transparency in the functioning of AI. Ethical solutions and ethical codes of conduct shall influence the interpretation and application of law to cases involving the development and use of AI. This shall become apparent especially in the area of prevention and liability. Drafting these codes of conduct has been initiated at both international and global levels (see Chapter 4.1).

The legal study assesses the current regulation primarily with the goal of **ensuring legal certainty and predictability** in legal relations while providing a wide space for innovation. Regulation exerts its effects on several levels, the development of which needs to be promoted as an appropriate and flexible addition to legislation. These levels also effectively enable the involvement of all stakeholders.

With respect to the universal applicability of AI in many areas, the legal study identifies a number of **general and specific legal areas**, including for example the financial and banking sector, antitrust law, research and development, social security, autonomous mobility, or autonomous weapons (see Chapter 4.2), in which certain problems emerge.

- **The status and legal nature of AI**. The absence of a generally accepted definition of AI is also reflected in law. In various documents, the EU defines AI by reference to a wide range of technologies and focuses in particular on its characteristic features. However, none of the definitions is legally binding. Depending on the nature of a particular application, AI can fulfill a definition of various legal institutes (a computer program, a thing, a product, a service, a computer virus). This will in particular have an impact on a liability regime.
- **Liability for AI**. Liability for AI is a key problem associated with AI as it shall significantly affect economic relations in the future. Contractual liability represents a key tool for regulating individual relationships between providers and users of intelligent systems. Legal certainty would be strengthened by the development of model contractual solutions that would propose a fair distribution of rights and obligations. Liability is also significantly influenced by the duty of prevention, the scope of which is unclear in relation to AI. Therefore, in the future, it will be necessary to specify what is considered the best practice. What regards tort liability, given the current state of use of AI, the existing legal provisions can still be used. However, in order to increase legal certainty, some provisions need to be interpreted specifically with regard to AI (in particular the term "proper oversight" and the reasons for the liberation related to product liability). However, given the increasing interdependence and complexity of intelligent systems, existing regulations may prove not to be sufficient in the future.
- **Privacy protection, electronic communications and non-personal data processing**. The GDPR is the main regulation governing the protection of privacy through the protection of personal data. This regulation does not necessarily limit the research and development of AI but, on the contrary, it stimulates it. However, it is necessary to determine the scope of specific provisions in relation to AI. In the area of electronic communications, there is a strong dependence on European law, which is now undergoing major changes. At European level, rules for processing of non-personal data are also being developed.

- **Cybersecurity**. Czech law provides a high level of cybersecurity with help of special law that imposes obligations on certain subjects. Other subjects need to interpret general provisions on prevention and obligations stemming from special legislation to achieve compliance.
- **Intellectual property protection**. Existing copyright does not provide legal certainty about rights related to works generated by AI. As an author can only be a natural person, the question arises up to a which degree an intelligent system can be considered a mere tool to create a work and when it already fully replaces an author.
- **Other legal issues related to AI**. With regard to the principle of autonomy, an obligation to inform a person that he or she is dealing with AI (a chatbot, etc.) should be established. At the same time, it is also necessary to address the issue of exercising own rights through an AI system that acts on behalf of a user based on the knowledge of his/her preferences.
- **Problems in specific legal areas**. Specific problems appear in various legal sectors. The main obstacle to the development and use of AI is in the field of autonomous mobility. At present, it is not possible to test and operate partially autonomous vehicles with a higher degree of autonomy in the Czech Republic. Existing legislation also does not allow the operation of autonomous drones. Specific rules are set for trading on capital markets for algorithmic trading and high frequency algorithmic trading.

1.2 SWOT analysis

Strengths	Weaknesses
- R&D is carried out in an adequate number of R&D institutions. - R&D infrastructure for AI is at a good level. - R&D covers both basic and applied AI research. - Results of the R&D are excellent in the international comparison. - R&D institutions set up Centres of Technology Transfer. - R&D application is heading to sectors with largest AI impact.	- Absence of a national strategy for the development of AI in the Czech Republic. - Applied R&D does not address key innovations. - Low participation in international R&D. - Transfer of results from research institutions to start-ups and application sector is inflexible in the field of AI. - Applied R&D does not cover administration and trading sectors.
- The Confederation of Industry of the Czech Republic has set up a platform for AI. - Targeted R&D support grows in long term. - The distribution of targeted AI support is adequate, used by 80% by universities, the rest by micro and small enterprises. - Both basic and applied research is supported.	- In the Czech Republic is missing a strong Association for research, development and applications of AI and involvement in associations such as EurAI, Claire. - Targeted support R&D is split among multiple providers. - R&D targeted support programs are not focused on AI. - Targeted support for applied R&D lags behind support for the basic research.
- Approximately 40 AI start-ups operating in the Czech Republic matches to comparable EU countries. - There are qualified experts in AI and computer science. - Start-ups develop internationally relevant technologies. - Venture capital is available to start-ups. - Research results are transferred to the start-ups. - There are branches of multinational IT companies operating in AI.	- Cooperation of start-ups with universities and R&D centres is not common. - The Czech Republic is a small market for AI start-ups. - Large businesses, which are the largest AI customers, are mostly controlled from abroad, and thus AI is implemented by their foreign parent companies. - Venture investment in the Czech Republic is insufficiently used for key technologies and, in terms of volume, it is significantly lower than abroad.
Opportunities	**Threats**
- Preparation of the national strategy in the field of AI. - Conceptual development of the education system, lifelong learning and retraining. - Coverage of foreign markets with advanced AI technologies by emerging SMEs is essential for the economy of the Czech Republic and can significantly improve its competitiveness.	- Insufficient weight given to AI in the strategic-policy documents, long implementation period for the strategies. - Czech Republic is among the countries with the greatest expected AI automation impact on the labour market, deepening of economic inequalities in the society.
- The focus of R&D on prospective technological AI sectors. - Broader involvement in international research and international research associations. - Development of local research capacities and attracting of foreign researchers to the Czech Republic.	- Foreign research will invest more and faster in AI. - Lagging behind in engaging into international research, the inability to attract foreign leaders in the industry. - The brain drainage from research into multinational companies and abroad for better working conditions.
- Improving of cooperation between public and private sector in R&D and in the area of transfer of R&D results into practice. - Development of digital innovation hubs, the creation of AI Centres of Excellence and involvement into AI international associations - Improve the incubation and acceleration environment and services for start-ups. - Sharing of data from the public sphere and the removal of barriers for data sharing between businesses for the development and training of AI systems.	- Venture investments to start-ups can´t match with foreign volumes, the lack of crucial technologies in the Czech Republic. - Control over innovations will gain foreign headquarters of local branch offices. - Fast testing and piloting of new technologies will not occur in practice. - The public sector will not create conditions for data sharing and rapid implementation of new services for the public.
- Setting up of self-regulatory mechanisms by industry and professional organizations, and the formulation of best practices in the sector in accordance with the legislation. - Development of technical solutions to ensure the effective operation of the law ("regtech"). - Support of creation of regulatory sandboxes and data trusts.	- Legislative barriers limit the effective data sharing, the development and use of AI.

1.3 Overview of Suggested Recommendations

This chapter provides a brief overview of proposed recommendations for public administration. A full description of the recommendations listed here is contained in Chap. 0 of the summary report.

Recommendations to support R&D for AI development and deployment	
Using AI to increase competitiveness of the Czech Republic (see Chap. 5.1.1)	• Creation and development of start-up companies with high added value in AI and with majority share of Czech entities • Support for AI application ecosystems • Support for cross-sectoral and interdisciplinary cooperation and training of AI systems on shared data
Using and linking data from all sectors (see Chap. 5.1.2)	• Data sources accumulation and enrichment • Enabling the provision of independent services over public data
Rapid verification of AI research results in applications and their transfer to practice (see Chap. 5.1.3)	• Need to increase the number of research results realised in practice • Effective transfer of research results into practice • Support for experimenting with AI technologies
Retaining and attracting top AI experts and researchers (see Chap. 5.1.4)	• Attracting top foreign researchers to the Czech Republic and retaining top domestic researchers • Developing the mobility of experts and researchers • Multidisciplinary expansion of education and study programs and AI skills courses
National strategy, smart investments (see Chap. 5.1.5)	• Development of the national AI strategy • Stronger support for the deployment of AI technologies into real world • Expanding and improving expert skills, education, training and retraining • Building an international overlap, participation in EU initiatives
Recommendations in the field of labour, retraining, and education	
Social security, social safety net (see Chap. 5.2.1)	• Assessment of usability of new social models to support the transition of employees to new positions • Assessment of the usability of potential shortening of working hours • Support of development of work opportunities in more affected regions and support of employee mobility
Raising qualification for perspective professions (see Chap. 5.2.2)	• Development of a state supported lifelong learning and higher vocational education system with a focus on technical and soft skills • Support of retraining and digital skills improvement options as a part of employment • Development and continuous updating of the National System of Occupations and National System of Qualifications databases • Development of the complex system of retraining for workers threatened by automation
Education and training of new workforce (see Chap. 5.2.3)	• Transforming the education system • Improving the school equipment for development of digital literacy and informatics thinking • Developing competencies and increasing the social status of teachers • Adopting the potential of AI in education
Development of public policies with linkages to AI (see Chap. 5.2.4)	• Developing structural policies that effectively support entrepreneurship and innovation • Developing competition and regulatory policies • Reacting to growing international reliance in innovation and knowledge dissemination • Tax policy development

	• Ensuring adequate assessment of digitalisation impact and changes on the labour market
Recommendations for the regulatory area	
Active engagement in international activities (see Chap. 5.3.1)	• Contribute to creating an international legal framework and ethical and technical standards
Support of the self-regulation of industry (see Chap. 5.3.2)	• Ethical codes of conduct • Formulation of "best practices" • Certification
Support of the development of technical solutions for ensuring the efficiency of law ("regtech") (see Chap. 5.3.3)	• AI Transparency • Legal regime of data • Tool for the management of individuals' rights
Promoting a public debate aimed at forming a unified doctrinal interpretation of the law (see Chap. 5.3.4)	• Prevention duty • Contractual liability • Tort liability • Administrative and criminal liability • Risks of AI • Interpretation guidelines for the GDPR and ePrivacy Regulation after its adoption
Desirable changes in legislation (see Chap. 5.3.5)	• Amendment to the Civil Code • Amendment to the Copyright Act • Adaptation Act to the GDPR • Amendment to acts related to traffic on roads • ePrivacy Regulation
Continuous assessment of the impact of laws on the development and use of AI (see Chap. 5.3.6)	• Establishment of a specialized center dealing with the assessment of the impact of the development of artificial intelligence on society and the use of data
Support of establishment of regulatory sandboxes and data trusts (see Chap. 5.3.7)	• Analysis of a suitable model of a regulatory sandbox and a data trust for the development of AI models in the Czech environment

2 Research, technological, and business background for AI development

This chapter presents the main findings and conclusions of the specialised baseline study examining in detail the analysis of research, technological, and business background for AI development in the Czech Republic.

2.1 Position of the Czech Republic in the field of AI technological development

The technological ecosystem in the Czech Republic includes all the main actors in the AI field, as well as the necessary support infrastructure. The main actors are research organisations, private businesses divided into small and medium-size enterprises, counterweighed by large multinational corporations and their own research centres. The ecosystem is further affected by finances from public and private sources. The system also includes large publicly-funded infrastructures such as the supercomputer centre IT4Innovations, which is a supporting infrastructure for large scale calculations and calculations related to the development of AI systems.

The process of machine learning based on big data is of a strategic importance for development of AI systems. This requires a strong computer background and a sufficient amount of training data. In comparison, the subsequent deployment of these systems is less demanding. Therefore, if we speak about supporting infrastructure, we mean especially the stage of preparation of AI systems, which is extremely demanding in terms of hardware and data resources. This part must be included in strategic planning, e.g. the issue of provision and use of public domain data.

In this context, special attention should be given to the relationship between the academic and the private sphere. The academic sphere is focused on the research of AI systems, their clarity and principles, as well as on the principles of system training and data analysis. The private sphere is more oriented towards the implementation of algorithms, providing it has its own R&D department. Eventually, the private sphere uses already trained systems and just deploys them within the final products.

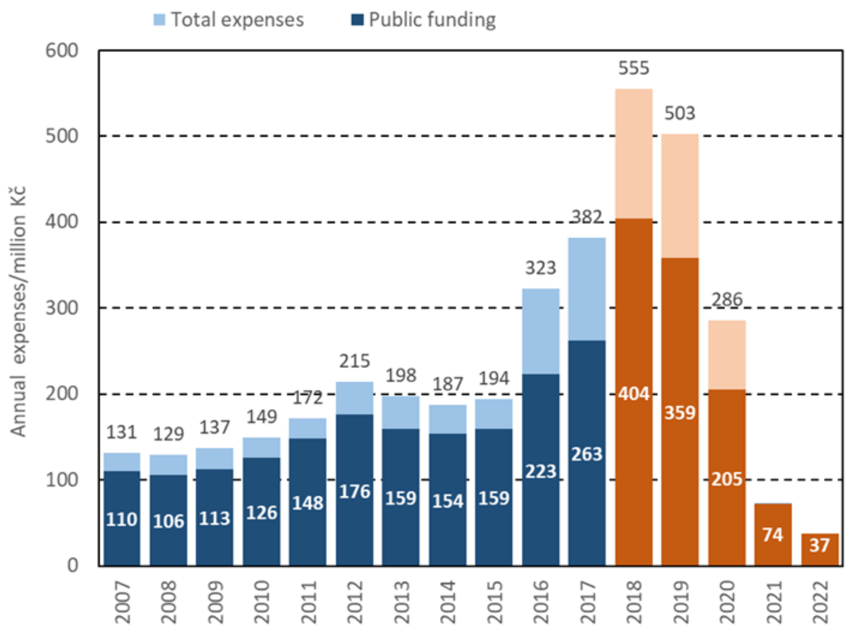
The position of the Czech Republic is described in more detail in Chapter 6 of the technological study, where the basic findings are summarised.

PUBLIC SUPPORT OF RESEARCH AND DEVELOPMENT

A significant source of Artificial Intelligence R&D funding in the Czech Republic are the Operational Programs of targeted support of research, development, and innovation, implemented by several providers. A large increase of public support, as well as total costs, occurred between 2016 and 2018. Public aid for AI R&D in 2017 amounted to approximately CZK 260 million, which is more than twice as much as in 2007. Public support for AI R&D will grow in the following years. As shown in Fig. 1, public spending in 2018 should exceed CZK 400 million (extrapolation based on the planned budgets of the ongoing projects).

In the past, the largest part of public support for R&D in the AI area in the Czech Republic has been used by universities (see. Fig. 2), where public support has grown approximately three times since the beginning of the decade (the largest increase occurred after 2015). Almost 20% of public support has been spent by enterprises (i.e. approximately a quarter of the total volume of public resources in the university sector). Public research institutions outside the Czech Academy of Sciences (CAS), government funded organisations, and government bodies received support of millions of CZK per year in the monitored period of 2015-2017. The most significant financing avenue was the program of standard projects of the GA CR, which provided around a quarter of the total AI R&D support in the period 2015-2017.

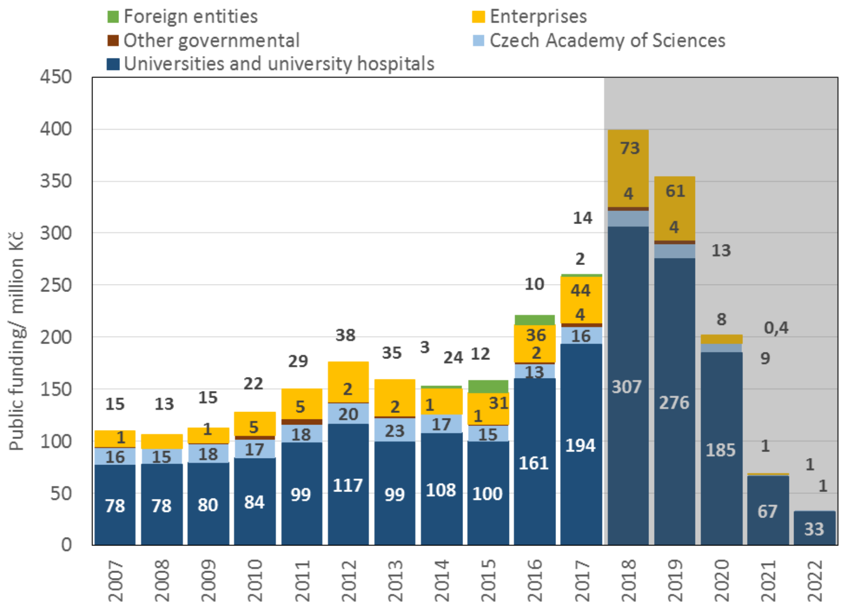
Fig. 1 Annual public support and total cost of AI research and development between 2007 - 2023



Note: The national R&D Information system does not provide the annual financial breakdown for the projects before 2017. Data for 2018 and beyond are planned.

Source: The national R&D Information System

Fig. 2 Annual public AI R&D support in the research sectors



Note: For 2018 and beyond the expenditure is planned[7].

Source: The national R&D Information System

[7] Other governmental: public research institutions not affiliated with the Czech Academy of Sciences, institutions financed by ministries or local governments.

In the university sector, three universities dominate in terms of total expenses of state support – Brno University of Technology (BUT), VSB – Technical University Ostrava (VSB–TUO), and Czech Technical University Prague (CTU), which together with Charles University Prague (CU) received approximately eighty percent of state support provided to the university sector in the last three monitored years (2015-2017) (see Tab. 1). Charles University is significantly different from other universities in terms of the average size of projects. Although it has a comparable number of projects with BUT, the public support it received is approximately half of BUT. BUT and VSB–TUO received significantly more non-state resources, both in absolute and relative terms to state support (49 and 80% of state support) unlike CTU and CU, where non-state resources amounted to mere units of percent of the state support.

Within the Czech Republic, there is a number of research centres that carry out high-quality and internationally recognized research, which are summarized in chap. 6.1 of the technological study.

Within the Framework programmes RDI OP, RDE OP and national support programmes, additional specialized centres have been established, which carry out research in the field of AI:

- "Research Centre of Informatics RCI" at CTU in Prague (http://rci.cvut.cz/), linking Faculty of Electrical Engineering and Faculty of Information Technology. The establishment of the RCI was initiated by the long-established AI centre, which conducts the AI research at the Computer Science Department of the Faculty of Electrical Engineering CTU. (http://aic.fel.cvut.cz)
- "Czech Institute of Computer Science, Robotics and Cybernetics (CIIRC)" at CTU in Prague. (http://www.ciirc.cvut.cz)
- "New technologies for the information society NTIS" at the University Western Bohemia in Pilsen. (http://ntis.zcu.cz)
- "Center of Excellence for Cybercrime, Cybersecurity and Protection of Critical Information Infrastructures" at Masaryk University Brno. (https://www.muni.cz/research/projects/41145)

As a part of the large infrastructures programmes, which are a part of the Roadmap of the Czech Republic of Large Infrastructures for Research, Experimental Development, and Innovation for the years 2016-2022, centres IT4Innovations, CESNET, and CERIT SC, whose infrastructural support is suitable for the AI development, were supported.

Tab. 1 Universities and university hospitals participation (not divided to organisational units/faculties) taking place in years 2015 to 2017

Institution	Number of projects	Total expenses, thousand Kč	Public funding, thousand Kč	Fraction of public funding in the category
Brno University of Technology	27	159 479	107 221	23.6%
VSB - Technical University of Ostrava	7	147 315	81 967	18.0%
Czech Technical University in Prague	34	123 218	114 036	25.1%
Charles University in Prague	26	57 679	55 689	12.3%
University of West Bohemia	7	27 290	22 797	5.0%
Masaryk University	10	20 349	19 567	4.3%
University of Ostrava	2	13 791	7 334	1.6%
Palacky University Olomouc	6	13 725	12 503	2.8%
Technical University of Liberec	4	12 548	11 781	2.6%
Silesian University in Opava	2	7 853	4 655	1.0%
Mendel University in Brno	3	5 193	4 057	0.9%
Czech University of Life Sciences Prague	4	5 080	4 740	1.0%
University of Hradec Králové	2	4 599	4 599	1.0%
Tomas Bata University in Zlin	1	1 528	1 426	0.3%
University of Pardubice	1	1 506	1 311	0.3%
University Hospital Brno	1	697	697	0.2%

Source: The national R&D Information System

Private and start-up sphere

By far the strongest AI ecosystem in the EU is in the United Kingdom, followed by Germany, France, and Spain. London is the largest AI centre for European companies, followed by Berlin, Paris, Madrid, Stockholm, and Amsterdam. British, German, and French AI companies represent more than 50% of the total number of European AI companies. Interesting is a comparison of countries when the size of population and number of start-up companies is taken into account. In this case, Switzerland takes the lead, followed by Finland, United Kingdom, Sweden, Ireland, and Denmark. In this comparison, United Kingdom is a smaller player, on par with Spain, Germany and France. See Chapter 6.1 of the technological study for more information.

The European start-up scene differs from the worldwide one in terms of the application fields in focus. At the European start-up scene, cyber security drops down to the second half, as well as robotics, the Internet of Things, and FinTech. Automotive is virtually not represented. On the other hand, marketing and business, and personal assistants are more in the forefront within the EU.

In the Czech Republic there are approx. 37 start-ups operating in the AI field. A large majority (78%) of all technological start-ups in the Czech Republic (not only from the AI field) used only own resources to start with. Czech AI start-ups focus on product and service development mainly in the information and communication technologies sphere and in professional, scientific, and technical area. Specific product area, namely security, is in a mere third place within the application areas – it involves cyber security and biometric security systems.

Financial comparisons of Czech start-ups, i.e. their performance metrics and market representation, could not be done because there are no publicly available data for these companies. Those that are available, such as annual financial reports, do not provide the necessary detail information. At the same time, such information can be significantly biased since start-ups in the early phases of their existence significantly consume resources and their profitability is minimal if any.

Compared to the degree of possible automation by sectors based on Eurostat Report (see Deloitte [14]), the smallest number of start-ups in the Czech Republic operate in sectors which, on the contrary, require the highest level of automation. Thus, there is a considerable potential for the emergence of new companies. These sectors include transport and logistics, mining, hotel and restaurant services, manufacturing and commerce. Start-ups in the Czech Republic are more oriented towards creating support tools rather than creating final products or services in a particular sector. Therefore, there is a significant risk that foreign companies will carry out final implementation of products of Czech start-ups. In such a situation it can be expected that the further development of Czech start-ups will have the character of a sale to the foreign capital rather than the building of strong Czech companies.

On the international scene, the most important areas of start-up activities are especially cyber security, healthcare, business systems, robotics and marketing, the media, and finance and insurance.

An integral part of any effective start-up ecosystem is a quality investment environment, especially venture capital, which in particular supports new and disruptive technologies carrying a high risk of an unsuccessful implementation. In terms of the availability of support for AI start-ups in the Czech Republic, there is a fairly well developed network of venture capital investors. It includes about 13 investment funds, 4 crowdfunding platforms, and 3 business angels associations. On average, investors have in their portfolios about 10 start-ups from the Czech Republic (up to 20). The average investment reaches hundreds of thousands to a few millions €. Unlike the world start-up scene, the Czech start-up scene lacks the health, robotics, media and automotive sectors. Especially the automotive case is interesting. In the Czech Republic, the automotive industry is strong and cooperates with research institutions, but AI start-ups around this sector have not appeared. A possible reason is apparent separation from R&D headquarters of leading companies in the automotive industry. Therefore, in the Czech Republic there are no start-ups common in the world which deal with automotive sensor systems such as the surroundings objects detection, self-steering support systems, electric vehicle charging systems, virtual reality aids for navigation and mediation of the car's surroundings, systems for 3D printing of parts, etc.

The volume of financial resources procured by start-ups abroad is higher than in the Czech Republic. The reason for this is clearly the size of start-up ecosystems, i.e. the size of the primary market on which start-ups operate. Investors have more resources and the market provides greater turnovers and returns. The reason is also the maturity of financial instruments and equity markets. The median of the funds raised by the world's 100 most significant start-ups is $ 48 million, the third quartile is $ 110 million and first quartile is $ 25 million. Czech start-ups procured similar resources but in CZK (i.e. CZK 25 mil. instead of $ 25 million.).

LINKING RESEARCH AND APPLICATION SPHERES[8]

Between the years 2015-2017, 56 unique enterprises, completing 48 projects in total, took part in research application projects in the AI area as a part of Czech public support program (see Tab. 2). The most represented areas measured by the number of enterprises were information and communication technologies, manufacturing industry, professional, scientific and technical activities, followed by projects within the security area. Six enterprises in total (11% of all participating enterprises) can be considered AI start-ups. In the context of the need for start-ups to quickly deliver the product to the market and a relatively slow cycle of the public support (on average a year from the preparation of the proposal), it is a relatively high number of companies. From the total of 37 AI start-ups in CZ, 16% took part in state supported projects.

Tab. 2 shows the number of small and medium-size enterprises that have received public support, and its volume. Small and medium-size enterprises prevail in obtaining support for technology projects focused on AI. This is good news - despite the slow cycle of getting the support from the application, SMEs participate in the competitions, they are successful and the sense of targeting support for SMEs is preserved.

Tab. 2 State support distribution and total R&D expenses in relation to the size of enterprises between 2015 - 2017

Enterpise category* (emploees)	Number of enterprises	Number of projects	Total expenses, thousand Kč	Public funding, thousand Kč	Public funding as fraction of total expenses	fraction of total public funding of enterprises	Average cost of project, thousand Kč	Average total expenses/enterprise, thousand Kč
micro (1 - 9)	11	9	36 314	19 213	52.9%	17.4%	4 035	3 301
small (10 - 49)	21	17	103 500	55 902	54.0%	50.5%	6 088	4 929
medium (50-249)	14	15	41 170	18 036	43.8%	16.3%	2 745	2 941
large (250 +)	6	4	21 296	14 331	67.3%	13.0%	5 324	3 549
not stated	4	3	6 035	3 118	51.7%	2.8%	2 012	1 509

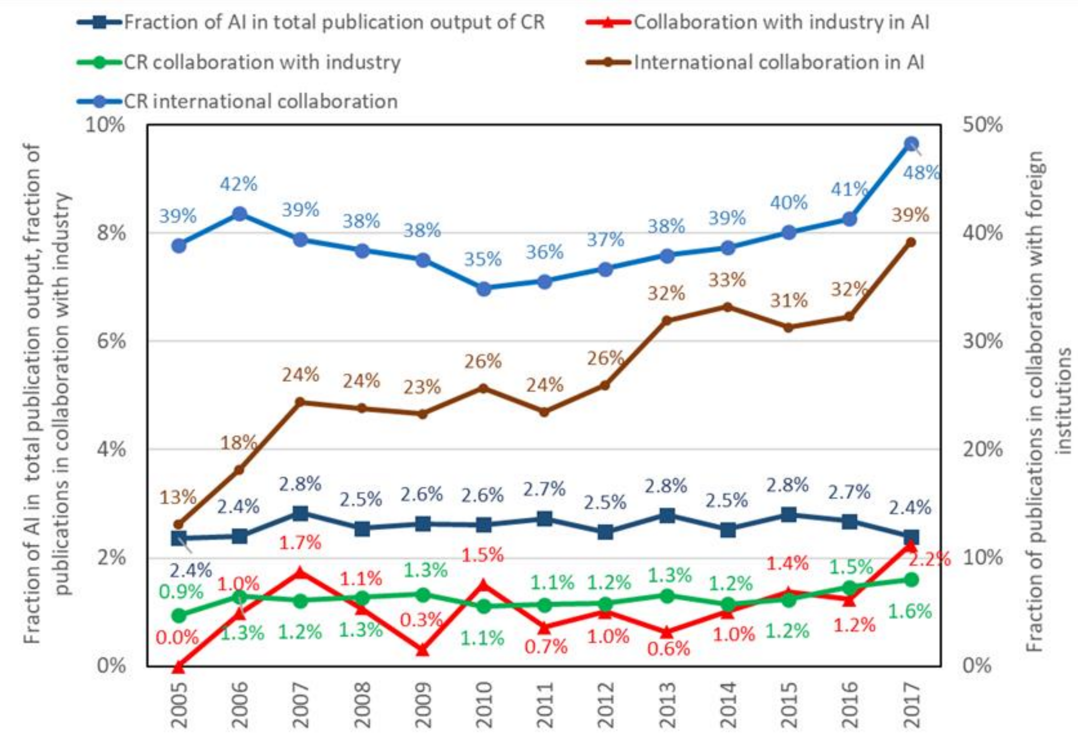
Source: The national R&D Information system, Czech Statistical Office

The number of professional publications focusing on AI is growing significantly in the Czech Republic, and from 2005 to present, the annual publication output in AI has approximately tripled. However, it must be taken into account that during that time, the great growth of publishing activity occurred throughout the whole Czech R&D system. Therefore, the share of AI publications in the total publication output of the Czech Republic has practically not changed since 2005. The share of publications in the AI field with international participation grows constantly, however it is still

[8] Interactive maps of the cooperation of research organisations and application sphere can be accessed at the following link: http://svizualizace.tc.cas.cz/ai/main.html.

approximately 9 percent points below the total level of the Czech Republic (see Fig. 3). In the group of the R&D results of the application character, software and technically implemented results dominate.

Fig. 3 Czech publishing output in AI, share of publications with foreign collaborators, and in cooperation with industry (total values for the Czech Republic are stated for comparison)



Source: WoS, InCites

Tab. 3 Projects started in 2012-2017 according to NACE classification (descending order based on total costs)

Fields of AI	Number of projects	Fraction of total number of projects	Total expenses, thousand Kč	Fraction of total expenses	Public funding, thousand Kč	Fraction of total public funding
R&D without direct application	56	34,8%	1 249 910	57,6%	785 603	52,7%
R&D with direct application	105	65,2%	921 118	42,4%	704 299	47,3%
of which						
Manufacturing	15	14,3%	128 817	14,0%	90 724	12,9%
Transport and warehouses	8	7,6%	114 019	12,4%	73 184	10,4%
Information and communication technologies	8	7,6%	104 516	11,3%	89 787	12,7%
Professional, research and technical	18	17,1%	87 306	9,5%	84 896	12,1%
Health and social services	10	9,5%	76 797	8,3%	54 655	7,8%
Agriculture, forestry and fisheries	6	5,7%	66 343	7,2%	44 132	6,3%
Other activities	4	3,8%	62 966	6,8%	53 321	7,6%
Leisure, entertainment and culture	4	3,8%	52 554	5,7%	45 973	6,5%
Fnancial services and insurance	11	10,5%	51 507	5,6%	41 635	5,9%
Cross-area	6	5,7%	40 751	4,4%	31 385	4,5%
Administrative and support	2	1,9%	34 443	3,7%	22 200	3,2%
Wholesale and retail, service and repair of vehicles	2	1,9%	23 440	2,5%	11 569	1,6%
Education	2	1,9%	19 582	2,1%	18 478	2,6%
Utilities, grids, power, gas, building micro climate	2	1,9%	19 226	2,1%	9 258	1,3%
Public administration, defense, social insurance	4	3,8%	17 787	1,9%	16 899	2,4%
Mining	1	1,0%	12 142	1,3%	7 281	1,0%
Civil engineering	2	1,9%	8 922	1,0%	8 922	1,3%

Source: The national R&D Information system

In Tab. 3 the share of research without a direct application and application projects in the AI field is compared, and the shares of individual application areas are also shown. The largest number of projects is focused on professional, scientific, and technical activities, predominantly focused on the use of AI methods as a support tool for the solving of tasks in some the technical field. It is therefore not directly affecting the automation of human activity. The next in order are manufacturing, financial services and insurance, and health and social care sectors. The smallest number of projects is in the areas of administrative and support activities, mining and extraction, and trade. Transportation, warehousing and logistics are at average values in terms of number of projects, but in terms of the financial volume of projects, they have the largest volumes together with manufacturing industry.

2.2 The strategic directions and sectors of AI development in the Czech Republic

The technological study presents in Chapters 8.2, 8.3 and 8.4 the main research directions, which are covered by research projects supported from public resources, including their application orientation and focusing on automating human work. The Chapter 6.1 lists the main field of research in that individual research institutions are involved. In the Czech Republic both basic and applied research in AI are strong. The ratio of the project proportion is 60:40 with the prevailing funding for the basic research. The Chapter 6.2 of the Technology part of the study describes the start-ups scene and its sectoral focus. Here, the basic information is summarised. The details are presented in the relevant chapters of the technology study.

In terms of quantity and financial volume of the funded applied projects, following research areas prevail (in the order of occurrence):

- Statistical and stochastic methods, prediction, optimization, machine learning, neural networks, state space search - this is the most strongly represented group of methods in the application's output.
- Multi-agent systems and their use for planning, collaborative systems, negotiation, distributed systems and simulation.
- Natural language understanding (methods of Neuro-Linguistic Programming).
- Computational robotics methods and computer vision - both groups are represented approximately to the same extent.

The presented statistics corresponds also with the size and number of institutions dealing with the applied research. In the application area the following application fields are less represented:

- Virtual and augmented reality
- Game theory
- Simulation
- Speech recognition

These methods have lower application rate of utilisation, on the other hand, they have a strong research background in the Czech Republic and we may expect that their wider application utilisation is rather a matter of time.

In the realized application projects, the AI methods are used for the implementation of application technologies which are subsequently deployed in various spheres of business. Following key technologies that are successfully developed by the projects of applied research in the Czech Republic, are worth of mentioning:

- Technology of robotization: Projects dealing with collaborative robotics, robots and control systems for robots that can be deployed in the start-up environment, and for experimental and flexible production lines. This area attracts 16% of all applied research projects.
- Cyber security and safety, where 5% of all applied research projects can be found.
- Autonomous traffic technology: Projects that process data from the traffic flows, management of urban transport infrastructure, etc. fall into this category as well. These projects represent 4.4% of all applied research projects.
- Autonomous technology and unmanned transport vehicles: This includes the assistive technology with processing of sensory information from the surrounding environment, including the computer vision. Furthermore, it includes control systems of these vehicles and systems for the support of decision, collaborative negotiations and planning, and including multi-agent systems.
- Systems for data processing and knowledge discovery: These are technologies for gathering data for use in learning systems, data mining, big data processing and knowledge discovery from data, including the data processing for social analysis.

These research methods and technologies are deployed in projects in application fields. We present a summary of their deployment in the Czech Republic in Tab. 4. In the columns there are listed sectors of application. In the rows we quote the intensity of representation of these sectors in application programmes supported from public funds and also the intensity of the expected impact of AI deployment in the Czech Republic.

Tab. 4 Comparison of the intensity of applied research projects of AI technologies in the Czech Republic with the expected impact

	Manufacturing Industry	Logistics, transport. and storage	Information systems, data processing	Professional, scientific and technical activities	Health and social care	Agriculture, forestry and fishing	Culture, leisure, recreation	Banking and insurance sector	Administrative, supporting activities	Wholesale and retail trade	Education	Energy	Public Administration	Mining, quarrying and construction
Applied res. acc. to the no. of projects	dark green	green	green	dark green	dark green	green	light green	dark green	yellow	yellow	yellow	yellow	light green	yellow
Applied res. acc. to costs per project	dark green	dark green	dark green	green	green	light green	light green	light green	yellow	yellow	yellow	yellow	yellow	yellow
Applied res. of automation human work	dark green	dark green	white	light green	white	green	yellow	green	light green	yellow	yellow	white	light green	white
Risk of autom. of human work in CR	dark green	dark green	yellow	yellow	light green	light green	green	light green	green	dark green	yellow	green	green	green

Dark green – strongest representation; green – strong; light green – weaker; yellow – low, white – none

Source: Chapter 8 of the technology study

From the previous comparison, the following sectors can be highlighted to which the majority of applied research in the Czech Republic is concentrated, according to the number of projects and/or the financial volumes:

- Manufacturing industry
- Logistics, transportation and storage
- Fintech, data processing and information systems (we connect these fields, since they are closely related)
- Professional, scientific and technical activities – i.e. use and application of AI as a supporting tool in specialized activities, such as for information processing in astronomy, construction activities, etc.
- Health and social care
- Agriculture, forestry and fishing
- Culture, leisure, recreation (gambling industry can be associated therewith as well)

In the row "risks of automation" the sectors that are not covered by the applied research are highlighted. These may be the sectors which can offer not yet explored opportunities for the applied research, namely the wholesale and retail trade, administrative and support service activities, public administration, energy, mining and extraction, and construction.

The education sector will strongly benefit from the new opportunities brought by the AI technology, both for classical teaching and online education and training courses as well. Their impact on human work, however, will be minimal. The creative approach, human work of teachers and lecturers involved will not be replaced in the near future. The online education will expand, but will not physically replace the teaching staff.

Of course, an ongoing rapid development occurs in AI technologies. We may expect that in the near future the following technologies and their application deployment will play an important role. They are of a strategic importance and the research institutions in the Czech Republic are already working on them:

- **Explainable AI**: AI methods based on machine learning, neural networks and genetic algorithms do not provide, for the time being, a feedback to the question, how the decisions are justified. Certification of AI autonomous systems for real traffic, such as in autonomous vehicles, will strongly depend on the plausibility of the subsequent explanation of their decisions.
- **Certification of the AI systems**: This issue is related to the accountability. For the real operation of AI systems in daily life, the certification will be required.
- **Large scale and precise simulation**: The models of real systems will become significantly cheaper and accurate (e.g. production lines, warehouse logistics and logistics, transport system, urban infrastructure etc.).
- **Systems of interaction of robots/AI systems/human factor**: Systems for cooperation in the common area, both on the level of physical robotic systems and the interaction interface.

In Tab. 5, this comparison is provided for the start-up scene. The fields structure is simpler and it also includes technologies that companies are deploying intersectoraly. For this reason, at start-ups case the comparison in combination of disciplines and technologies is selected.

Tab. 5 Comparison of the intensity of sectoral and technology activities of start-ups in the Czech Republic

	Information systems and data processing	Professional, scientific and technical tasks	Cybernetic safety	Marketing	Corporate management	Banking and insurance sector	Aerial Earth observation	Logistics, transportation,	Manufacturing industry
Focus of start-ups	dark green	dark green	dark green	dark green	green	green	yellow	yellow	yellow

Dark green – strongest representation; green – strong; light green – weaker; yellow – low, white – none

Source: Chapter 6 of the technology study

Tab. 6 The comparison of the AI technologies used in application sectors for applied research projects supported by the public funds in the Czech Republic

	Cross field	Administrative and support activities	Real estate	Transportation and storage	Information and communication	Cultural, entertainment and leisure activities	Other, not cathegorized	Finance and Insurance	Professional, scientific and technical activities	Construction	Mining	Accommodation, food and beverages	Wholesale and retail trade	Public administration and defense; social security	Energy	Education	Water supply; waste and remediation	Health and social work	Agriculture, forestry, fishing	Manufacturing
Game theory								1												
Machine Learning	1				8	1	2		14									10		3
Multiagent systems	3			5	1				1					1	1			1	1	4
Natural Language Processing		3			1	2			6					1		2		1		
Pattern recognition	1			1										2				1	1	
Simulation		1		1				2	2					2					1	5
Speech Recognition					1	3														
Statistical - Neural networks, genetic alg.	1	2		3	6	1		3	38	3			1	4	1	1	1	9	3	7
Statistical, stochastic methods				3	2			19	9	7	1	1	1	4	1	2		7	2	6
Subsymbolic	2	1			1		1		1					1				1		2
Subsymbolic - Control systems									1								2	1		3
Subsymbolic - Evolutionary alg.				1	2				4											2
Subsymbolic - Information retrieval						1							1	1		1		2		1
Subsymbolic - Robotics				3					1							1				10
Subsymbolic - Vision	1	1		1			1	1	1									3	1	
Symbolic methods					4				1											

Dark green – the third quartile, the strongest representation; green – the second quartile, strong; yellow – the first quartile, the low, white-No. The numbers correspond to the number of projects.

Source: Technology Centre CAS

Sectors such as banking and insurance are closely related to information systems and data processing, in the same way as the corporate management is related to information systems. For strongly represented we may thus consider all sectors except for those that are marked yellow in the table.

For the comparison, Table 6 maps the use of AI methods in sectors. The table shows the deployment of AI technologies in application sectors in the Czech Republic in projects with public R&D support.

Comparison of data on the significance of the AI impact on the individual application sectors (see [14]) with the above findings on the applied research projects (see table 5) show that in the Czech Republic there are application areas with high expected impact of the introduction of AI technologies, with a number of them not sufficiently covered by the applied research. In particular, it is the public administration, wholesale and retail trade, and mining and construction. Here the space is opened for new research projects. It makes thus sense to support projects in these areas, which will be largely automated. At the same time, it is reasonable to expect that the supported projects would be implemented in cooperation between research institutions and businesses and/or the start-ups from the Czech Republic.

Table 7 lists the categories of sectors and technologies in the Czech Republic in the form of a SWOT analysis.

Tab. 7 Comparison of sectors, technologies and AI methods in the Czech Republic as a SWOT analysis

Strong application sectors, technologies and methods	Weak application sectors
Application sectors: Manufacturing industry Logistics, transport and storage Cybersecurity Fintech, data processing and information systems Professional, scientific and technical activities Health and social care Agriculture, forestry and fishing Culture, entertainment and leisure, gambling industry **Application technologies:** Robotic systems for special deployments, small production lines, collaborative systems Autonomous transportation technologies, traffic flows Technology of autonomous unmanned vehicles, multi-agent systems Systems for data processing and acquisition, knowledge acquisition **R&D AI methods in application outputs:** Statistical and stochastic methods, prediction, optimization, machine learning, neural networks, state space search Multi-agent systems – planning and negotiation, collaborative and distributed systems, simulation, etc. Neuro-linguistic programming (NLP) Methods of computational robotics, and computer vision	**Sectors of R&D applied research projects in CR that are worldwide mostly covered by applications but in the CR only weakly by the R&D projects:** Automotive Trading Hardware for AI Media and broadcasting Teaching Agriculture Legal service Traveling, sports Personal assistants **Sectors of start-ups that are worldwide mostly covered by applications but only weakly by the start-ups in CR** All as stated above and in addition: Health services Robotics Internet issues
Opportunities	**Threats**
Sectors covered weakly or not at all by applied research with a high degree of automation in the CR: Wholesale and retail trade, Administrative and support service activities, public administration, Energy, Mining , and construction **AI methods at present only weakly represented in the applications, with strong potential for the foreseeable future:** Virtual and augmented reality Game Theory simulation speech recognition **AI methods with a strong expected potential:** Explainable AI: reasoning of decisions of AI systems Certification of the AI systems: for the real operation of AI systems in daily use. Large precision simulation: for the design of real systems. Cooperating systems machine-AI system-man	**Application sectors of AI in the Czech Republic with a high expected impact on automation, which are currently insufficiently covered by applied research:** Wholesale and retail trade Public administration Administrative and supporting activities Energy Mining and construction There is a risk that their automation will be taken over by subjects from abroad. As threats are, further on, all areas listed in the part of weak AI application sectors in the Czech Republic. These areas are strongly supported abroad, especially by venture capital. There is a risk that of a strong competition will arise in AI technology, difficult to be catch up with. Strong negative impact would follow the potential loss of the current strong position of the Czech Republic in cyber security, where we belong to the world leaders in computer security/anti-virus products.

2.3 Examples of applied research projects in AI in the Czech Republic

The following are examples of applied research projects, mainly collaborative projects of research institutions with application sector, in the implementation of research results into practice.

CYBER SECURITY: ANOMALY DETECTION IN COMPUTER NETWORKS

The company Cognitive Security (COSE) was founded to commercialize the research of the Faculty of Electrical Engineering of the Czech Technical University (CTU) in the field of AI application in network security and agent-based systems. An AI system was created which acts on the basis of the Network Behaviour Analysis. The system is generally able to detect in real time any anomaly occurring within the network. Failures are identified and reported to the monitoring person. In this way the system works as an analogy of an immune system.

Credo Ventures got involved in COSE in April 2011 after months of testing and verification. It had kept the investment for 20 months (a very short time, generally the venture capital exposure spans over 3-5 years) when the company was sold again to the US giant Cisco Systems. For Cisco an investment in Central and Eastern Europe is a very unusual one. At that time Cisco was forced into a quick decision because of interest in COSE from other parties (e.g. the famous Sequoia fund). All this was only possible due to the fact that the earlier success of AVG and Avast provided an excellent reputation for the Czech Republic in the field of IT security worldwide.

Source: Club of investors, http://www.klubinvestoru.com/cs/article/1734-success-story-cognitive-security

GAME THEORY: PLAYING POKER

Researchers from the CTU, Faculty of Electrical Engineering, AI Centre at the Department of Computer Science, from the Faculty of Mathematics and Physics of Charles University Prague and the University of Alberta in Canada have achieved a great success in the AI field. The international team has developed a computer program called Deepstack, which has in December 2016, for the first time in history, beaten professional players in one of the most popular card games in the world - two players no-limit Texas Hold'em poker. The scientific discoveries that have led to this result, are published by the magazine Science, one of the most prestigious scientific journals.

Scientists from the Faculty of Mathematics and Physics further work in the Canadian City of Edmonton on artificial intelligence for the company Google DeepMind. Viliam Lisý, researcher from the AI Centre at the CTU, returned home and formed a research team at the Centre, He says: "In the Czech Republic, there are not such a bad condition for research. There are skilled students and there are many interesting opportunities for cooperation with the applied research in the industry."

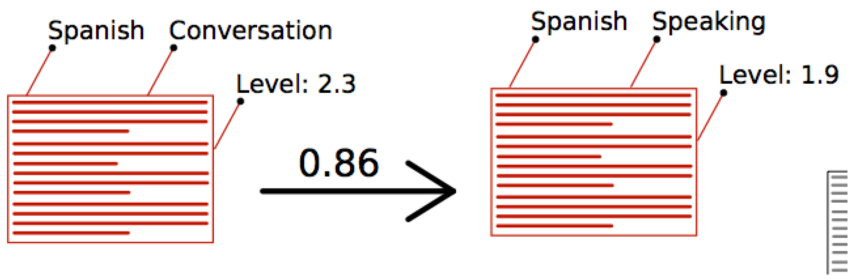
Because of the massive amount of poker situations, a regular program is not able to choose an appropriate strategy by using precise calculation. Therefore, the DeepStack is programmed in order to learn how to estimate the correct value by himself. It decides on the basis of its previous experience and/or on the basis of situations previously shown to it. This approach is to a large extent similar to the intuition, used by poker players. The whole process is based on artificial neural networks.

The game theory has wide use, for example, it is used traditionally as the basis for economic and biological models. One of the founders of modern game theory, John Forbes Nash, was awarded the Nobel Prize for economics.

Source: CTU, http://cs.felk.cvut.cz/en/news/detail/1278

UNDERSTANDING OF THE CONTENT OF THE DOCUMENTS: AUTOMATIC SUPPORT FOR STUDIES PLANNING

University of West Bohemia in Pilsen prepared AI algorithms for an U.S. company, allowing to plan the education and professional career. The algorithm automatically evaluates to what extent the subjects and courses listed by various schools are similar in terms of the content and levels. For example, at the listed language courses, it was possible to determine if the same language is taught, if it is about the same type of teaching, and how the levels of difficulty match. The know-how consists not in the keyword search, but in understanding of the natural content of the text. The algorithm understands the content of the text so that it is able to assess the conformity of the subjects and courses on a scale from 0% to 100% with a success rate comparable to the human.



Why is it a difficult task? The information searched is generally available on the Internet. But it is coded in natural language without prescribed structure, and there is a huge amount of it. For example, in the USA there are approximately 420 000 job offers, 80 000 traineeships, 47 000 vocational schools and universities, 15 000 possibilities to study financing. For this reason, the AI algorithms for neuro-linguistic programming (NLP methods) were used, which were then implemented by an U.S. company into the final product.

Zdroj: ZČU, http://nlp.kiv.zcu.cz/projects/pathevo

AUTOMOTIVE: CTU TAKES PART IN THE DEVELOPMENT OF DRIVERLESS CARS FOR TOYOTA

The team of researchers from the Faculty of Electrical Engineering, Czech Technical University, Centre for machine perception, which is also part of the Research Centre for Informatics at CTU (RCI) significantly expanded its cooperation in the field of technology of autonomous vehicles in partnership with Toyota. The carmaker will pay to the university annually more than a EUR 1 million.

"It will be one of the largest research teams within the CTU, that is paid by a private company," Professor Jiří Matas of the Department of Cybernetics of the Faculty of Electrical Engineering said. Under the leadership of Professor Jiří Matas the team deals with the analysis of the space, in which the car operates. They are using to this purpose a camera and optical sensors. However, this is only a part of the systems, which are necessary for driving a car without driver. For the mapping of the area around the vehicle they use, for example, lidars (laser radar); their development, however, is run by other teams that are partners of the Japanese vehicle factory.

The Prague team currently focused primarily on the detection of the moving objects around the car. However, in the past the engineers from CTU worked for example on the development of the traffic sign recognition system which is now commonly integrated in the cars. In addition to the financial gains, the University benefits from the cooperation also by half-ownership of resulting patents.

Source: CTU and E15, https://www.e15.cz/byznys/prumysl-a-energetika/japonska-toyota-rozsiri-spolupraci-s-cvut-univerzita-se-podili-na-vyvoji-aut-bez-ridice-1338463

3 Expected socioeconomic impacts of AI

This chapter presents main outputs and conclusions of a specialised background study, which deals in detail with the analysis of expected socioeconomic impacts of the AI development in the Czech Republic.

3.1 Economic model of labour market impacts

The model of automation and of the AI impact on the labour market in the Czech Republic was developed by the Technology Centre CAS using a Deloitte computational and data model. The model is based on an estimate of the activity-based automation potential of individual work activities carried out in each profession, and the time horizon where the required levels of ability will be met by technology (the so-called activity-based approach). The model thus follows the approach used in the McKinsey Global Institute study [35], which is based on the decomposition of the different occupational categories. Unlike the McKinsey Global Institute study, the model does not deal with activities carried out in individual professions but directly with the information about the skills needed to practice the profession. For this purpose, the O*[9] Net database information on the skills required for the performance of each category of occupation was used (see Tab. 4). This data has been linked to information from the McKinsey Global Institute study on technological capabilities at present and future years (see Tab. 5). The result of the model is an estimate of the impact on individual categories of occupations and, consequently, on the labour market in the various sectors of the economy. The model provides a technological potential estimate of substitutability of human labour by artificial intelligence for the individual profession groups and for the individual sectors of the Czech economy in the time frames of 5, 15, and 30 years. A detailed description of the methodology and the modelling process used, is available in the specialised background study dedicated to the socio-economic impacts of AI.

Tab. 4 Overview of the observed skills crucial to perform the individual occupations

Skill area	Skills	Skills description
Sensory perception	Sensory perception	Ability to respond to signals by movement, to see objects at a close range and at distance, to see objects in low light, to recognise colours and their hues, to recognise distances, differences in sounds, differences in the direction of sound, to recognise sound in a disruptive environment.
Cognitive capabilities	Recognising existing patterns and categories (supervised *learning)*	Ability to recognise a problem, derive a meaning from known categories of stimuli, to identify known patterns (object, sound, image) in a disruptive environment, to compare similarities and differences, to estimate the form of patterns (shapes, objects, …) when a part of them is rearranged.
	Generating novel patterns/categories	Ability to develop new ideas (important is their number, not originality, quality or correctness).
	Logical reasoning and problem solving	Ability to apply general rules to specific problems and formulate answers that make sense, to combine information that give rise to general rules or conclusions (includes finding a relationship between

[9] The authors decided to use the O* Net database instead of the national Central Competence Database (part of the National System of Occupations) administered by the Ministry of Labour and Social Affairs, mainly for three reasons. First, the O* Net database contains a more detailed breakdown of skills without reference to the professional skills and knowledge required in the individual professions. Secondly, the O* Net database makes it possible to assess not only the skill level required for the occupation but also the importance of the skills required to practice the profession, as opposed to CCD. Thirdly, data values in the O* Net database are of a continuous nature, while in CCD they are discrete. For analytical purposes, the O* Net database seemed more appropriate.

		seemingly unrelated events), to determine correct mathematical methods or formulas to solve a problem.
	Optimization and planning	Ability to create or use different sets of rules for combining or grouping objects in various ways, add, subtract, multiply, or divide in a fast and a correct way.
	Creativity	Ability to develop unusual and clever ideas about a given topic or situation, or to develop creative ways to solve a problem.
	Information retrieval	Ability to organise objects or actions in a certain order or pattern based on a particular rule or on a set of rules (e.g. patterns of numbers, letters, words, images, mathematical operations), ability to remember information such as words, numbers, images, and processes.
	Coordination with multiple agents	Ability to focus on a certain task for a certain amount of time without distraction, to switch between two or more activities or sources of information (e.g. speech, sounds, touches or other sources).
	Output articulation/presentation	Ability to deliver information and thoughts in writing so others can understand it.
Natural language processing	Natural language generation	Ability to deliver information and thoughts in spoken word so others can understand it.
	Natural language understanding	Ability to listen and to understand information and thoughts presented in spoken word and sentences, to read and to understand information and thoughts presented in writing.
Social and emotional capabilities	Social and emotional sensing, understanding, and expression	Ability to identify and understand the speech of other person and to speak clearly so others can understand emotional nuances
Physical capabilities	Fine motor skills	Ability to carry out accurately coordinated finger movements of one or both hands to grab, to manipulate or to assemble very small objects, to quickly and repeatedly set machine or vehicle controls to exact position, to carry out quick, simple, and repeated finger, hand, and wrist motions.
	Gross motor skills	Ability to generate maximal muscle strength to lift, push, pull or move objects, to bend, stretch, turn or reach the body, arms or legs, to coordinate arm, body, and leg movement, endurance.
	Navigation	Ability to identify own location in relation to the surroundings or to determine relative position of objects
	Mobility	Ability to physically move for a long time without fatigue.

Source: TC CAS with the use of McKinsey Global Institute [59]

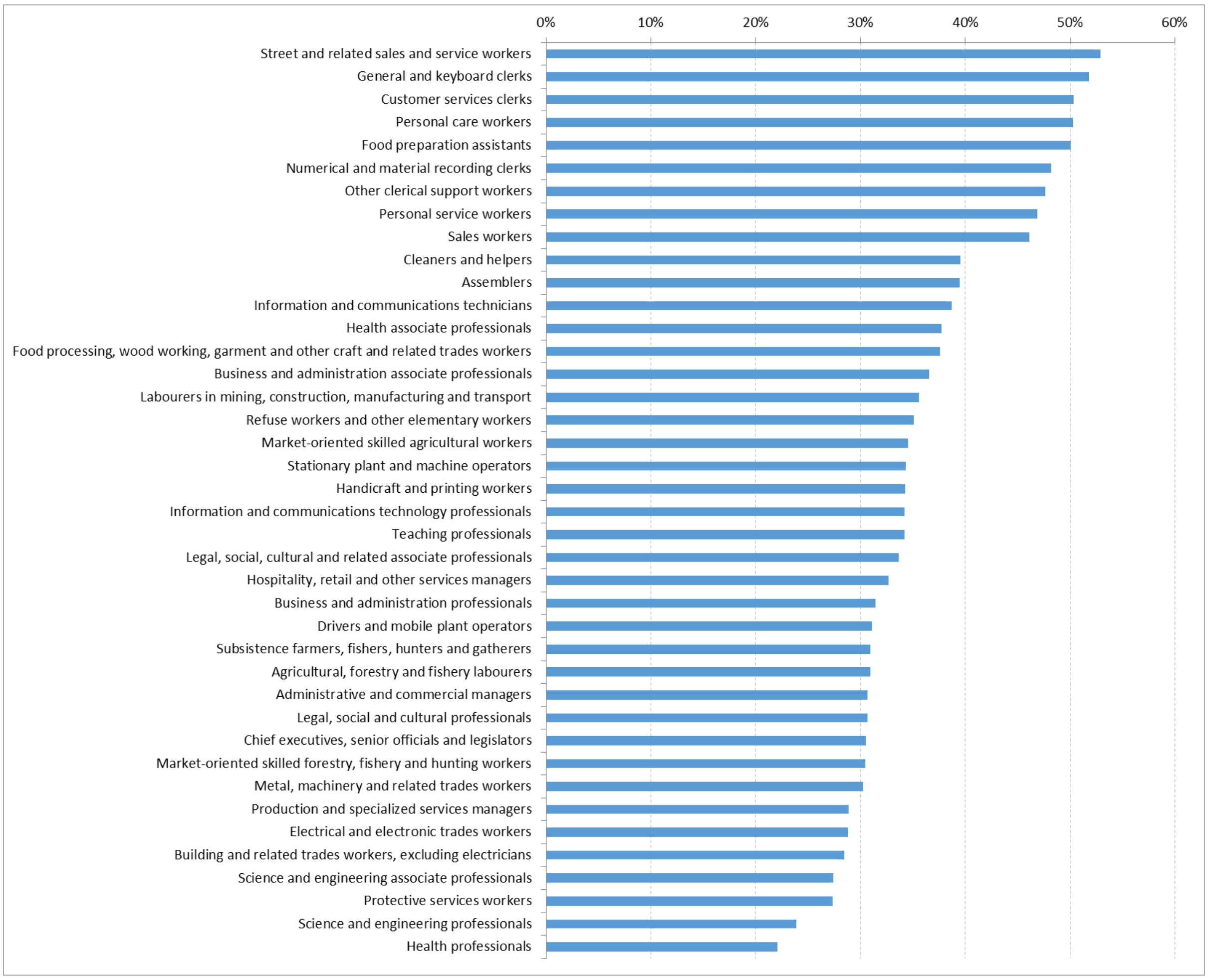
Tab. 5 Estimation of the time-scale of the technological substitution of key skills

Up to 5 years	6 – 15 years	16 – 30 years	Over 30 years
• Optimization and planning • Recognising existing patterns and categories • Information retrieval • Navigation • Gross motor skills	• Fine motor skills • Generating novel patterns/categories • Output articulation/presentat ion • Sensory perception	• Mobility • Coordination with multiple agents • Natural language generation	• Logical reasoning and problem solving • Creativity • Natural language understanding • Social and emotional capabilities

Source: TC CAS with the use of McKinsey Global Institute [59]

Nevertheless, to interpret the results in terms of impacts on the labour market, it must be emphasised that our approach takes into account only one of the factors that determine the potential for work automation. In general, we can identify three basic determinants of the work automation potential. The first is the technical maturity of the technologies, which must achieve at least the level of skills that people do. In addition, there must be a realistic solution (application) for the performance of these skills and the technologies must be able of perform these skills reliably. The second factor is the cost-effectiveness, which measures the costs of the production technology implementation and the labour costs. Even if there is a realistic technical solution to implement technologies in economic activities. However, it can be expected that such solution will only be deployed once the costs of implementation and operation are lower than the labour costs. The third factor affecting the potential of work automation is the existence of a functional regulatory framework and the readiness of the society to accept technologies in real economic activities. This factor is mainly related to the question of security and responsibility associated with the introduction of technologies, as well as with ethical and moral aspects that determine the readiness of the society to accept the substitution of humans by technologies. Another important factor is also the achievement of a sufficient level of digital literacy across the entire society.

Fig. 4 Share of substitutable skills in a 5-year time frame[10]



Source: TC CAS

In our approach, we address only the first of the factors stated above that determine the potential of the work automation, i.e. the technical maturity/readiness. From this it can be generally assumed that the time frame for real applications of technologies in economic activities replacing human labour will most likely be longer than the time frames we outlined. Therefore, for practical reasons,

[10] The occupation categories are grouped according to the 2-digit CZ-ISCO codes.

the following text will focus in detail only on the shortest possible time frame, i.e. the potential substitutability of skills in individual professions that can be reached from technological point of view within five years. Details for the longer timeframes are examined in specialised background study dedicated to socioeconomic impacts of AI.

Given the current technological level of AI, it can be expected that in the shortest timeframe of five-year technologies will be able to replace more than 50% of the skills required to carry out work in 11% of professions. Occupations with the highest share of substitutable skills in the shortest timeframe include Street Sales and Service Providers, General Administrators, Secretaries, Data Entry and Text Processing Staff, Information Services Staff, Counsellors and Associates, Personal Care Workers in Education, Healthcare and Related Areas, and Helpers in Food Preparation (these are the occupation categories at the level of 2-digit CZ-ISCO codes, see Fig. 4).

It is clear from the above list that the high potential for skills replacement is not limited to manual occupations. The gradual implementation of technologies into economic activities can affect both manual and administrative jobs associated with data management.

On the other hand, the lowest proportion of substitutable skills in a 5-year time frame is found within the areas of Health professionals, Science and engineering professionals, Protective services workers, and Science and engineering associate professionals.

In a more detailed division of occupations, the professions with the highest share of substitutable skills in a 5-year time frame include, for example, accounting officials, treasurers, librarians, data recorders and archivers. On the other hand, scientists and technologists (physicists, chemists, biologists, etc.), doctors, civil engineers and architects, and firefighters have the least substitutable skills.

Professions with the highest share of substitutable skills in the 5-year time frame:

- **Quality and product testers, laboratory workers (excluding food and beverages)**
- **Text processing staff, typists**
- **Sales and shipping agents, customs declarants**
- **Accountants an bookkeepers**
- **Employees of labour offices and employment agencies**
- **Data loggers and archivers**
- **Medical records and health information technicians**
- **Treasurers and ticket vendors**
- **Clerks not mentioned elsewhere**
- **Information service staff not mentioned elsewhere**
- **Librarians**

Professions with the lowest share of substitutable skills in the 5-year time frame:

- **Dentists**
- **Biologists, botanists, zoologists and related specialists**
- **Veterinarians**
- **Civil engineers**
- **Geologists, geophysicists and related professions**
- **Specialists in eye optics and optometry**
- **Members of the fire brigade of the Czech Republic and other units of fire protection**
- **Chemical engineers and related specialists**
- **Building architects**
- **Pilots, navigators and board technicians**
- **Physicists and astronomers**

In the medium term, within the time frame of up to 15 years, based on the expected technological development in the AI area, it can be assumed that technologies will be able to replace over 50% of skills in almost 70% of professions. The technological development in the sensory and fine motor skills area will play a significant role in this. For this reason, it can be expected that in the medium term, technologies will be able to replace the skills currently required by some craftsmen, and electronics and electrical workers. A significant share of skills substitutable by technology can be expected in the time frame of 6-15 years in professions such as clerks, assembly workers, cleaning staff or general administrative employees.

In the long-time frame of up to 30 years, it can be expected that technologies will be on such level to replace over 50% of skills in a vast majority of professions.

3.2 Summary of expected socioeconomic changes

Conclusions of studies examined in the research section of a specialised background study dedicated to socioeconomic impacts of AI, as well as from our original model of AI impact on the Czech labour market, can be generalised to the following expectations. Although the numerical results of the individual models used in various studies differ to some extent depending on the approach, assumptions, and estimates of the individual authors, all the studies are consistent with the basic trends of the further development.

GENERAL TRENDS OF AI EXPOSURE

- The benefit of automation lies primarily in taking over of routine and repeatable, as well as strenuous work activities by machines and in freeing human resources for more creative work activities with a higher value added. At the same time, automation increases efficiency, quality, and effectivity of work activities, where machines can perform better than humans. Automation is also a way to replace the human workforce missing due to the unfavourable demographic development in developed countries.
- Given the current development, it can be assumed the AI technologies can substitute 50% of work skill demands in 11% of roles (see the outputs of the economy model in Chapter 3.1). Over a longer time frame (approximately 30 years), automation can replace over 50% of skills in a vast majority of current professions. At the same time, new professions will continuously emerge, but they will place different demands on the workforce and will require different skills and abilities compared to current professions. The decline of jobs in the field of routine manual and knowledge skills will be compensated by new positions in the area of non-routine manual roles, but they will demand non-routine knowledge, social, emotional, and technological skills.
- Occupations with a high proportion of routine skills in the manual area (machine operators, packaging and palletising, batching), as well as in the knowledge area (counting, accounting, data collection and processing, proofreading and data proofing, physical values measuring, and quality control) are among the professions where significant changes in the nature of work due to automation and the introduction of AI can be expected. Lower risk of human labour being replaced is in professions with a higher proportion of non-routine and creative skills in the manual area (repairs and renovations, services, and personal care), as well as knowledge area (research, analysis, planning, design, rules and procedures construction, negotiation, management, teaching and training, leadership, entertainment and presentation).
- The substitution of human work in the performance of specific skills or professions on a larger scale depends not only on achieving the necessary technical skills (technological potential), but also on the ability to apply them in the real world (application potential), the regulatory frame (legislation), the level of digital literacy achieved in society, and last but not least on how beneficial the economic changes are (economic benefit). It can thus be expected that the substitution process will be slower in practice than suggested by the studies, which are generally based only on achieving the necessary technological potential.
- Especially professions with middle qualifications and income levels are facing a higher risk of substitution. In low-skilled, low-income manual professions, automation is not in many cases beneficial, while in non-routine, high-income and creative professions, the automation potential is reduced by the limited availability of the necessary technologies. The loss of

occupations in the middle-income category caused by automation can therefore lead to a deepening of economic inequality in the society. Therefore, this process must be controlled in the context of retraining, and social security policies.

- The substitution of workforce can follow different scenarios, depending on the attitude of employers, employees, and the state to the process of change. The greatest benefit for the economy and the society as a whole (potential for economic growth), and for all the aforementioned actors, brings the so-called "job substitution and retraining" scenario. It presumes not only the economically efficient automation and robotization, but also the ability of people to adjust and to retrain (see [14]).
- Nevertheless, the speed of the retraining and the finding of a new employment varies for different employers and substitution of humans by robots creates a certain amount of frictional unemployment even in the work substitution and retraining scenario. The social safety net must be adapted to this and must support vulnerable employees seeking the retraining and the acquiring of knowledge skills for the more perspective professions. At the same time, the retraining and the lifelong learning processes must be made more effective and the employees themselves (perspective of attractive job in the future), employers (perspective of own human resources potential development), and state (perspective of prosperity, economic competitiveness, and social stability) must participate. The finding the most efficient forms will be a matter of empirical evaluation (for instance the right of work hours relief for educative activities in France, or the rather unsuccessful unconditional basic income experiment in Finland).
- It is necessary to adapt the whole system of education, lifelong learning and retraining to the changing demands on the skills of the human workforce. The microeconomic data show the increasing importance of the technical expertise (STEM - Science, Technology, Engineering and Mathematics) and the multidisciplinarity. The weight of specialized knowledge is decreasing in favour of the importance of complex skills, especially so-called 21st century skills[11], along with the informatics thinking.
- In the area of work organisation, the involvement of AI in the production and services will require deep structural changes in enterprises. Corporate IT departments will be of a great importance. There will have to be a closer collaboration between different structures within companies and collaborating organisational structures on the part of both suppliers and customers. Instead of a hierarchical pyramid structure, a direct and a flexible networking will be preferred (virtual work groups, matrix structure).
- Considering the changes in the nature of work, work tasks in production and services will be more outsourced to non-core employees. This will, from the state perspective, bring new demands on social security system which will have to serve a growing number of self-employed people.
- Greater expectations will be placed on employees in terms of both the time and the space flexibility of the jobs, requiring greater flexibility in the wages system. The new digital nature of work provides better opportunities for the measurement of the work carried out. The wages of workers will depend more on the work actually done, rather than on the time at work. In the new context, it will be necessary to re-examine, for example, the issue of a minimum wage, minimum working hours or overtimes. The new production and wages

[11] Sometimes also referred as so-called soft skills, i.e. skills aimed at developing creativity, critical thinking, collaboration and communication with people as well as machines, presentation, project management and problem solving.

system will also require changes in tax collection, including the coordination of tax rules at an international level.

Specifics of AI effects in the Czech Republic

- In the short term of up to 5 years, a part of the skills of 1.3 million employees will be substitutable by technologies in the medium term of up to 15 years the number rises to 2.2 million and in the long term almost 3.4 million employees can be substituted. Nevertheless, this is only an estimate based on the technological potential of substitutability. It does not take into account the specific application options, the effect of the regulatory framework or the effect of the economic benefit factor.
- From a professional point of view, in the short term up to 5 years, in addition to street vendors, the highest share of substitutable skills has the administrative and the information services staff. In the mid-term up to 15 years, it is also clerks, assembly workers, cleaning staff and general administration employees, and in the long term up to 30 years, personal care staff in education and healthcare as well. On the other hand, the smallest extent of skills substitutable by technologies, in the course of all monitored time frames, can be expected among managers and professionals.
- From the sectoral structure point of view, the greatest potential for skills substitution as a result of AI development in the short term up to 5 years can be expected in accommodation, catering, and administrative activities. In the medium term up to 15 years, we can also expect a significant impact of AI development on skills within building and manufacturing, and, in the long term up to 30 years, the greatest amount of substitutable skills will be in agriculture, mining, transportation and warehousing. Conversely, the lowest share of substitutable skills can be expected in information and communication activities, and in education.
- From the regional point of view, due to the economy and workforce structure, the greatest negative impact of automation on employment can be expected in Ústecký and Karlovarský regions in particular. The largest structural benefits of automation (new jobs creation, missing labour force replacement) will be in Prague and Central Bohemia regions (see [50]).

SWOT analysis of the position of the Czech Republic from the viewpoint of social and economic impact of AI

Strengths	Weaknesses
- High-quality R&D in the field of AI. - Innovative businesses and support of innovation in the businesses. - Qualified experts in AI and computer science. - Functioning system of education and lifelong learning. - Functioning system of retraining. - Functioning social security system and social safety network. - Strategies that covering partly the issue of the socio-economic impact of AI (Work 4.0, Digital Czechia).	- The structure of the labour force and involvement of the Czech Republic in the global value chains increase the susceptibility to the effects on the AI. - There are regions exposed to a high degree of risk due to automation. - In education, the need for the development of skills for the 21st century and information technology skills are not adequately reflected. - Schools lack facilities for the development of digital literacy and information technology skills. - Teachers are not adequately prepared for changes in education, their prestige is low.
Opportunities	**Threats**
- Increasing the productivity and competitiveness of the economy. - The use of freed human resources for creative activities with a higher added value of the human labour. - Conceptual reform and development of education,	- Firms shall be governed only by the criterion of minimizing costs, will not support the retraining of workers. - Lagging behind in economic growth and competitiveness.

lifelong learning and retraining. - Finding of new social models to support the transition of the vulnerable employees to new positions. - AI as an assistant teacher in education. - AI in processes of retraining (personalized diagnostic and proposal of the best solution for a specific vulnerable employee).	- The increase of structural and frictional unemployment. - Deepening economic inequality in the society. - Barriers in business as a result of the non-adaptation of new regulatory framework to the nature of the work (outsourcing) and organizational changes in firms and value chains (new models and ways of cooperation).

4 Legal and ethical issues related to the development of AI

This chapter presents the main outputs and conclusions of a specialised study that analyses ethical and legal issues related to the development and use of AI.

4.1 Ethical Issues

General Ethical Issues Related to AI

Professional literature connects many ethical questions with AI. In general, these questions can be divided into two categories – so-called "*roboethics*", i.e. the area of ethical problems faced by people designing, developing and using intelligent machines, and "*machine ethics*", i.e. the area dealing with situations where machines decide on ethical issues.

Roboethics deals in particular with the following general questions: the lack of transparency of AI in combination with its mass use; anchoring prejudices in autonomous systems (so-called "algorithmic bias"); classification of people and their possible discrimination including reinforcement of social stereotypes; protection of privacy, which may be jeopardized by mass monitoring or by identifying mental states of people resulting in increased possibilities of influence leading to reduction of individual personal autonomy; impact of using AI on human behaviour by altering the natural behaviour and inner life of a person as well as increased dependence on technology or reducing personal communication and other social skills; enhancement of humans and other organisms; AI resilience to new types of attacks; social acceptance of the creation of so-called superintelligence exhibiting the same or higher level of intelligence than a human being; robot rights; social impact related to unemployment and inequality and possible solutions in the form of taxing robots or introducing so-called basic income; or acceptability of the development of autonomous weapons. Specific issues arise, in particular, in the field of health (prediction of occurrence of a disease, chances of survival, provision of information to patients, use of AI in the treatment of mental illness), at workplace (monitoring and influencing employees, evaluation during a selection procedure), in communication (definition of inappropriate expression, false statements); or in trading (trading ethics). A separate and very important category is the ethics of fully autonomous vehicles which significantly overlaps with machine ethics as these vehicles may need to make ethical decisions in the future in the event of unavoidable damage.

Machine ethics deals mainly with the question whether and under what conditions we should allow AI to independently decide on ethical issues. This area has proved to be very problematic, especially because it is not possible to formulate universal rules. A recent MIT project called "Moral Machine" has shown that, although there are general moral preferences, there are also cultural deviations. In view of the global recognition of the principles of accountability and transparency, there are opinions that AI should not be allowed to make ethical decisions at all. It is, therefore, necessary to decide on acceptability of machines making ethical decisions first. When formulating the decision, we need to bear in mind that AI has the potential to come up with innovative solutions that could ideally lead to increased security. The solution could be found with the help of AI based on the data from this specific area (for example, car accident reports, police approach and resulting court decisions) and related analysis.

Ethical Codes of Conduct for Development and Use of AI

Ethical codes for the development and use of AI will play a significant role in the future. Recommendations regarding AI have already been drafted at the global level. The "*Asilomar AI Principles*" are a great example. These principles emphasize especially security, transparency, developer's responsibility, compliance with widely socially recognized values, the need for human control, benefit sharing, risk assessment and prevention, or prohibition of deadly autonomous weapons.

Ethical codes are currently being developed also in the European Union. The European Parliament formulated the Charter of Robotics, which contains the Code of Ethical Conduct for Robotics Engineers, the Code for Research Ethics Committees, the License for Designers, and the License for Users. The content of this Charter could be applied analogously to intelligent systems without physical structure, i.e. software. The European Commission is currently preparing a proposal for ethical guidelines for AI that should be based on the principles previously formulated by the European Group on Ethics in Science and New Technologies. These principles refer to the need to protect the following values while also respecting guidelines for specific implementation of this protection: *human dignity* (limiting the classification of persons, informing humans that they are dealing with an intelligent machine); *autonomy* (respect for human freedom of choice); *responsibility* (designing autonomous systems so that they are in line with fundamental human values and rights and do not pose a risk); *justice, equality and solidarity* (prevention of algorithmic prejudices, fair distribution of benefits, access to key technologies of artificial intelligence); *democracy* (regulation based on public debate, self-determination); *rule of law and accountability* (fair trial, effective rules and solutions for determining responsibility); *security, safety, bodily and mental integrity* (external safety for environment and users, reliability and internal robustness, emotional safety in human-machine interaction); *data protection and privacy* (compliance with existing law); and *sustainability* (human wellbeing and environmental protection). The European Commission's ethical guidelines should be published by the end of 2018. These guidelines should ensure trust in technology by guaranteeing the protection of the values on which the EU is built. The main emphasis is put on ensuring accountability and transparency of AI. In connection with the ethics of the AI development, it is also necessary to focus on the issue of ethical processing of data as in certain areas it overlaps with the ethics of AI.

The Importance of Ethical Issues and Solutions for Legal Regulation

Ethical solutions and ethical codes of conduct will greatly influence the interpretation and application of law to cases involving the development and use of AI. This will be particularly evident in the area of preventive duty and related concepts of liability due to the need to interpret the concept "usages of private life". Moreover, ethical solutions and codes of conduct can be also reflected in interpretation of the concept of "good morals". This concept serves as a flexible means of correction of legal norms in individual cases in which simple application of law leads to obviously unfair results. Initiatives for drafting ethical codes are emerging at both global and transnational levels. The Czech Republic, as an EU Member State, should join the activities not only at the European but also at the global level and actively contribute to the debate towards the formation of future ethical rules. At the same time, the Czech Republic should also be active in the development of sector-specific codes and promote their interconnection with law. It is also advisable to introduce specialized subjects on ethics and standards in the various disciplines in education and to support establishing ethics committees in science and research. When formulating ethical rules and codes, the above-mentioned "rights-based approach", that is based on an internationally recognized standard of basic human rights and the promotion of their individual realization, should be used. In the future, it will also be necessary to continuously address the ethics of data processing for research and development of AI. A dedicated centre should, therefore, be established to assess emerging issues in the field of intelligent data processing that would continuously help to shape a national strategy in this field in consultation with all concerned stakeholders.

4.2 Legal Issues

With regard to the universal usability of AI in many application areas, the development and use of this technology is regulated by a wide range of laws. Foreign national studies dealing with the legal and regulatory impacts of AI have identified a number of general thematic areas that will require a deeper legal analysis in the future. These areas include, in particular, ensuring security by means of standardization and certification, verifiability and review of the functioning of AI, establishment of liability rules possibly supplemented by insurance obligations, legal acts of AI, privacy protection, and the creation of so-called sandboxes, i.e. protected environments in which research and development of AI can be performed on collected data without any obstacles. In addition to the above mentioned topics, the Czech legal and ethical study also deals with the legal nature and status of AI, issues related to intellectual property protection, electronic communications and non-personal data processing, or cyber security. In addition to general questions, the analysis is also carried out for specific legal sectors including, for example, the financial sector, antitrust, research and development, social security, or autonomous mobility. The legal study assesses the current regulation primarily with the goal of ensuring legal certainty and predictability in legal relations while providing a wide space for innovation. To this end, the study suggests the least invasive means to address identified problems.

THE STATUS OF AI IN LAW

AI has no legal definition. The European Parliament called for formulating "*common Union definitions of cyber physical systems, autonomous systems, smart autonomous robots and their subcategories*".[12] Subsequently, a broad definition of artificial intelligence was formulated, highlighting in particular the main characteristics of intelligent systems, such as self-learning, autonomy and adaptability.[13] A brief definition of AI was then formulated by the European Commission in its Communication of April 2018. Here the term refers to computer programs and systems that "*display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals*".[14] At the same time, the European Commission distinguishes between AI that exists only in the form of software (i.e., relatively independent of the device in which it is used) and AI embedded in the hardware of a particular device. Moreover, in relation to this definition, the role of the data on which systems are learning and improving their functioning is emphasized.

Depending on a particular application, the status of AI can be regulated by different legal regimes. Typically, AI can be considered a computer program. AI can also be considered a thing in a legal sense despite a dispute regarding the nature of software. The Product Liability Directive is currently under the review with the aim to determine the applicability of the concept of a product to software systems including AI. The software is considered to be a product already in two European regulations of 2017 regulating medical devices.[15] Under certain conditions, AI may be considered a service or possibly a computer virus. In the future, AI could be also considered as "digital content".

In the context of the AI status, it is necessary to add that the European Parliament proposed to consider introducing a special status of so-called electronic person for the most sophisticated

[12] See point 1 of the European Parliament resolution of 16 February 2017 with recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL)).

[13] Opinion of the European Economic and Social Committee on 'Artificial intelligence — The consequences of artificial intelligence on the (digital) single market, production, consumption, employment and society' (own-initiative opinion) (2017/C 288/01).

[14] European Commission. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions. Artificial Intelligence for Europe. April 2018. COM(2018) 237 final.

[15] See Art. 2 point 1) of the Regulation (EU) 2017/745 of the European Parliament and of the Council of 5 April 2017 on medical devices, amending Directive 2001/83/EC, Regulation (EC) No 178/2002 and Regulation (EC) No 1223/2009 and repealing Council Directives 90/385/EEC and 93/42/EEC (Text with EEA relevance) and the Regulation (EU) 2017/74ž of the European Parliament and of the Councilof 5 April 2017 on in vitro diagnostic medical devices and repealing Directive 98/79/EC and Commission Decision 2010/227/EU (Text with EEA relevance).

autonomous robots in the future. This proposal provoked a heated debate and was largely rejected by the professional public. This was mainly due to the concerns about a potential misuse of such institute and concerns about granting AI protection comparable to humans. From a practical point of view, it is possible to consider introducing a definition of an autonomous system with regard to its specific characteristics. Such a procedure would, however, constitute a significant conceptual change of the existing law, because it would also need to be reflected in specific legal areas. It would be appropriate to proceed with such a step only after the changes will be made in the area of tort liability at the level of European law.

LIABILITY FOR AI

The question of liability of AI is one of the most discussed legal issues in this field. In relation to the damage caused by an autonomous system legal scientists have, for example, researched a scope of a prevention obligation of both producers and users, compared the liability for the behaviour of autonomous systems with the existing concepts of liability for the behaviour of animals, children or even employees or trustees, highlighted the need to maintain the principle of strict liability, or analysed the existing product liability regulation. However, the ideal model of liability has still not been identified. The liability for AI is currently being analysed by the European Union, which focuses mainly on the issue of liability for damage and, in particular, product liability. In order to assess the existing legal framework and its sufficiency in relation to AI and autonomous systems, the European Commission set up the Expert Group on New technologies and liability whose goal is to assess the applicability of the existing Product Liability Directive to new technologies and to formulate principles that could potentially inspire changes in national laws. The outputs of this group will be available in June 2019. With regard to the diversity of AI applications, the Czech study focuses on liability rules both in civil, administrative and criminal law.

Civil Law

In the area of civil law, there are rules on prevention, rules governing liability for breach of contractual obligations (contractual liability) and rules on compensation of damages that may not necessarily have been caused by breach of a contractual provision (tort liability).

Prevention

Preventing damages lies in everyone's obligation to "to act so as to prevent unreasonable harm to freedom, harm to life, bodily harm or harm to the property of another." At the same time, it is necessary to take into account individual circumstances of a case or the usages of private life that should justify a particular preventive action. With regard to AI, application of prevention duty can be considered in machine learning, which uses data to create either static or dynamic models. In particular, the developer should take care to prevent occurrence of damage in the future already while collecting data or using existing datasets, processing the data itself (for example, ensuring sufficient representativeness when selecting the data or when removing data noise, etc.), or when securing data, including securing the process of their acquisition. The prevention duty could be fulfilled for instance by so called black-box testing. Black-box testing comprises continuous testing of an intelligent system without knowing its internal logic that provides developers information on whether a system will achieve a desired result in a required number of cases. The general prevention duty is also related to a duty to intervene and a duty to notify. Both of these obligations could be reflected in technical solutions of intelligent systems. In particular, the duty to intervene could be interpreted as a need to develop a specific functionality for monitoring intelligent systems (e.g. intelligent platforms for provision of certain services) and developing intervention mechanisms in the event of threats. In order to ensure legal certainty, it will be necessary to specify the duty of prevention in relation to intelligent systems.

Contractual Liability

A contract is a flexible tool for defining a legal relationship between parties. The Civil Code (CC) provides that a person who has breached a contract has an obligation to compensate for the damage resulting therefrom. Contracts relating to the sale of intelligent systems and the provision of intelligent services can be connected with misuse of adhesion contracts[16] and with confusion stemming from entering into a huge number of contracts. A solution could be to design model contracts and to create technical solutions that would allow for simple and transparent management of contractual relationships. In the future, it will be necessary to amend the law in line with the European Digital Content Directive, the current proposal of which includes regulation of contractual provisions and in Article 9 obliges the provider to bear the burden of proof.

A special case is a liability from contracts entered into by an intelligent software agent. The term "software agent" can be generally defined as a software to which performance of certain tasks can be delegated. A software agent has a certain degree of autonomy, it can interact with the environment, and is proactive (i.e. by itself initiates activity to achieve a particular goal). In the case of entering into a contract by an intelligent software agent (e.g. agreements between agents in the Internet of Things), validity of such a contract could be questioned. Depending on the degree of autonomy of an agent, any party may argue that entering into a contract was merely a "putative juridical act" (an ostensive act) because of the lack of will of the parties. This legal deficiency cannot be resolved by the existing provisions of the CC on representation, because a software agent is not a subject of law. It can be considered an electronic means for making a juridical act. To ensure legal certainty, it would be appropriate to include special provisions on the validity of juridical acts by software agents.

Tort Liability

The CC sets out a general duty to provide compensation for pecuniary and non-pecuniary harm including the compensation for damage. For applicability of the obligation to compensate harm, existence of the following preconditions must necessarily be proven: an unlawful act, damage, a causal link between the unlawful act and the damage and fault. With regard to AI, the main problem lies in proving a causal link, i.e. a question of fact of how damage has occurred. The causation needs to be proved by a damaged party. However, with regard to the lack of transparency and the complexity of the functioning of certain intelligent systems, the obligation to prove causation by a damaged party can become an inappropriate condition which significantly reduces the protective function of the law. Among other things, this is because courts require proving factual causality with "practical certainty" and not only on the basis of probability. The situation is all the more complicated as a damage could have occurred as a result of acts of more persons (a developer, data providers or infrastructure providers, etc.). A possible solution would be to presume a causal link in these special cases and require the person who has the greatest amount of information to disprove this presumption. Another option is to introduce a special insurance for cases where damage has occurred, but a causal link cannot be proven. This would at least support the compensation function of law. However, the national solution should be in line with the European approach, which will only be known in mid-2019.

Another precondition, whose existence must usually be proven, is fault of a tortfeasor, i.e. an internal relationship of this person to causing the damage (so-called subjective or fault-based liability). The question here is the interpretation of the concept of negligence in relation to intelligent systems and a possibility to be released from the duty to provide compensation. Interpretation

[16] An adhesion contract is defined in the Civil Code in § 1798 par. 1 as a contract whose essential terms were determined by one of the parties or according to the party's instructions, without the weaker party having any real opportunity to affect the contents of these essential terms.

guidelines that could be utilized also in the area of administrative and criminal liability would prove as very useful for practice.

In cases specifically provided by a statue a tortfeasor has a duty to pay for damages regardless of their fault. With regard to AI, in Czech law especially the following cases are applicable: damage resulting from operating activities (§ 2924 of the CC), damage caused by a particularly hazardous operation (§ 2925 of the CC), damage caused by the operation of a means of transport (§ 2927 et seq. of the CC), damage caused by a thing (§ 2937 of the CC), damage caused by a product defect (§ 2939 et seq. of the CC) and damage caused by information or advice (§ 2950 of the CC). When applied to AI cases, it is necessary to develop interpretation guidelines to determine limits of applicability of the institute of particularly hazardous operation and the scope of the term "proper oversight" for damage caused by a thing. Liability for damage caused by a thing is an institute that is most likely to be applicable in the field of intelligent systems. However, with regard to the main function of AI, i.e. to act autonomously, the concept of "proper oversight" can significantly limit an independent functioning of a system. The provisions on damage caused by a product defect are also very relevant. However, their interpretation needs to be based on future results of the current evaluation of applicability of the Product Liability Directive. In this context, it will also be necessary to interpret the scope and applicability of liberation on the grounds that the state of scientific and technical knowledge at the time the product was placed on the market did not allow the defect to be discovered.

Existing liability rules are currently applicable. However, with regard to an increasing rate of use of AI and an increasing complexity of these systems and their interconnection these rules are unlikely to be sustainable. Therefore, depending on the specific developments at European level, it would be appropriate to consider creating a specific liability regime for intelligent systems with a certain degree of autonomy that would remove any shortcomings in situations where a responsible person cannot be identified. Typically, this will concern applications that are independent and constantly evolving and, therefore, neither causation can be proven, nor fault could be considered. In these situations, one could consider to introduce a compulsory insurance of these systems as well as limitation of liability as in the case of the Directive on electronic commerce and the Act on Certain Information Society Services (limitation of liability for “mere conduit”, “caching” and hosting). At the same time, the applicability of these limitations of liability to individual AI applications will need to be clarified. However, even when introducing a compulsory insurance, it is not possible to completely waive the requirement for the attribution of at least some liability. All stakeholders still need to stay motivated to comply with legal obligations associated with the development and use of intelligent systems. For these purposes, it will be necessary to disseminate information on the way of AI operation and its risks.

Administrative law

Administrative liability is primarily governed by the Law on Liability for Offenses. An offense under Section 5 of this Act is “a socially harmful act of unlawful conduct which is expressly identified in law as an offense, and which has the features prescribed by law if it is not a criminal offense”. Particular offenses are, therefore, based on individual legal regulations imposing specific obligations and their breach is marked as an offense. In the case of offences, it is necessary to establish a causal link between an unlawful act and a harmful consequence. However, with regard to the frequent lack of transparency of the functioning of intelligent systems, proving a causal link can become a critical factor that affects imposition of an administrative punishment. The impossibility of proving a causal link could lead to a failure to enforce the law in certain cases. In order to secure effective application of administrative law as well as prevention of damage, it would in particular beneficial to create freely available information materials describing the risks of intelligent systems and the possibilities of their prevention, as well as to develop interpretation guidelines on the concept of “reasonable risk”, which can serve as a reason for exoneration.

Criminal Law

Problems in criminal liability are similar to those of administrative law. A key problem here is to prove the culpability. It is necessary to prove either an intent or familiarity with the possibility of violation or threatening an interest protected by law. Therefore, transparency of functioning of information systems needs to be ensures in order to prevent the misuse of AI for committing offenses. In the area of criminal law, the creation of freely available information materials describing the risks of intelligent systems and the possibilities of their prevention, as well as the creation of interpretative rules on the concept of "reasonable risk" and possibly "making all possible efforts" would be of a great benefit.

Privacy Protection, Electronic Communications and Non-Personal Data Processing

AI and machine learning in particular pose a major challenge for privacy and data protection law. This is particularly because of the fact that this technology uses huge amounts of data for its operation, including data about human behaviour. The issue of privacy and personal data protection in recent years has been highlighted not only by the European Union, but also by national data protection authorities, non-profit organizations, industry representatives and legal professionals. In relation to AI, this issue is also closely related to the protection of privacy in the field of electronic communications and the processing of non-personal data.

The European General Data Protection Regulation (GDPR) can be considered as one of the "first artificial intelligence laws in the world",[17] especially with regard to Article 22 GDPR, which specifies "the right not to be subject to a decision based solely on automated processing including profiling". However, the GDPR itself does not include the concept of artificial intelligence or machine learning. The influence of the GDPR on the research, development and use of artificial intelligence in relation to personal data has been examined in several analyses and recommendations documents. The Norwegian Data Protection Authority – Datatilsynet – issued in January 2018 a specialized report "*Artificial Intelligence and Privacy*".[18] The essence of this report is the statement that it is possible to use AI while protecting personal data at the same time because we are still in the early stage of development of AI, when it is still possible to ensure compliance with legal requirements. The UK Data Protection Authority ICO formulated six key recommendations for organizations to help them meet legal requirements in the field of artificial intelligence and large data in the "*Big Data, Artificial Intelligence, Machine Learning and Data Protection*" report.[19] In opposition to the two reports, there is a report on "*The Impact of the EU's New Data Protection Regulation on AI*"[20] by the Center for Data Innovation. The report strongly criticizes the GDPR and suggests that the entire concept should be reworked due to AI and the digital economy. Although this report points out some of the issues that need to be addressed in the implementation of the GDRP, it does not take into account the basic European Union strategy to guarantee a high standard of protection of basic human rights and freedoms as a competitive advantage. Therefore, the GDPR cannot be condemned as an inappropriate and restrictive tool, but viewed rather as an opportunity that, through regulatory demand, stimulates the development of innovative technical solutions that can become a global standard like the GDPR. In order to ensure legal certainty, it is necessary to develop interpretation guidelines to the GDPR that would clarify the scope of the obligation to provide information on the

[17] PATTYNOVÁ, Jana, SUCHÁNKOVÁ, Lenka, ČERNÝ, Jiří et al. *Obecné nařízení o ochraně osobních údajů (GDPR). Data a soukromí v digitálním světě. Komentář*. Praha: Leges, 2018. See p. 23.

[18] DATATILSYNET. Artificial intelligence and privacy. In: *Datatilsynet* [online]. 2018 [2018-10-27]. Available at: https://www.datatilsynet.no/globalassets/global/english/ai-and-privacy.pdf.

[19] ICO. Big data, artificial intelligence, machine learning and data protection. In: *Information Commissioner's Office* [online]. 9. 4. 2017 [2018-10-27]. Available at: https://ico.org.uk/media/for-organisations/documents/2013559/big-data-ai-ml-and-data-protection.pdf.

[20] WALLACE, Nick, CASTRO, Daniel. The Impact of the EU's New Data Protection Regulation on AI. In: *Center for Data Innovation* [online]. 27. 3. 2018 [2018-10-27]. Available at: http://www2.datainnovation.org/2018-impact-gdpr-ai.pdf.

procedure used in automated decision making, including profiling. The interpretation guidelines should respect not only the rights of data subjects but also the rights of controllers to protect their intellectual property.

The GDPR is complemented by regulation in the area of electronic communications. In particular, the proposal for the ePrivacy Regulation[21] is very important. In the opinion of the German Digital Association Bitkom it raises several fundamental problems with regard to AI. As the negotiations on the form of the ePrivacy Regulation are still ongoing, it would be advisable to enforce establishment of a possibility to enable further processing of communication metadata, that was not set out in the original proposal of the regulation. Following the adoption of the ePrivacy Regulation, it will be necessary to amend the Electronic Communications Act. In this respect, the proposal of the European directive on the European Code for Electronic Communications should also be taken into account.

What regards processing of non-personal data, the European Union is developing enough activity to allow for the compilation of data while ensuring a high standard of protection of fundamental rights. In this context, the Regulation on the free movement of non-personal data was adopted at the European level. In this area, however, it seems appropriate to develop technical solutions that would facilitate automated assessment of the legal regimes of data, i.e. whether it is personal or impersonal data. Furthermore, research and development would greatly benefit from establishment of so-called data trusts that would contain data associated with no legal restrictions. In this context, however, it is necessary to find the ideal legal model of such a data trust (assessment of suitability of a private-law institute of partnership) and to identify the preferences and needs of science and industry.

CYBERSECURITY

In the area of cybersecurity AI can be used either to protect it but also to carry out new and very effective attacks. The European Union considers reliability and security of networks and information systems as one of the essential conditions for ensuring the functioning of the online economy. In this context, the EU adopted Directive 2016/1148 concerning measures for a high common level of security of network and information systems across the Union (NIS Directive). The objective of the NIS Directive is to ensure a high level of network and information security in the Member States. The directive is technologically neutral (as underlined, for example, in Art. 19 par. 1) and generally requires the use of appropriate and proportionate technical and organizational measures to manage security risks. However, it can be said, that the directive, in essence, indirectly requires use of AI systems in the future, since these measures are assessed in the light of the latest technological developments (Art. 16). The European Commission also published a proposal for a Regulation on the "EU Cyber Security Agency" and on information and communication technology cybersecurity certification.[22] The aim of the regulation is to achieve a high level of cybersecurity, resilience to cyberattacks and trust in the European Union by granting powers to ENISA – the EU Cyber Security Agency and by establishing European Cyber security certification schemes. Certification is considered a suitable tool to ensure cybersecurity, but it should remain voluntary. Since it should replace national certification in the future, it would be appropriate for the Czech Republic to be involved in the certification process.

[21] Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL concerning the respect for private life and the protection of personal data in electronic communications and repealing Directive 2002/58/EC (Regulation on Privacy and Electronic Communications) COM/2017/010 final - 2017/03 (COD). In: *EUR-Lex* [online]. 10. 1. 2017 [2018-11-01]. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52017PC0010.

[22] EUROPEAN COMMISSION. Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on ENISA, the "EU Cybersecurity Agency", and repealing Regulation (EU) 526/2013, and on Information and Communication Technology cybersecurity certification ("Cybersecurity Act"). COM/2017/0477 final - 2017/0225 (COD). In: *EUR-Lex* [online]. 13. 9. 2017 [2018-11-01]. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2017:477:FIN.

At the level of Czech law, there is a special Act on Cybersecurity which imposes obligations on a limited number of subjects. It focuses in particular on the protection of critical information infrastructures, important information systems, major networks and basic services. Entities not covered by this act are in general required to ensure safety in cyberspace under other legislation. Typically, this is the prevention duty set out in the Civil Code or the obligation laid down in particular in Art. 32 and 33 of the GDPR. For these entities, it is appropriate to promote self-regulation in individual sectors. Furthermore, it seems appropriate to promote certification in cybersecurity, which would greatly enhance legal certainty as regards compliance with otherwise generally formulated legal obligations.

INTELLECTUAL PROPERTY PROTECTION

Czech copyright law does not provide legal protection for works generated by AI applications. The Copyright Act states that the author of a work must be a human. In this context, the doctrine specifically states that "*under the Copyright Act, a computer-generated work or work of other apparatus that is capable of self-organization or learning, for example, in the fields of artificial intelligence, is not considered to be creative work since it is not an intellectual creation of a natural person (author)*".[23] AI can be used as a tool to create a work in the sense of the Copyright Act but it is necessary to individually assess creative participation of a person who created the work. This, of course, raises legal uncertainty about the rights to works created by AI. This uncertainty can then be negatively reflected in innovation in this area as it translates to the uncertainty as to the return on investment in research and development. A working legislative solution can, however, be found abroad. Specifically, in the United Kingdom in the case of work which is computer-generated, the author shall be taken to be the person by whom the arrangements necessary for the creation of the work are undertaken. However, there is also a lack of clarity about the interpretation of the term "arrangements necessary for the creation of the work".

The existing provisions of the Copyright Act could in many cases lead to a situation when works created by AI would not enjoy copyright protection despite the tendency to recognize computer-generated works as a copyrighted works at the European Union level.[24] The only solution for establishing the protection of works created by AI in Czech law is to make an amendment to the current Copyright Act that would establish clear rules for granting protection and distributing rights to works created by AI. However, this should only be done depending on the adoption of the European Directive on copyright in the Digital Single Market, which deals, among other things, with the issue of text and data mining.

SPECIFIC LEGAL AREAS – SELECTED PROBLEMS

Financial and Banking Sector: An example of best practice for innovations in these sectors are so-called regulatory sandboxes, i.e. controlled environments in which lawmakers, firms, and other stakeholders work together to develop new technologies. The European Commission is currently working on a report on the best practices of regulatory sandboxes that should contribute to development in these areas in the future. In the financial and banking sector there is also a tendency to use AI to achieve compliance with legal regulation, the so-called "regtech". This trend needs to be promoted and extended to other areas as well. For the purposes if testing systems of algorithmic trading on capital markets it would be beneficial to formulate and disseminate best practices in the field.

[23] TELEC, Ivo, TŮMA, Pavel. *Autorský zákon*. Praha: C. H. Beck, 2007, see p. 17.
[24] Jugdment of the Court (Third Chamber) of 1 December 2011 in Case C-145/10 Eva-Maria Painer v Standard VerlagsGmbH and Others.

Research and Development: Current activities at the European Union level aim to create favourable conditions for AI research and development. However, in the context of the GDPR, it is appropriate to create interpretation guidelines for Art. 89 of the GDPR. Moreover, the Czech Republic should also adopt derogations at national level from the right of access by the data subject, the right to rectification, the right to restriction of processing, notification obligation, the right to data portability, and the right to object in order to ensure the widest possible space for data processing in relation to scientific research.

Autonomous Vehicles: The current legal framework does not allow testing or operation of partly autonomous vehicles. Although reports on a draft of an amendment to the Act on Traffic on Roads have appeared, this amendment has not yet been submitted to the Chamber of Deputies of the Parliament of the Czech Republic. The current state prevents innovation in the field of autonomous vehicles and it is, therefore, necessary to submit the amendment as soon as possible. Based on the available information, this amendment should allow testing and operation of partially autonomous vehicles by amending the definition of a driver and the definition of a motor vehicle as a vehicle that can be equipped with highly or fully automated driving functions. This amendment assumes that a driver must immediately take over the control of a vehicle when requested. In this context, it would be also appropriate to establish an obligation to periodically review driving abilities that may disappear over time.

Unmanned Aerial Vehicles (Drones): The current legal framework does not allow operation of autonomous drones. If the Czech Republic would choose to allow operation of autonomous drones, it is possible to use the possibility to establish rules for aircrafts and their parts that serve military, rescue, police, firefighting and similar purposes, or to change the Civil Aviation Act.

SWOT analysis of the position of the Czech Republic from the viewpoint of legal questions related to the development of AI

Strengths	Weaknesses
- Sufficient flexibility of the existing legislation that can be applied by analogy on problems related to AI.	- Legal uncertainty caused by the dynamics of changes in law and unpredictable results when applying the existing laws to new problems.
Opportunities	**Threats**
- Setting-up self-regulatory mechanisms of industry and professional organizations and formulation of best practices in a particular industry in line with laws. - Development of technical solutions for ensuring the efficiency of law (“regtech”). - Support of establishment of regulatory sandboxes and data trusts.	- Legislative barriers will limit efficient sharing and processing of data in research and use of AI. - Lagging behind developments on the global level in case a continuous monitoring of AI developments and appropriate adaptations in law would not be performed.

5 Summary of proposals and recommendations for public administration

These recommendations are based on the conclusions set out in Chapters 2, 3 and 4 of the summary report, which are detailed in three sub-studies. The overview of strategic directions and fields of AI deployment in the Czech Republic is presented in Chap. 2.2 of the summary reports.

5.1 Recommendations to support R&D for AI development and deployment

Recommendations to support development of AI tools and their adaptation in companies involve the public as well as the business sphere, their mutual cooperation, and the provision of the necessary number of highly qualified experts for research and application of new AI technologies.

5.1.1 Using AI to increase competitiveness of the Czech Republic

Different sectors and businesses are in different stages of the AI application. It is why they require different measures: in one extreme, a company requires a world-class research to develop own AI and competitive advantages, while in the other extreme, another company is only at the stage of motivation and persuasion about the importance of this technology. Both cases must be underpinned by specific support measures.

- **Creation and development of start-up companies with high added value in AI and with a majority share of Czech entities.** The Czech Republic has to engage in the international digital economy. One of the ways is to support the development of the start-up ecosystem and small and medium enterprises experimenting with revolutionary technologies.

  The key is to use venture capital to a greater extent for testing and introducing new revolutionary products. Public support programs should be targeted at breakthrough AI technologies and their application piloting. It is also important to support the entry of Czech small and medium-sized firms into foreign markets and to simplify legislation for the emergence of new businesses. It is important, as well, to support incubators and accelerators in developing services to help start-ups to scale up on foreign markets, and to connect venture capitalists with emerging businesses.

  To support verification and implementation of new and disruptive innovations on the market, it would be appropriate to introduce grants as a support tool for young engineers and researchers who want to transfer their research results to start-ups. This form of support is still lacking (an overview of the state of the start-up scene is given in Chapter 6.2 of the technological study).

- **Support for AI application ecosystems.** It is important to support the development of AI centres, digital innovation hubs, incubators and business accelerators with a focus on AI. These infrastructures interconnect individual actors who develop and implement AI technologies, specifically research organizations, businesses, the public sphere, and various interest groups. Based on expected synergy effects, these ecosystems will actively contribute to the technological development of AI and its practical deployment, particularly on an international scale. The ecosystems cannot be built in the top down manner, but their creation should be encouraged by the adoption of supporting policies.

- **Support for cross-sectoral and interdisciplinary cooperation and training of AI systems on shared data.** The use of data to train AI technologies must be made as accessible as possible to companies of all sizes. It is necessary to support a strong interconnection of the university and business sectors, including the data sharing for the training of AI systems. It is necessary to take into account the interdisciplinary overlap of AI systems (health, finance, commerce, journalism, etc.), including the interdisciplinary use of training data. The development of own

R&D departments of Czech companies for experimentation with AI technologies is essential. Support for implementation of the breakthrough technologies in cooperation with research organizations is necessary as well. (See also overview of strategic directions mentioned in chapter 2.2 and current state of cooperation in R&D in chapter 6.4 of the technological study.

5.1.2 Using and linking data from all sectors

Data are the fuel for development and application of AI. Beside quantity, quality and accessibility of data have a significant impact on the benefits that can be achieved by AI. By active approach, the Czech Republic can contribute to building and implementation of data sources in businesses and public sector.

- **Data sources accumulation and enrichment** – In the upcoming period of implementation of AI technologies, a key role will be played by sharing of data for the training of AI systems and the subsequent creation of new services and automation of existing services. It is necessary to develop a legislative framework that would enable access to and sharing of public data for the purpose of training and application of AI systems. The same applies for data sharing between companies hampered by often unjustified fear of violating the existing regulation.
- **Enabling the provision of independent services over public data –** It is necessary to create an environment where the state offers the opportunity to build AI systems, test them over typical anonymised data and, subsequently, after authorisation, integrate these systems into its management and offer enhanced services to users without violating their privacy. The current state of large orders and an inefficient system development is not sustainable in the long term for deploying small but efficient services as an extension of a large data infrastructure.

5.1.3 Rapid verification of AI research results in applications and their transfer to practice

The pace of AI development and its adoption is heavily reliant on experiments. For companies, the ability to quickly and efficiently experiment with newly explored and developed technologies is of utmost importance. Companies need help and tools that will facilitate the development and acceleration of innovation activities in collaboration with research organizations, while at the same time leading to the creation of their own strong corporate research and development background. This will reinvigorate the importance of research organizations and motivate researchers to stay and develop quality research there.

Currently supported models of co-operation between sectors are subject to a classical approach that includes exploration, development, production deployment and sales. This is a one-way, inflexible string, which is unfortunately also implemented in support programs.

- **Need to increase the number of research results realised in practice.** The Czech Republic is a country with a high proportion of patents generated by AI research projects against a small number of patents realised in practice. Typical application output of AI research is not a patent, but an algorithm, software protected by copyright (see also Chap. 7 of the technological study). The specific nature of AI technologies and research results should be reflected in the priorities and objectives of public support programs, the evaluation of submitted application research projects and the evaluation of the benefits of the research results as such.
- **Effective transfer of research results into practice.** Effective transfer of intellectual property from research to practice and their rapid verification in the production environment will play an important role. Technological transfer systems in research organizations that were established in previous years are still in the process of their development.

It is necessary to implement a model of simply available intellectual property (IP) of research organizations for experimental application deployment and validation. This is also linked to the revision of regulations within research organizations towards the flexible provision of intellectual property, its verification in practice and start-up experiments. In case of commercial success of the research result, higher returns for research organizations will also be expected, thanks to lower adoption barriers and higher output. This is the opposite of the current approach with a high input barrier, low returns and a small amount of IP tested in practice.

- **Support for experimenting with AI technologies.** It is necessary to create support tools for experimenting with AI, for working with shared and public data and for their subsequent application. Incubators, hubs, and accelerators will support this experimentation.

  Current public support at the level of programs and providers is geared towards creating application outputs of the product type and their location and application in the market. We recommend introducing support for creating experimental platforms to collect and enrich training data and develop experimental products and services. We also recommend targeting public support programs for the development of AI technologies and their experimental deployment.

  We also recommend a revision of the attitude to indicators such as market returns, number of products sold, market research and competition research for publicly supported projects focussed on application of disruptive technologies. These methods are dedicated to conservative products and evolutionary innovations. The assessment of the potential of technology is more authoritative.

  Introducing support for young engineers and researchers who want to transfer their research results to start-ups would help to apply revolutionary technology in practice. Such a form of support in the Czech Republic is still missing.

5.1.4 Retaining and attracting top AI experts and researchers

Competencies and expertise will be used to build competitiveness. Expert knowledge will play the key role. Researchers, experts and technicians trained in AI will be crucial in the process of economic transformation using the benefits of AI technologies. Education and competencies create flexibility in employability and contribute to non-destructive use of technology by companies.

- **Attracting top foreign researchers to the Czech Republic and retaining top domestic researchers.** Development of the research environment can only be done with excellent research teams with foreign experience, involving top researchers. It is very difficult, almost impossible, to obtain the relevant funds to address top foreign researchers and to provide long-term motivation for domestic researchers to develop a research career in the public sector. Support for the funding of top foreign researchers operating in the Czech Republic would significantly contribute to the development of Czech research facilities.
- **Developing the mobility of experts and researchers.** In the Czech Republic the Ministry of Education, Youth and Sports supports the mobility of researchers. For specific calls such as the intersectoral cooperation call within the OP RDE, the mobility of experts between research organizations and the application sector is also supported. The extension of similar mobility programs will significantly support the increase of the expert domain in the Czech Republic
- **Multidisciplinary expansion of education and study programs and AI skills courses.** As in the case of informatics and programming, also the AI technology deployment will require new technical skills. To master them will not necessarily require engineering or doctoral

education. The secondary technical education or bachelor's degree will be sufficient. These missing elements of education must be designed and implemented. It is necessary to take into account the multidisciplinarity of AI technologies and to implement appropriate education also in disciplines such as medicine, law, journalism and the like.

5.1.5 National strategy, smart investments

When our resources are limited, we must use them exceptionally well. The Czech resources for the use and the application of AI are marginal in comparison to international programs. We must aim investments into particular selected areas. The public financing must be carried out effectively and emphasis must be put on impact. The basic strategy document for digitalization in the Czech Republic is the Digital Czechia strategy [17], defined by its three pillars: the Czech Republic in Digital Europe, the Czech Republic's Information Concept and the Digital Economy and Society.

For the further development of R&D in the field of AI, the efficient use of resources and the timely response to the expected impacts and opportunities, it is necessary to incorporate the AI issue into the strategic documents and implementation tools.

- **Development of the national AI strategy** – The creation of this strategy is a key issue, which will send out a clear signal of the Czech Republic's incentive to use all the opportunities provided by AI, and clearly declares the Czech Republic's direction for a competitive innovation-based economy.
- **Stronger support for the deployment of AI technologies into real world** – Existing support programs by major providers such as the Technology Agency of the Czech Republic, Ministry of Education Youth and Sports, Ministry of Industry and Trade and other relevant ministries include the implementation of innovation technologies into practice. These programs should be expanded by assigning a clearly defined support to AI technologies, be it a departmental or program assignment.
- **Expanding and improving expert skills, education, training and retraining.** The education system needs to be expanded at all levels. The second part of the task is an effective support for the retention and attraction of educational and research experts, including teachers and trainers. Further detailed recommendations in this area are given in Chap. 5.2.
- **Building an international overlap, participation in EU initiatives.** The Czech Republic must get involved in emerging initiatives and programs such as the emergence of AI centres of excellence, which will be supported at the EU level. This is already one of the goals of the Digital Czechia Strategy [17]. It is also desirable to engage in initiatives such as Claire [11] and the EU Strategy [23]. Further examples of associations and centres for the development of AI in Europe are given in Chap. 6.1.4 of the technological study.

5.2 Recommendations in the field of labour, retraining, and education

The government should strive for proactive, rather than just to the reactive employment and education policies based on expected labour market changes which are summarised in chapter 3 of this document. The concept of Work 4.0[25] national initiative, which was published by the Ministry of Labour and Social Affairs in 2016, can be used as a starting point, and together with the follow-up Action Plan[26] it can be updated based on the expected impacts of AI and proposed approaches to their solution. The conclusions of the updated Work 4.0 initiative should be subsequently reflected in other existing and newly prepared documents and action plans of the state administration. In

[25] Work 4.0 initiative. https://portal.mpsv.cz/sz/politikazamest/prace_4_0/studie_iniciativa_prace_4.0.pdf
[26] Work 4.0 action plan https://portal.mpsv.cz/sz/politikazamest/prace_4_0/akcni_plan_prace_4.0.pdf

particular, it is important to ensure the coherence of the proposed measures with the objectives of the new government program Digital Czechia [17], respectively its part Digital Economy and Society.

5.2.1 Social security, social safety net

Automation will increase the structural and the frictional unemployment and it will cause changes in the nature and the organisation of work that will put new demands on the social security system and the social safety net.

- **Assessment of the usability of new social models to support the transition of employees to new positions** (following Actions 1.2 and 4.1 of the Work 4.0 Action Plan) – Taking into account that automation will lead to changes in the organisation of work with an inclination to looser employee-employer relations, a number of people working as freelancers will lose social security in the form of pension, maternity or sick leave benefits. Policymakers must therefore create an environment where all actors are lead towards a socially responsible behaviour. Other employees will have to be supported during the move to new positions. It will be necessary to verify empirically which forms of support work best (e.g. the recently negatively evaluated experiment with the basic unconditional income in Finland).
- **Assessment of the impact of potential shortening of working hours** (following the Action 3.2 of the Work 4.0 Action Plan) – In the past, automation lead to shorter working hours. However, the relationship between shortening of working hours and a drop-in wages must be considered. The shorter working time requirements can be partially offset by a support of education within employment (as it was tested in France, for example). However, no clear answer has been found so far to the question whether shorter working hours lead to a higher employment rate.
- **Support of development of work opportunities in more affected regions and support of employee mobility** (following the Strategic Framework for the Economic Restructuring of the Ústecký, Moravskoslezský and Karlovarský Regions[27]) – Increased impact of automation can be expected in regions with a less favourable workforce structure (particularly Ústecký and Karlovarský regions), which should help to eliminate negative social impacts. In different regions and sectors, human labour will be replaced at different pace depending on the local conditions. The motivation of the employees to accept greater mobility can also help to mitigate the local imbalances.

5.2.2 Raising qualification for perspective professions

Thorough retraining and the use of professionally competent human workforce in cooperation with AI is the prerequisite for the full exploitation of the growth potential AI brings to the economy. However, this requirement is not sufficiently addressed in the Digital Czechia strategy and its implementation in other strategic documents deserves attention.

- **Development of a state supported lifelong learning and higher vocational education system with a focus on technical and soft skills** (following the Actions 2.1 of the Work 4.0 Action Plan) – Technical knowledge becomes obsolete quickly. It is why a system of "fast-moving" lifelong education must be created and developed to enable workers to continually prepare for new challenges in technology and on the labour market.
- **Support of retraining and digital skills improvement options as a part of employment** (following Actions 2.1 and 2.2 of the Work 4.0 Action Plan and projects POVEZ II[28] and VDTP

[27] Strategic Framework for the Economic Restructuring of the Ústecký, Moravskoslezský and Karlovarský Regions. https://restartregionu.cz/
[28] Support for professional training of employees II.https://portal.mpsv.cz/upcr/esf/projekty_v_realizaci/celorep/povez-ii

II[29]) – Encouragement of the development of in-house training and strengthening the motivation of businesses and staff to use it (e.g. the skills development programs in Norway[30], Luxembourg[31] or Singapore[32]).

- **Development and continuous updating of the National System of Occupations[33] and National System of Qualifications[34] databases** following the European ESCO[35] classification – The systems provide an information base about the scheme of nationally recognised professional qualifications in the Czech Republic.
- **Development of the complex system of retraining for workers threatened by automation** (following the Action 2.1, 2.2 and 3.5 of the Work 4.0 Action Plan) – The aim is to provide vulnerable workers with the option of professional assessment of their skills and abilities, and offer them a retraining program corresponding to their abilities, skills and motivation (the concept of protection of the particular worker rather than the workplace).

5.2.3 Education and training of new workforce

The development of AI puts new demands on the educational process at all levels and, at the same time, brings new tools to the education process itself that increase its quality and effectivity.

- **Transforming the education system** (as a part of the preparation of a new Strategy of Educational Policy and of the Digital Education Strategy beyond 2020, and the ongoing revision of the Framework Education Programs) **-** The education system must be redirected to support new technical skills in the STEM area (Science, Technology, Engineering and Mathematics) and so-called 21st century skills[36]. There is also the need to increase the expertise and the competence of pupils and students in information technologies and the so-called informational thinking including the phenomenon of AI and related ethical issues. Inspiration can be found in the reform of primary education towards the digital education in United Kingdom[37], Estonia[38], Sweden[39] or Finland[40].
- **Improving the school equipment for development of digital literacy and informatics thinking** – This means enhancements of hardware, infrastructure (connectivity) and software. For software, it is desirable to support the development and use of open source licenses, i.e. freely extensible and modifiable programs that enable spontaneous dissemination of pedagogical innovations by students and teachers (e.g. through projects to support digital education within RDE OP).
- **Developing competencies and increasing the social status of teachers** - The development of AI not only changes the subjects of teaching but also changes the character of the work of teachers. The importance of the teacher diminishes as a source of knowledge and his

[29] Education and skills for the labour market II.https://portal.mpsv.cz/upcr/esf/projekty_v_realizaci/celorep/vdtp-ii
[30] Skills Norway in English. https://www.kompetansenorge.no/English/
[31] INFPC (The national institute for the development of continuing vocational training), Luxembourg. http://www.infpc.lu/INFPC/Article/Accueil/en
[32] SkillsFuture, Singapore. http://www.skillsfuture.sg/
[33] National System of Occupations. https://www.nsp.cz/
[34] National System of Qualifications. https://www.narodnikvalifikace.cz/
[35] European Skills/Competences qualifications and Occupations. https://ec.europa.eu/esco/portal
[36] Sometimes also referred as so-called soft skills, i.e. skills aimed at developing creativity, critical thinking, collaboration and communication with people as well as machines, presentation, project management and problem solving.
[37] The Computing at School Community, United Kingdom. https://www.computingatschool.org.uk/
[38] ProgeTiger Programme, Estonia. https://www.hitsa.ee/it-education/educational-programmes/progetiger
[39] Introducing micro:bit in Swedish primary schools.http://publications.lib.chalmers.se/records/fulltext/252630/252630.pdf
[40] Coding in Schools - Comparing Integration of Programming into Basic Education Curricula of Finland and South Korea. http://mediakasvatus.fi/wp-content/uploads/2018/06/Coding-in-schools-FINAL-2.pdf

importance grows as a motivator and guide in the learning process. Teachers must be guided to this new role with use of appropriate methods and tools (e.g. projects for the development of teachers' digital and soft skills financed by the Operational Programme Research, Development and Education, mentoring of teachers by practitioners, support of spontaneous dissemination of pedagogical innovations[41]).

- **Adopting the potential of AI in education** - The use of AI tools has a potential to contribute to the increase of the quality and efficiency of the learning process. AI can replace the teacher in routine assignments and it can free up his capacity for the creative part of the lesson. AI can also monitor learner's progress (learning analytics) and design individualized approach to further learning. However, it is necessary to ensure compliance with the data protection legislation (GDPR).

5.2.4 Development of public policies with linkages to AI

The need for an intense development and usage of new AI tools puts new demands not only on social and educational policies, but in the cross-section of general public policies.

- **Developing structural policies that effectively support entrepreneurship and innovation** – This includes measures to support the entry of new businesses, as well as to support increase of efficiency of existing businesses. These measures involve a balanced mix of an open market support, market regulations, and an effective system for dealing with insolvencies. The provision of accessible funding and the development of competence support centres is very desirable for the business development in the small business and start-up sector. The policy of development of a smart and an AI urban infrastructure in Canada[42] can serve as an example.
- **Developing competition and regulatory policies –** The aim is to provide a balanced competitive environment even in the digital transformation context, which will guard the development potential for smaller start-ups as well as larger companies already established in the market. At the same time, there is the need to establish fair conditions for collaboration and entrepreneurship at cross-border level.
- **Reacting to growing international reliance in innovation and knowledge dissemination** – Leading technology companies are largely global and thus represent a challenge to the development of innovation policies at the national level since they can easily transfer the research results obtained in one country to another. It is therefore necessary to pursue new mechanisms for joint public and private R&D funding at national as well as international level.
- **Tax policy development** (following the Action 1.2.3 of the Work 4.0 Action Plan) – Technological changes have significant impact on the wealth distribution in the society. Tax policies must therefore be modified to support stable growth of digital economy while securing a sustainable tax revenue. In relation to this, the tax system progressivity re-evaluation in terms of labour and capital is on the agenda. In the context of digitalisation, it is also necessary to deal with international law and international cooperation in the tax collection.
- **Ensuring adequate assessment of digitalisation impact and changes on the labour market** – The Czech Republic should take part in international collaboration of the preparation of proposals to improve metrics for monitoring the development and impact of digital

[41] See e.g. portal https://www.rvp.cz/
[42] Canadian Smart Cities Challenge. https://www.infrastructure.gc.ca/cities-villes/index-eng.html

technologies and their influence on the labour market. Only reliable data can support a rational response to new challenges that automation and AI will bring.

5.3 Recommendations for the regulatory area

Development of a regulatory framework can be done not only by amendments to legislation. Regulation should be developed on more levels that can function as appropriate and flexible supplement to legislation. Such an approach also enables involving all stakeholders in an efficient and effective manner.

5.3.1 Active Engagement in International Activities

The Czech Republic should participate in the creation of an international legal framework for AI and in the development of ethical and technical standards, both at global and European level.

5.3.2 Support of the Self-regulation of Industry

Individual industries have specific needs. At the same time, they develop effective self-regulation tools under existing legislation.

- **Ethical Codes of Conduct** – Take an active part in the debates at the global, European and national levels to project our national specificities at the transnational scale. Initiate drafting of sector-specific ethical codes of conduct.
- **Formulation of "best practices"** – The areas of cybersecurity and data processing in particular are very diverse. Formulation and sharing of best practices in these sectors will create room for more effective innovation.
- **Certification** - Especially in the area of cybersecurity, certification will increase legal certainty as regards compliance with generally formulated legal obligations.

5.3.3 Support of the Development of Technical Solutions for Ensuring the Efficiency of Law ("regtech")

Certain technical solutions can be a prerequisite for ensuring effective functioning of the law or can greatly help to achieve legal compliance.

- **AI Transparency** – Develop technical solutions for ensuring transparency of intelligent systems that would allow for obtaining evidence to prove or rebut a causal link between an unlawful conduct and a harmful effect (for instance with help of instruments set out in eIDAS).
- **Legal regime of data** – Develop technical solutions that would facilitate assessment of legal regimes of data and help to comply with legal requirements on data processing.
- **Tool for the management of individuals' rights** – Develop an independent solution that would help individuals to manage and exercise their rights especially in the area of privacy, informational self-determination and entering into contract by electronic means. Such a solution would strengthen individual autonomy of persons.

5.3.4 Promoting a Public Debate Aimed at Forming a Unified Doctrinal Interpretation of Law

Interpretation guidelines and instructions for achieving legal compliance can, in certain cases, remedy shortcomings in legislation that are caused mainly by the uncertainty about the content or the extent of legal rules. Especially official opinions of ministries and of public authorities can significantly reduce the uncertainty associated with interpretation of laws in relation to AI.

- **Prevention duty** – With regard to the vague formulation of the prevention duty and its influence on other legal sectors, it is appropriate to develop interpretative rules on the extent of the preventive duty in relation to individual technologies, in particular on machine learning, data processing and intelligent systems testing, and on the duty to intervene and the duty to notify. This interpretation will also influence specific legal areas such as antitrust or health law.
- **Contractual liability** – Drafting model contracts that would provide an example of a fair distribution of rights and obligations between the parties would help to increase legal certainty.
- **Tort liability** – Create interpretation guidelines on applicability of the institute of damage caused by a particularly hazardous operation, on the term "proper oversight", and with regard to a product defect on applicability of liberation on the grounds that the state of scientific and technical knowledge at the time the product was placed on the market did not allow the defect to be discovered. A special liability regime connected with insurance should be created depending on the changes in the EU law.
- **Administrative and criminal liability** – Create interpretation guidelines on the scope of the terms "reasonable risk" and "making every possible effort". These interpretation guidelines should be formulated in cooperation with technical experts and should be based on concrete realistic scenarios.
- **Risks of AI** – Create freely available information materials describing risks of intelligent systems and ways of preventing them.
- **Interpretation guidelines for the GDPR** – Create interpretation guidelines on the scope of Art. 89 of the GDPR with regard to scientific research and on the scope of the obligation to provide meaningful information about the logic involved in automated decision-making and profiling. These guidelines should respect not only the rights of data subjects but also rights of controllers to intellectual property protection.

5.3.5 Desirable Changes in Legislation

Although the majority of problems related to AI can be solved with help of interpretation guidelines, in some areas it is necessary to adopt amendments to existing laws.

- **Amendment to the Civil Code** – Adopt special provisions on the validity of juridical acts performed by software agents with a certain degree of autonomy. Possible introduction of the definition of the autonomous system itself into Czech law should be made only depending on developments in the field of European and international law.
- **Amendment to the Copyright Act** – Establish protection of works created by AI and distribute rights to these works depending on developments in the field of European law and it upcoming changes.
- **Adaptation Act to the GDPR** – Adopt derogations on the national level from the right of access by the data subject, the right to rectification, the right to restriction of processing, notification obligation, the right to data portability, and the right to object in order to ensure the widest possible space for data processing in relation to scientific research.
- **Amendment to the Act on Traffic on Roads** – Submit and adopt the amendment that would allow testing and operation of partly autonomous vehicles.
- **ePrivacy Regulation** – Once ePrivacy Regulation is approved, the Electronic Communications Act will need to be adapted.

5.3.6 Continuous Assessment of the Impact of Laws on the Development and Use of AI

The Czech Republic would significantly benefit from the establishment of a specialized centre dedicated to assessing the impact of development of AI on the society and the appropriate use of data. Within the framework of the Centre's work, it will be appropriate to identify certain areas (e.g. autonomous mobility, fintech, etc.) and assess the impact of the regulation on these areas at regular intervals in order to timely adapt the regulation. Given the need to continuously address problems of ethical data management for AI research and development in the future, this specialized centre could also assess emerging issues in the field of intelligent data processing and help shape the national strategy in this areas in cooperation with all concerned stakeholders.

5.3.7 Support of Establishment of Regulatory Sandboxes and Data Trusts

In the future, it would be advisable to consider establishing regulatory sandboxes, i.e. protected environments under the supervision of a regulator in which AI research and development will take place, and data trusts. A data trust is a legal model of sharing data with no legal restrictions intended for training of AI and development of new applications. In this respect, it is necessary to analyse the ideal model under the Czech law.

6 The most important information sources

THE RESEARCH, TECHNOLOGICAL, AND BUSINESS BACKGROUND FOR AI, AND THE SOCIOECONOMIC IMPACTS OF AI

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7 List of Abbreviations

AI	Artificial Intelligence
BUT	Brno University of Technology
CAS	Czech Academy of Sciences
CC	Civil Code
CEITEC	Central European Institute of Technology
CERIT SC	CERIT Scientific Cloud national centre
CESNET	An association of universities and the Czech Academy of Sciences which operates and develops the national e-infrastructure for science, research and education.
CIIRC	Czech Institute of Informatics, Robotics and Cybernetics, CTU in Prague
CTU	Czech Technical University in Prague
CU	Charles University Prague
DIH	Digital Innovations Hub
EC	European Commission
EPO	European Patent Office
ESIF	European Structural and Investment Funds
EurAI	European Association for Artificial Intelligence
FTE	Full Time Equivalent
GA CR	Czech Science Foundation
GCI	Global Competitiveness Index
GCR	Global Competitiveness Report
GDPR	The European General Data Protection Regulation
GVC	Global Value Chain
H2020	Horizon 2020
IP	Intellectual property
IPC	International Patent Classification
ISCO	International Standard Classification of Occupations
IT4I	IT4Innovations national supercomputing center
MEYS	Ministry of Education, Youth and Sports
MIT	Ministry of Industry and Trade
MoLSA	Ministry of Labour and Social Affairs
MUNI	Masaryk University in Brno
NACE	Nomenclature statistique des activités économiques dans la Communauté européenne (the Statistical Classification of Economic Activities in the European Community)

NLP	Neuro-linguistic Programming
NTIS	New Technologies for the Information Society research centre, UWB in Pilsen
OECD	Organisation for Economic Co-operation and Development
PATSTAT	EPO Worldwide Patent Statistical Database
PCT	Patent Cooperation Treaty
RCI	Research center for Informatics, CTU in Prague
RDE OP	Framework programme Research, Development and Education.
RDI OP	Framework Programme Research Development and Innovation
RIS3	Research and Innovation Strategy for Smart Specialization
R&D	Research and Development
STEM	Science, Technology, Engineering and Mathematics
TA CR	Technology Agency of the Czech Republic
UWB	University of West Bohemia in Pilsen
VC	Venture capital
VSB-TU	VSB-Technical University of Ostrava
WEF	World Economic Forum
WIPO	World Intellectual Property Organization
WoS	Web of Science