TECHNOLOGY CENTRE PRAGUE

Analysis of challenges in the field of innovation diffusion and digitalisation, and a proposal for focusing the priorities of the National RIS3 Strategy after 2025

Executive summary

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1 Introductory information

The aim of the study prepared by the Technology Centre Prague (TCP) for the Ministry of Industry and Trade (MIT) under the contract "Analysis of challenges in the field of innovation diffusion and digitalization and a proposal of the focus of priorities of the National RIS3 Strategy after 2025" is to identify significant technological and societal challenges that the Czech Republic will face in the future. Subsequently, the objective is to assess these challenges in terms of their relevance to the National Research and Innovation Strategy for Smart Specialization of the Czech Republic 2021-2027 (NRIS3) with regard to research and innovation capacities of the Czech Republic. The conclusions of the analysis will be used in particular for the update of the NRIS3 and as a basis for the definition of further missions that will be included in this strategy after 2025, respectively in the follow-up NRIS3 for the next financial period of the European Structural and Investment Funds (ESIF).

The study was based on the most recent statistical data and other data from publicly available databases and information sources, as well as from commercial databases to which TCP has access. The data were matched to Grand Societal Challenges (GSCs) and advanced technologies using sets of keywords. Additionally, some findings from the literature searches were also employed to address the questions posed by the MIT. The results of the desk research and quantitative analyses were discussed with experts on advanced technologies in two workshops.

2 Main findings

2.1 Grand societal challenges and advanced technologies

A review of strategic documents developed in the Czech Republic and at the EU level revealed the following five grand societal challenges (GSCs) that are relevant to NRIS3:

- Adaptation to climate change;
- Preparedness for demographic change and an ageing population;
- Energy transition and a sustainable future;
- Trust in democracy, societal resilience, security and defence;
- Technological and digital transformation of the economy and society.

In addition, advanced technologies have been identified that can assist in addressing these GSCs with the input of research and development. The advanced technologies have been grouped into six broad technology areas:

- Advanced manufacturing technologies;
- Advanced material technologies;
- Biotechnology;
- Digital technologies;
- Information and communication technologies;
- Other advanced technologies.

2.2 Trends in advanced technologies and their use in GSCs

The number of publications in the majority of advanced technologies is growing globally. The highest growth can be observed in digital technologies, particularly in artificial intelligence (AI), blockchain and augmented/virtual reality. Publication activity is also growing significantly in advanced manufacturing technologies and biotechnology. There has also been an increase in the number of publications in information and communication technologies (ICT). In contrary, publication activity in advanced

materials technologies has been stagnating in most of the technologies included in this domain, with a slight decline evident in micro- and nanoelectronics.

Similar trends can be observed in patenting. The number of patent applications in most advanced technologies has been increasing, with some technology domains experiencing a particularly substantial growth. Patenting activity has been increasing significantly in most digital technologies. The biggest increase can be observed in AI. High growth is also evident in advanced manufacturing technologies, particularly in robotics. Conversely, there has been a stagnation in patenting activity in the domains of material technologies and biotechnology. This indicates that research activities have been concentrated in digital technologies and ICT in recent years. This suggests that there will be an expansion of their capabilities in the future and their increased use in various applications.

Advanced technologies are used in R&D projects focused on GSCs. This is most evident in the GSC *Technology and Digital Transformation of Society*, *Energy Transformation and Sustainable Future* and *Trust in Democracy, Societal Resilience, Security and Defence*. In particular, digital technologies (mainly AI), ICT (cybersecurity) and material technologies (advanced materials, nanotechnologies) are highly applicable in these GSCs.

The application of specific technologies in the GSCs depends on the nature of the challenge and the focus of its sub-areas. In the *Energy Transformation and Sustainable Future* GSC, advanced material technologies, biotechnologies, AI and some ICT (in particular the Internet of Things, IoT) are most applicable. In the GSC *Confidence in Democracy, Societal Resilience, Security and Defence*, technologies such as cybersecurity and AI are most applicable. Connectivity and big data are also significant technologies applicable in the later GSC.

In projects addressing the GSC *Adaptation to Climate Change*, AI and biotechnology have been often mentioned. Material technologies and cyber security are also highly applicable in some specific areas. The use of AI, robotics and IoT have been often mentioned in projects addressing the GSC *Preparedness for demographic change and ageing*. In the *Technology and Digital Transformation of Economy and Society* GSC it can be expected that digital technologies and ICT such as AI, connectivity, cybersecurity, big data and IoT will be used to the greatest extent.

2.3 Research and development in advanced technologies in the Czech Republic

The Czech Republic has a well-developed research and development (R&D) sector for advanced technologies. A high number of entities from all sectors are involved in projects that are focused on the development of advanced technologies. Faculties and institutes of higher education operating in the fields of mechanical engineering, electrical engineering and ICT play a significant role in the R&D of advanced manufacturing technologies. A wide range of faculties and departments of higher education institutions (HEIs) and a high number of public and private research institutes are involved in advanced material technology R&D. This illustrates the significant potential of advanced materials for application in diverse range of products and industries. R&D in the field of biotechnology is primarily conducted by faculties and institutes with a focus on (bio)chemical, natural and health sciences. Electrical engineering faculties, ICT faculties, science and physics faculties and research institutes with a focus on digital technologies are most active in digital technology and ICT R&D projects.

Businesses are also involved quite intensively in projects focusing on advanced technologies. The highest participation of businesses is evident in projects focused on advanced material technologies and advanced manufacturing technologies. Conversely, the lowest engagement of businesses can be observed in projects on quantum technologies.

In the projects supported by the R&D programmes, a well-developed cooperation between research organisations (ROs) and entities from the application sphere is evident. Technology-oriented faculties,

some institutes of the Czech Academy of Sciences and research centres supported by the European structural and investment funds (especially European Centres of Excellence) play an important role in this cooperation.

The participation of major HEIs in EU Framework Programme projects provides evidence of their potential for conducting internationally competitive research. In the EU Framework Programmes, entities from the Czech Republic cooperate with a number of research teams from abroad, including teams from leading foreign research institutions.

2.4 The Czech Republic's position in advanced technologies

The international position of the Czech Republic in R&D of advanced technologies is relatively satisfactory. Research in the Czech Republic is more focused on advanced technologies than in other countries. In this comparison, the Czech Republic is also above the average of EU Member States. The Czech Republic performs particularly well in advanced materials technologies, where domestic research focuses significantly more than in other countries. However, the situation is somewhat less favourable for digital technologies, where the Czech Republic lags behind the world and EU average.

The Czech Republic's weakness is low patenting activity in advanced technologies. The share of advanced technology patent applications in the total number of patent applications is lower in the Czech Republic than in the world (except for advanced material technologies). Although patenting activity is influenced by several factors related to the environment in the Czech Republic and differences between industries, the low number of patent applications may lead to a lower use of R&D results in business innovation.

The Czech Republic's position in digital technologies is less satisfactory. In the composite indicator "Digital Economy and Society Index", the Czech Republic ranks nineteenth out of 27 EU countries, which is five places below the EU average. The most recent values of the indicators monitored in the DESI 2023 show that the Czech Republic has a relatively favourable position in terms of digital skills when compared to other European countries. This creates good conditions for the use of digital technologies in society. In this context, it is favourable that mobile broadband in the Czech Republic is at a higher level than the EU average. The willingness of society to use digital technologies is also reflected in the above-average number of enterprises using e-commerce. It is also positive that the Czech Republic has a relatively good position in the digitisation of public services in European comparison.

However, a significant weakness is the digital transformation of businesses, where the Czech Republic is still lagging far behind the EU average. Given the growing importance of these technologies, it is concerning that Czech businesses make far less use of digital technologies such as artificial intelligence and big data than their European counterparts. This is particularly concerning in the context of the crucial role digital technologies play in addressing the current GSCs.

3 Recommendations

The proposed recommendations are structured according to the priorities of the National Research and Innovation Strategy for Smart Specialisation of the Czech Republic 2021-2027.

3.1 NRIS3 cross-cutting priorities

3.1.1 Business research, development and innovation

The use of AI and other digital technologies will help increase the efficiency of domestic businesses, boost their competitiveness and transform supply chains. In addition to stimulating businesses to adopt these technologies, other tools need to be put in place to help businesses become more competitive, including the creation of an enabling business environment. Well-developed links

between research organisations and businesses can also contribute to strengthening the business competitiveness within the domain of advanced technologies. These links need to be leveraged in advanced technology R&D programmes, where businesses from various sectors will collaborate with HEIs.

Given the continuous evolution of advanced technologies and the growing importance of their practical applications, it is necessary to stimulate and support the creation of new companies based on R&D results in these technological domains. At the same time, it is essential to create a suitable environment for the initial development of start-up companies.

3.1.2 Public research and development

Public R&D results are not effectively used in the Czech Republic in the commercial sector. To address this, all R&D programmes with a focus on GSCs should emphasise the application of public research results, especially in advanced technologies, to drive business innovation.

Research centres with cutting-edge infrastructure and application-oriented centres supported by the ESIF, with which a significant number of entities from the public and business sectors cooperate, play an important role in R&D focused on advanced technologies. It is essential to take advantage of this when formulating programmes and public competitions aimed at addressing GSCs, where entities from both sectors can cooperate in R&D projects covering all phases of the innovation process.

3.1.3 People and smart skills

Although the Czech Republic is at the EU average in most of the indicators monitored by the DESI 2023 in its Digital Skills dimension, it lags behind the European average in terms of advanced skills. As these skills are crucial for the implementation of digital technologies, there is a need to encourage students to study these fields and develop their skills. Efforts to develop digital skills and to increase the number of ICT graduates need to start well in advance.

3.1.4 Digital Agenda

The Czech Republic lags behind the EU average in a number of indicators monitored by the DESI 2023. The gap is particularly evident in the area of fixed high-speed connections. Although the Czech Republic is above the EU average in mobile high-speed connectivity the quality and speed of fixed connections need to be improved. The Czech Republic has a relatively weak position in the digital transformation of businesses, which may be a limiting factor for the use of digital technologies in addressing GSCs. In addition to incentives aimed at promoting the digital transformation of businesses, there is also a need to improve the transparency of digital services provided by the state and their user support. Access to health data should also be significantly improved.

3.2 Vertical priorities NRIS3

3.2.1 Domains of research and innovation specialisation

Based on the results of the analyses, we recommend expanding the existing definition of key enabling technologies (KETs) in the NRIS3, specifically those of "Artificial Intelligence" and "Digital Security and Connectivity". The analyses indicate that other digital technologies, such as big data, cloud computing, augmented/virtual reality, and blockchain, are increasingly being used to address GSCs. It would therefore be appropriate to extend the KETs to include "Other Digital Technologies," which would include the digital technologies mentioned above.

Similarly, the use of advanced technologies covered by the current KET "Digital Security and Connectivity" is increasing. In the future, this KET could be divided into two distinct categories, each with a different nature and mission-specific applications – “Connectivity and IoT” and “Cybersecurity”.

3.2.2 Societal challenges

The two missions "Making the economy more material, energy and emission efficient" and "Strengthening the resilience of society to security threats" included in the current NRIS3 should be expanded to include the remaining three GSCs that are relevant to the Czech Republic at present and in the near future - Adaptation to climate change, Preparedness for demographic change and ageing and Technological and digital transformation of society.

Given the cross-cutting nature of most missions, it is essential to develop R&D programmes in close cooperation of all relevant funding providers. Experts from different sectors should actively participate in designing and focusing these programmes. In order to implement R&D programmes that address the issues outlined in the NRIS3 mission, it is essential to utilise the resources of the relevant funding providers in a synergistic manner. For R&D programmes that do not have a specific focus on missions, it is appropriate to launch open calls for projects addressing specific challenges of the mission that align with the program's objectives. When selecting projects, priority should be given to those that utilise advanced technologies, as these are more likely to make a significant contribution to addressing the challenges outlined in the mission.

Given the global scope of the current two NRIS3 missions and the three newly proposed missions, it would be appropriate to leverage resources from multiple countries to address them. This could be achieved, for example, through the implementation of specifically targeted bilateral or multilateral R&D programmes. At the same time, projects that align with the objectives of the NRIS3 missions and have successfully passed the evaluation process in Horizon Europe and other European programmes, but have not been funded due to limited call budgets (Seal of Excellence), should be supported.