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Foreword

This report is published in the context of AI Watch, the European Commission knowledge service to monitor the development, uptake and impact of Artificial Intelligence (AI) for Europe, launched in December 2018. AI has become an area of strategic importance with potential to be a key driver of economic development. AI also has a wide range of potential social implications. As part of its Digital Single Market Strategy, the European Commission put forward in April 2018 a European strategy on AI in its Communication "Artificial Intelligence for Europe". The aims of the European AI strategy announced in the communication are:

- To boost the EU's technological and industrial capacity and AI uptake across the economy, both by the private and public sectors;
- To prepare for socio-economic changes brought about by AI;
- To ensure an appropriate ethical and legal framework.

In December 2018, the European Commission and the Member States published a "Coordinated Plan on Artificial Intelligence", on the development of AI in the EU. The Coordinated Plan mentions the role of AI Watch to monitor its implementation.

Subsequently, in February 2020, the Commission unveiled its vision for a digital transformation that works for everyone. The Commission presented a White Paper proposing a framework for trustworthy AI based on excellence and trust.

Furthermore, in April 2021 the European Commission proposed a set of actions to boost excellence in AI, and rules to ensure that the technology is trustworthy. The proposed Regulation on a European Approach for Artificial Intelligence and the update of the Coordinated Plan on AI aim to guarantee the safety and fundamental rights of people and businesses, while strengthening investment and innovation across EU countries. The 2021 review of the Coordinated Plan on AI refers to AI Watch reports and confirms the role of AI Watch to support implementation and monitoring of the Coordinated Plan.

AI Watch monitors European Union's industrial, technological and research capacity in AI; AI-related policy initiatives in the Member States; uptake and technical developments of AI; and AI impact. AI Watch has a European focus within the global landscape. In the context of AI Watch, the Commission works in coordination with Member States. AI Watch results and analyses are published on the AI Watch Portal.

From AI Watch in-depth analyses, we will be able to understand better European Union's areas of strength and areas where investment is needed. AI Watch will provide an independent assessment of the impacts and benefits of AI on growth, jobs, education and society.

AI Watch is developed by the Joint Research Centre (JRC) of the European Commission in collaboration with the Directorate General for Communications Networks, Content and Technology (DG CONNECT).

This report addresses the following objective of AI Watch: to provide an in-depth comparative analysis of the national strategies structured along the categories and priorities agreed between EC and Member States in the Coordinated Plan on AI review 2021. The aim of this report is to assess how national strategies contribute to the achievement of the goals of the reviewed Coordination Plan.

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[1] Disclaimer: The views expressed in this report are purely those of the writers and may not in any circumstance be regarded as stating an official position of the European Commission.

Executive summary

The Coordinated Plan on Artificial Intelligence (AI) is at the heart of efforts to put **the European AI vision into practice**. It presents a concrete and unified set of key actions and defines focus areas. The 2021 review of the Coordinated Plan[2] builds on the lessons and experience gathered in the implementation of its first 2018 edition.[3]

This AI Watch report provides an in-depth comparative analysis of national AI strategies in Member States, Norway and Switzerland, and assesses how national strategies contribute to the achievement of the goals of the reviewed Coordinated Plan. One of the recommendations of the Coordinated Plan is the encouragement for all Member States to develop their national AI strategies.

On 1 February 2022, **23 Member States and Norway published national AI strategies**, while four others are still in progress. Four countries have updated their initial AI strategies. This demonstrates Member States' commitment to develop strategic visions for AI with concrete policy actions and investments. Moreover, all countries recognise the importance of evaluating progress of strategies' implementation and of updating them on a regular basis, although just a few countries have explicitly set out specific plans to carry out this assessment so far.

The main takeaway of this report is that the **EU and Member States are on the right track** to seize the benefits and promote the development of human-centric, sustainable, secure, inclusive and trustworthy artificial intelligence in Europe. This conclusion emerges from an in-depth comparative analysis of the national strategies in the categories and priorities agreed between the European Commission and Member States in the 2021 review of the Coordinated Plan, as outlined below.

Enabling conditions for AI development and uptake

All national AI strategies recognise the importance of data and of the creation of open data policies with a strong focus on the public sector. Almost twenty countries have proposed national data spaces and public data frameworks providing open access to static or real-time data. While some countries included data policies within their national AI strategy, 21 countries plan or have already launched dedicated national data strategies or action plans to complement the national AI strategies.

With regards to the goal of **fostering critical computing capacity**, 20 countries are planning data processing and management policies and infrastructures, including a special perspective towards open data. Most of the Member States seek to foster these large-scale infrastructures through centralised, one-stop national data infrastructures. Other countries create "platforms" which are co-ordinated by several ministries or public departments.

Making the EU the place where excellence thrives from the lab to the market

Member States are setting up a wide range of policy measures to **encourage the development of AI technologies from the lab to the market**, including Public-Private Partnerships (PPPs), research excellence centres, experimentation and testing facilities and funding mechanisms to foster start-ups and scale-ups in their growth trajectories.

Half of the countries have set up national Public-Private Partnerships. The way these PPPs are governed differs across countries: half of them have centralised, one-stop schemes for all PPPs touching on AI, data, and related technologies, while the other half spreads PPP management amongst several agencies following a decentralised model. Furthermore, several countries are proposing bilateral PPPs with other countries.

Half of the countries have also deployed or plan to create national research excellence centres on AI. Twelve countries already have one or more centres, and eight others have committed to launching one. While ten centres are entirely devoted to AI research, others also conduct research on AI-related fields such as big data, the Internet of Things (IoT), and robotics. Countries will further rely on the Recovery and Resilience Plans to boost these capacities in AI basic research and the application of AI for e-Governance, education, and small and medium-sized enterprises (SMEs).

[2] European Commission, Coordinated Plan on Artificial intelligence 2021 Review, (COM(2021) 205 final).
[3] European Commission, Coordinated Plan on Artificial Intelligence (COM(2018) 795 final).

A vast majority of countries have committed to the creation of testbeds and experimentation facilities for AI, while roughly half of the countries plan or have developed regulatory sandboxes. Most experimentation facilities are sector-specific, targeting transport, healthcare and agriculture. Several countries have also established cross-border facilities to promote collaborations in the experimentation phase. In addition, all Member States support the creation of a network of European Digital Innovation Hubs and the Testing and Experimentation Facilities (TEFs) of the Digital Europe programme.

Lastly, all the national AI strategies set out policy actions to support start-ups and the scaling-up of firms and innovation ecosystems. The most widespread funding mechanism is direct funding to support start-ups through the whole business cycle. This includes seed investment schemes, venture capital and accelerator programmes to develop academic research into successful start-ups.

Ensure that AI works for people and is a force for good in society

All countries dedicate a section in their national strategies to AI skills. The focus is mainly put onto measures for higher education institutions and the reskilling of the working age population. While most of the countries address both primary and secondary education, a few countries also envisage policy measures for pre-school education and set out mechanisms for the impact assessment of skill policies. Some countries – mainly from western and northern Europe – provide gender-based educational measures.

Half of the countries have already developed or are drafting their own national standardisation processes in the form of early-stage assessments or roadmaps.

All national AI strategies have policies to ensure trust in AI systems and raise awareness of the economic and societal benefits and risks of AI. This includes policy actions to (1) attract and retain international talent and foreign investors, (2) promote awareness campaigns for citizens and (3) support national and international networks that foster public dialogues on AI.

Building strategic leadership in high-impact sectors

In the majority of cases, countries' national AI strategies prioritise the **high-impact sectors of the 2021 Review of the Coordinated Plan** (notably climate and environment, health and public sector). However, national strategies also tend include sectors such as education and manufacturing. A few countries include sectoral AI policies on "law enforcement, migration, and asylum".

Most of the countries acknowledge the importance of the twin green and digital transitions in line with the new Industrial Strategy for Europe and pay **particular attention to the sectoral area of AI for sustainability**, in which 17 countries are planning or implementing policy measures.

AI in the Recovery and Resilience Plans

This report also analyses how national Recovery and Resilience Plans (RRPs) address Artificial Intelligence from several perspectives. This information is gathered in each respective section where this analysis on a specific topic has been carried out.

1 Introduction

In recent years the European Commission and Member States have joined forces to make the EU a world-class hub for artificial intelligence (AI),[4] while ensuring that AI is human-centric and trustworthy and grounded in European values and fundamental rights.[5] To this end, all EU Member States and Norway signed a **Declaration of cooperation on Artificial Intelligence**[6] in April 2018 to work together on the opportunities and challenges brought about by AI. The European Commission proposed a strategy on Artificial Intelligence for Europe, which was endorsed by the European Council in June 2018.[7]

To increase synergies between national and EU level actions, the European Commission (EC) adopted a **Coordinated Plan on Artificial Intelligence**[8] in December 2018 to maximise the impact of investments at the EU and national levels, encourage synergies and cooperation across the EU, including on ethics and foster the exchange of good practices. The plan was developed together with the Member States and it proposes joint actions for closer and more efficient cooperation between Member States, Norway, Switzerland and the European Commission in key areas including increasing investment, making more data available, fostering talent and ensuring trust.

A European approach to AI is further developed in the **White paper on Artificial Intelligence – A European approach to excellence and trust**,[9] released in February 2020. The White paper presented policy options for a future EU regulatory framework for AI and announced the update of the Coordinated Plan on Artificial Intelligence.

As a next step, the European Commission adopted the **2021 review of the Coordinated Plan on Artificial Intelligence**[10] in April 2021. This builds on the lessons and experiences gathered in the implementation of the first Coordinated Plan from 2018 and the White Paper on Artificial Intelligence and puts forward a concrete set of joint actions for the European Commission and Member States on strengthening Europe's leading position in the development of human-centric, sustainable, secure, inclusive and trustworthy AI. On the same day, the European Commission also released a **legal framework on AI**[11] which addresses the risks of AI and proposes proportionate and flexible rules to address the specific risks posed by AI systems and set the highest standard worldwide.

The Coordinated Plan on AI is at the heart of putting **the European AI vision into practise**. It presents a concrete set of joint key actions and defines focus areas. One of the key actions in the Coordinated Plan is encouragement for all Member States to **develop their national AI strategies**. All Member States have made substantial efforts to develop national AI strategies or include AI dimensions in existing strategies and programmes. As the technology and policy environment evolves, forerunners have already updated their initial strategies. Comprehensive analysis, maintaining updated situational overview, highlighting best practices that could be taken to the European level, and connecting actions with similar goals are vital to ensure the efforts invested in national strategies create synergies and maximise the impact of joint AI-action on the European level.

In support of the Coordinated Plan on Artificial Intelligence, the European Commission has launched the **AI Watch**[12] initiative, its *knowledge service to monitor the development, uptake and impact of AI for Europe*.[13] This AI Watch report provides an **in-depth comparative analysis of national AI strategies** in Member States, Norway and Switzerland, and assesses how national strategies contribute to the achievement of the goals of the reviewed Coordinated Plan. The report is structured along the categories and priorities agreed between the Commission and Member States in the Coordinated Plan on AI review 2021. This report also analyses how

[4] For a definition of AI, see the European Commission Proposal for a Regulation laying down harmonised rules on artificial intelligence, (COM(2021) 206 final.
[5] European Commission, Communication Fostering a European approach to Artificial Intelligence COM(2021) 205 final.
[6] European Commission, Declaration of cooperation on Artificial Intelligence, 2018.
[7] European Commission, Communication on Artificial Intelligence for Europe, (COM(2018) 237 final).
[8] European Commission, Coordinated Plan on Artificial Intelligence (COM(2018) 795 final).
[9] European Commission, White Paper on Artificial Intelligence: a European approach to excellence and trust, COM(2020) 65 final
[10] European Commission, Coordinated Plan on Artificial intelligence 2021 Review, (COM(2021) 205 final).
[11] European Commission, Proposal for a Regulation laying down harmonised rules on artificial intelligence, (COM(2021) 206 final.
[12] AI Watch is implemented by the Joint Research Centre of the European Commission in close coordination with DG CONNECT. More information on the initiative is available on the AI Watch portal.
[13] Monitoring and analysing national AI strategies is in the core of AI Watch's mandate and goals. Since 2020, AI Watch has released two reports on national AI strategies (Van Roy, 2020; Van Roy et al., 2021). These reports provide a review of national AI strategies of Member States, Norway and Switzerland.

national AI strategies are being promoted through the Recovery and Resilience Plans (RRPs) by each country. Analysis is provided in most sections of the report. The box below reports some methodological clarification.

This report is framed as follows. The next section presents an overview of the current status of national AI strategies in the European Union, Norway and Switzerland. Section 3 presents the key insights of the comparative analysis along the key sets of proposals that the European Commission and the Member States put forward in the 2021 review of the Coordinated Plan on AI. Section 4 provides an overview of AI investments in Member States, Norway and Switzerland. Lastly, Section 5 contains concluding remarks.

Box 1. Methodological framework

This document is based on the revision of national AI strategies when available in all Member States, plus Norway and Switzerland as Associated Countries; specific AI-related national strategies, roadmaps and plans (on data, cloud, open data, digital skills, start-ups); Recovery and Resilience Plans released by each country as well as the Council Implementing Decision documents; and previous reports from the Joint Research Centre (JRC) which are founded on the same analytical rigour, mainly the 2nd edition of the AI Watch report on national AI strategies. Please note that countries with no national AI strategy have not been included in a number of analyses in this report.

This analysis has been undertaken through two steps: first, tables were created to transform qualitative information from these documents into quantitative figures. Information contained in tables is based on the goals the 2021 Review of the Coordinated Plan on AI released by the European Commission sets out, as well as a number of additions based on information delivered by the European Commission during the drafting of this report. The second step consisted of the qualitative analysis of these tables to proceed to a comparative analysis of main trends, which compares which goals of the 2021 Review of the Coordinated Plan on AI are followed than others by Member States, Norway and Switzerland, and to what extent these countries do so.

The authors have received feedback from several colleagues in DG CNECT and the JRC during all stages of the drafting process: design, analysis and contrast. Moreover, the authors carried out a consultation process with national points of contact from each of Member States, plus Norway at the last stage of the process. Some notes at the end of tables include additional information on this, when necessary and applicable. Countries have been given a complete version of the document and they have provided feedback in both analysis and tables when applicable.

<u>Specificities in Recovery and Resilience Plans</u>

The analysis refers to the 24 adopted RRPs. Hungary, the Netherlands and Poland are not analysed as, at the time of writing, they do not have RRPs adopted. The analysis is based and aligned with the information as published in national RPPs, Council Implementing Decisions and the direct feedback from Member States during the final revision of the report.

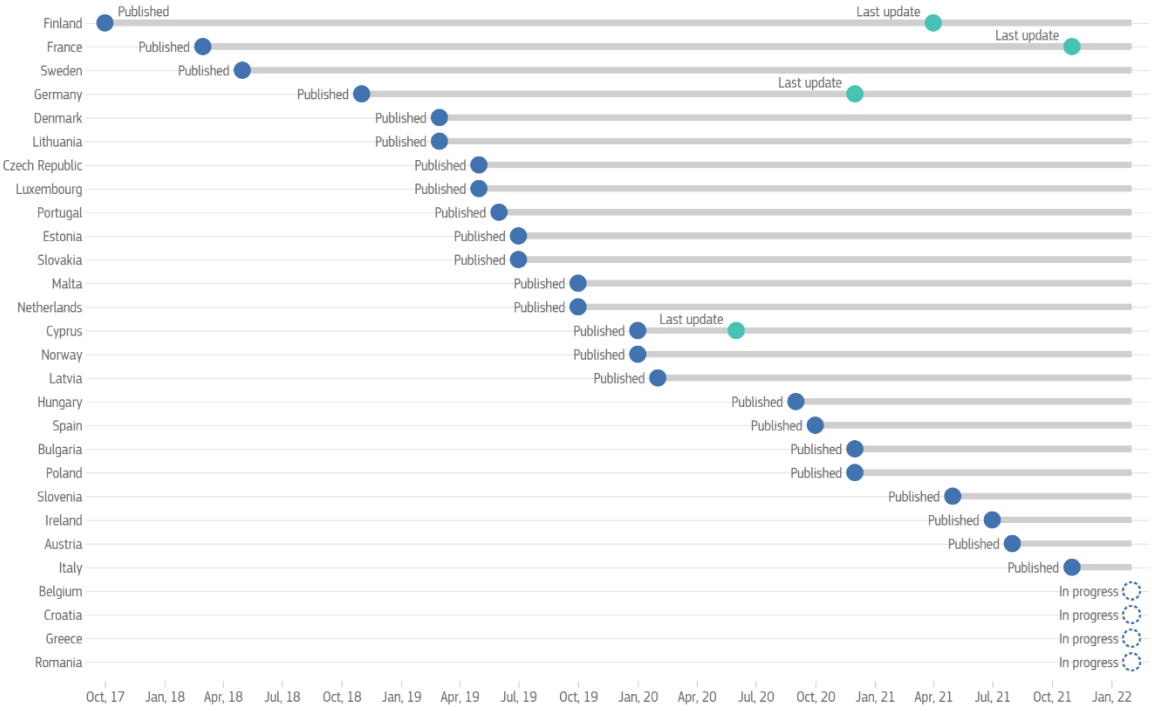
Measures on AI have been tracked under the RRPs as follows. Information has been gathered and used only when (1) the RRP explicitly dedicates a section on AI, or (2) the RRP explicitly has a section on digital technologies generally speaking, and AI is mentioned as a tool to undertake certain policy actions, or (3) the RRP does not include any section on AI or related digital technologies, but other sections, topics and themes refer to the design, use, implementation, deployment of AI, or the evaluation of certain action through AI, or when a specific policy action, itemised budget or planned action reflects on the importance of AI to a certain goal.

The report has excluded from the analysis any generalist statements which refer to AI, but do not specifically highlight any interrelation with policy actions, roadmaps, itemised budget, or at least commitments about initiatives that are expected to be developed in the future.

2 Overview of national AI strategies

In the Coordinated Plan on AI of 2018 and its subsequent 2021 review, the European Commission recommended that Member States should adopt national AI strategies with policy actions and investments to support the development and uptake of AI. Currently 24 countries have published national AI strategies. In addition, Finland, Germany, France and Cyprus have already published updated editions of their initial AI strategies. The **latest status of national AI strategies** in EU Member States, Norway and Switzerland is presented in Table 1.

Table 1. Overview of national AI strategies in the EU Member States and Norway



Source: JRC – European Commission
Note: Last update of the table on 1 February 2022. The information in the table is based on input from national contact points or public sources. It presents release dates of national AI strategies in their native language. In addition to EU Member States, this table also includes Norway as Associated Country highlighted with the superscript [AC]. Switzerland does not intend to release a national AI strategy.

Since the previous release of the AI Watch report on national AI strategies in June 2021 (Van Roy et al., 2021),[14] three more countries – Austria, Ireland and Italy – have published their first-ever national AI strategies. Two other countries updated their national AI strategy after June 2021. These are France and Finland. France updated its strategy in November 2021 with strategic actions and funding for the next five years. Finland also published the 2nd Interim report of the Artificial Intelligence 4.0 programme in December 2021. Detailed information on the policy actions in these countries is in the country reports of the AI Watch portal.

This section analyses main takeaways from the new three national AI strategies, as well as the two updates of previously existing national AI strategies. The results update the information contained in the 2nd edition of the AI Watch report on national AI strategies from June 2021.

Austria

In August 2021, Austria published its national AI strategy entitled Artificial Intelligence Mission Austria 2030 – AIM AT 2030 (Austria, 2021a).

The objectives of the national AI strategy are:

[14] For an overview of national AI strategies, see previous editions of the AI Watch report on this topic (Van Roy, 2020; Van Roy et al., 2021) and the AI Watch portal.

- Ensuring that the deployment of AI is grounded in European fundamental and human rights, and in line with the upcoming European legal framework;
- Positioning Austria as an internationally recognised research and innovation location for AI in key competitive areas;
- Supporting the use and development of AI through education and training activities in AI, a competitive business environment, and a more efficient and modern public administration.

The strategy aims to be agile (subject to regular updates); participatory (involving various federal ministries and including broad participation of civil society organisations, intermediaries and citizens in the implementation of the strategy); European (in line with the values and objectives of the European Union); international (by playing an active role in defining and strengthening the international legal framework for AI); and interdisciplinary. The Strategy Annex sets out a specific number of targeted application fields. These are climate, energy, mobility, tangible goods industry, agriculture and forestry, urban planning, construction sector, health, arts, culture, media and creative industry and education.

An inter-ministerial working group (AI Policy Forum) has been established to drive forward the implementation of the measures and the further development of the strategy. It also ensures exchange with stakeholders from politics, research and civil society. The working group is coordinated under the joint leadership of the Federal Ministries for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) and for Digital and Economic Affairs (BMDW).

Finland

In December 2021, the Finnish Government published the 2nd Interim report of the Artificial Intelligence 4.0 programme (Finland, 2021). It updates the first roadmap of the national AI strategy, released in October 2017, and reported on its results in March 2019. The Artificial Intelligence 4.0 programme aims to make Finland a pioneer in the use of machine learning and other individual AI technologies, combined with a wide range of other digital technologies, to enable industrial change and accelerate the twin digital and green transition of the economy by 2030. The programme is guided by the idea that the most significant areas of growth and business development effects of AI will impact on a greater range of Finland's industrial transformation. A particular focus is put onto getting SMEs on board of AI development and adoption, with subsequent positive influences on the ongoing Industry 4.0 revolution. The goal is to develop a strategy for the sustainable digitalisation of industry.

It defines four objectives to simultaneously address the challenges of the digital and green transitions in the economy:

- Investing in the development and deployment of cutting-edge technologies;
- Supporting companies to develop digital technologies to create economic, social and environmental benefits for society;
- Increasing the number of digitally advanced Finnish industrial SMEs;
- Enhancing Finland's effectiveness in creating and implementing EU AI, data and industrial strategies.

Five thematic working groups have been created to set out concrete measures and key performance indicators for each of these objectives. The thematic working groups focus on digital and green transition, technological leadership, digital capabilities of SMEs, the EU, and international affairs, and digital accessibility. The Finnish Government will evaluate the programme's progress in spring 2023.

France

In March 2018, the French Government presented its national AI strategy entitled AI for humanity (France, 2018). The National Strategy for AI – 2nd phase was subsequently released in November 2021 (France, 2021). The second phase of the strategy sets main priorities on the upscaling of education and training, development of embedded AI and trustworthy AI in critical systems in order to strengthen the national industrial base while accelerating the digital and ecological transition of companies thanks to AI.

The main objectives of the second phase of the strategy are to:

- Improve the AI education and training ecosystem;
- Make France a leader in embedded and trustworthy AI;
- Accelerate the deployment of AI in the economy;

Ireland

In July 2021, the Government of Ireland released its national AI strategy, entitled AI – Here for Good (Ireland, 2021). The strategy sets out how Ireland can be an international leader in using AI to benefit its economy and society, through a people-centred, ethical approach to its development, adoption and use. It identifies three pillars:

- Building public trust;
- Leveraging AI for economic and societal benefit;
- Enablers for AI.

The first pillar outlines strategic actions to (1) build strong public trust in AI as a force for societal good in Ireland and (2) put in place a governance ecosystem that promotes trustworthy AI. The second pillar supports AI as a productivity driver for the economy and society. As such, it includes support actions for the adoption of AI by Irish enterprises and the public sector. The third pillar strengthens enablers for AI. This entails supporting a strong AI innovation ecosystem with strategic investments in AI research and innovation and increased interaction and collaboration between researchers and enterprise. It also includes support actions to ensure that Ireland has a future-oriented workforce and population with the skills to drive the development, deployment and use of AI to increase productivity and benefit society. A last enabler includes a data, digital and connectivity infrastructure to provide a secure foundation for AI development and use.

For each of these pillars the strategy sets out a roadmap with strategic actions led by Government Departments, State agencies or other bodies.

The strategy also calls for the appointment of an Enterprise Digital Advisory Forum (EDAF), which will bring together representatives of indigenous enterprise, multinational corporations, and experts in the digital sphere to advise and work with Government to drive industry adoption of digital technologies by enterprise. This will be complemented by the appointment of an AI Ambassador to lead a national conversation around the role of AI in our lives, emphasising an ethical and compliant approach. The AI Ambassador will also sit on the EDAF.

Italy

In November 2021, the Italian Government published its National AI strategy (Italy, 2021). The Strategy presents a strategic programme on Artificial Intelligence for the period 2022–2024.

The Strategy outlines six objectives to strengthen Italy's competitive position in the field of AI and to stimulate all factors and actors that contribute to the development of a strong ecosystem:

- Strengthening frontier research on AI;
- Reducing AI research fragmentation;
- Developing and adopting human-centred and trustworthy AI;
- Increasing AI-based innovation and the development of AI technology;
- Developing AI-driven policies and services in the public sector;
- Creating, retaining and attracting AI talent.

In line with these goals, the Strategy identifies five guiding principles or challenges for the next three years: (1) aligning Italy's strategy to the 2021 review of the Coordinated Plan on AI; (2) investing in frontier research and applications to be at the forefront of AI developments; (3) promoting human-centred, trustworthy and sustainable AI; (4) supporting public-private partnerships; and (5) encouraging the uptake and use of AI in public administrations.

To achieve the stated objectives, the Strategy defines three key policy areas of intervention: (1) talent and skills, (2) research and (3) applications. The first area supports the development of AI training and skills, while the second focuses on fundamental research and challenge-driven AI research. The third area concentrates on strengthening the AI technology production ecosystem, both in the public and private sector. For these three areas, the Strategy indicates 24 policy initiatives that Italy should embrace.

As for funding, the Italian Strategy highlights for each policy initiative potential sources of funding including investments under the national Recovery and Resilience Plan (RRP). The strategy was jointly developed by the Ministry of Education, University and Research, the Ministry of Economic Development, and the Minister of Technological Innovation and Digital Transition.

3 National AI strategies in EU Member States, Norway and Switzerland

This section provides an **in-depth comparative analysis of the national strategies** structured along the categories and priorities agreed between EC and Member States in the 2021 review of the Coordinated Plan on AI.

The **2021 review of the Coordinated Plan on AI**, jointly developed by the European Commission and the Member States, puts forward key sets of proposals for the European Union and the Member States to achieve the following objectives:

Set enabling conditions for AI development and uptake in the EU. The Coordinated Plan proposes to focus on three key actions: (1) to build a governance framework to effectively acquire, accumulate and share policy insights on AI; (2) to unleash the full potential of data; and (3) to foster critical computation infrastructure to support capacity building and enhance the development of AI.

Make the EU the place where excellence thrives from the lab to the market. The Coordinated Plan sets out strategic actions and proposals to foster collaborations with relevant stakeholders, such as the public-private partnership (PPP) on AI, Data and Robotics. At the same time it outlines measures to boost AI research and innovation excellence and to improve European competitiveness. This goes along with financial instruments to help the business sector scaling up innovative ideas into marketable AI technologies. The 2021 review also focuses on tools to enable developers to test and experiment with AI technologies (through testing and experimentation facilities) and SMEs and public administrations to take up AI (through European Digital Innovation Hubs).

Ensure that AI works for people and is a force for good in society. The Coordinated Plan highlights actions to nurture talent and improve the supply of skills to enable a thriving AI ecosystem. It also puts forward policy instruments to ensure trust in AI systems in line with EU values and fundamental rights. Among others, this includes the legal framework on AI and EU's outreach efforts with the international community to promote its vision on a sustainable, secure, inclusive and trustworthy AI.

Build strategic leadership in high-impact sectors. The Coordinated Plan review identifies seven sectoral action areas including climate and environment, health, robotics,[15] public sector, migration and asylum, mobility and agriculture.

3.1 Enabling conditions for AI development and uptake

3.1.1 Acquire, pool and share policy insights

As stated in the 2021 review of the Coordinated Plan on AI, Member States are encouraged to develop and promote instruments that allow regular monitoring, coordination and evaluation of policy actions.

Member States have set up **various bodies to monitor the implementation of national AI strategies**, including inter-ministerial working groups, AI coalitions, Steering Committees and Advisory Councils on AI.[16] Specifically, inter-ministerial working groups, AI coalitions, and Steering Committees are responsible for new policy actions or to adapt existing ones to new needs in support of the development and uptake of AI. The Advisory Councils act as consultative bodies that provides advice and recommendations on policy measures.

As AI technologies impact the entire economy and society as a whole, many countries have created bodies to monitor the implementation of strategies in **specific policy areas**. For example, the Czech Republic has created dedicated working groups on education, R&D support, financing, industry, social impacts, regulation and international cooperation. Similarly, Poland has a Task Force on AI Policy enforcement, and in the near future plans to create a Scientific Council for AI, an AI Observatory for the Labour Market, an Observatory of international AI Policy, as well as a Legal Task Force for changing regulations as part of its governance centre for the national AI strategy.

[15] Given the strategic importance of robotics in the EU, also reflected in the Coordinated Plan, the recent AI Watch report 'Evolution of the EU market share of robotics: Data and Methodology' (Duch-Brown et al., 2021) highlights the EU trends in robotics over the past ten years. This report provides (1) an overview of the robotics industry; (2) reviews the scientific and institutional literatures on the economic impacts of robotics; and (3) describes available statistical data sources about robotics installations, sales and companies. This report will be updated in Q2 of 2022 to present the evolution of the EU market share of robotics.

[16] Most of these bodies or working groups involve representatives of governmental institutions, academia and the business sector.

While some countries rely on existing bodies to coordinate and monitor their strategies, other countries established **new governmental agencies** for this purpose. The French Government, for example, made Inria – the existing national research institute for the digital sciences – the coordinator of the national AI strategy. Spain established the Secretary of State for Digitalization and Artificial Intelligence (SEDIA) in 2020 as a new body of the Ministry of Economic Affairs and Digital Transformation to promote and coordinate the digitalisation of the country's economy and society. Poland's Task Force on AI Policy enforcement responsibilities include: giving an opinion on the implementation plans annually submitted to the minister responsible for IT, under the AI Policy, by each minister; presenting to the Committee of the Council of Ministers for Digitalisation draft information on the implementation of activities under the AI Policy for a given year; conducting ongoing monitoring and evaluation of the AI Policy implementation work; preparing proposals for recommendations for the Committee of the Council of Ministers for Digitalisation concerning the development of the artificial intelligence ecosystem in Poland; preparing opinions for entities involved in the AI Policy implementation. Poland's Working Group on Artificial Intelligence also brings together almost 400 market experts who suggest recommendations to provide appropriate conditions for the development of AI applications in the enterprise and public sectors.

In most cases, countries rely on **joint collaborations across ministries** to follow the progress of national strategies. Often these partnerships extend beyond governmental institutions to include experts from the business sector, educational and research institutions, as well as civil society organisations to ensure an active engagement of all relevant stakeholders.

In terms of updates, all countries indicate that **policy measures will be adjusted on a regular basis**. While all countries commit to amend their strategies, the timing of the update differs. Hungary and Spain say that they will revise their strategy every two years, while the Czech Republic, Ireland and Poland, have announced that they will monitor their strategies annually. Finland announced an update of its Artificial Intelligence 4.0 programme in spring 2020. The rest of countries commit to oversee the national AI strategy on a regular basis, but do not define a specific period of time.

Similarly, all countries agree on the **importance of evaluating the progress** of strategies' implementation and the outcome of their policy actions. Despite this awareness, few countries have set up evaluation instruments like key performance indicators or milestones for the next years. Specifically, only Finland, France and Hungary have provided a list of key performance indicators across which policy outcomes can be evaluated.

3.1.2 Tap into the potential of data

Data has become a central enabler of AI efforts. The availability of high-quality data, for example in respect of diversity, non-discrimination and the possibility to use, combine and re-use data are essential prerequisites and a precondition for the development and deployment of certain AI systems. Countries are therefore contributing to the goal of tapping into the potential of data at the national level through two mechanisms: by including data as a core part of their national AI strategies, and by creating or strengthening national data strategies and policies as well as national cloud strategies.

All AI strategies recognise the importance of data, and this is often developed further in separate data policies. **Main policy advancements have been undertaken in the realm of open data** by 25 countries. Most of them have a strong focus on the public sector. 22 countries have either committed to or have planned to create data spaces. 14 countries have devoted specific investments to the use and uptake of cloud in their respective Recovery and Resilience Plans (see Table 2).

Table 2 provides an overview of countries' contributions to the 2021 review of the Coordinated Plan's goal on tapping into the potential of data. It distinguishes between national initiatives and EU initiatives. Within national initiatives a distinction is made between those in (1) national AI strategies, (2) other national strategies, and (3) Recovery and Resilience Facilities plans.

National initiatives

a) Main data approaches within national AI strategies

All countries with a national AI strategy acknowledge data as a priority asset to enable AI, although with different approaches. There is no single policy trend that all countries agree on. However, the most mature, developed action is open data policy, which is either proposed or has already been launched by a total of 26 countries. For example, the Swedish Agency for Digital Government (DIGG), which supports open data policies to foster data-driven innovations and technology developments. Also, in October 2021 Sweden launched its data strategy for

secure access to open data and the use of data as a strategic resource to enable increased access to data for, e.g., artificial intelligence and digital innovation.

Germany's mCloud is also an open data platform that provides free access to data from the mobility, spatial and weather forecasting sectors. The database is constantly updated by the German Federal Government with raw data and takes into account data from private providers from the mobility sector as well. It is primarily aimed at users from administration, research and the business sector. Malta's Information Technology Agency (MITA) has also launched the Malta Data Portal, which included 41 registers and 200 data sets covering 10 sectors by September 2018.

Additionally, the creation of national data spaces across and within sectors is another initiative which is acknowledged by 22 countries. Some of these countries have already built them, as it is the case of the Danish Government, which is developing the preparation of a strategy for access to the existing public health data ecosystem. To support researchers in accessing health data, the Danish Government and Danish Regions have launched a common entry for health data. Also, Poland has designed and is on the first phase of implementing so-called "trusted data spaces" (DataTrust, Virtual Data Storage). In Germany, the Federal Ministry of Health has recently established a working group to build a national health data space, especially for research and public health purposes on the national and European levels.

In most of those countries proposing national data spaces, there is a correlation between the announcement of European Common Data Spaces at the EU level and country-level commitments to create national data spaces. For example, in Austria, "data circles" are a concept developed by Data Market Austria for a specific data ecosystem (mobility, energy, industry 4.0, etc.) in which sectorial data providers, users, brokers, developers or service providers engage in structured exchanges to address sector-specific challenges (e.g., ensuring security of supply, taking into account environmental concerns) through data-driven innovations. Only a few countries (e.g., Denmark and France) created these national data spaces before the EU proposal. Additionally, most national data spaces are ultimately nationally-based, but there are some exceptions, such as data spaces from the GAIA-X proposal led by France and Germany, or the case of Poland, which points out the need to connect "national data warehouses in the network of links between the economies of the Visegrad Group and the EU and beyond".

Concretely, **the most frequent application domain is the use of open data for AI in the public sector**. For example, Luxembourg plans to relaunch the government's open data policy with a new roadmap, taking into account the public sector's crucial role as a data provider for AI services development. Estonia aims its open data portal to give access to all data for AI which is collected by the public sector.

There are **other remarkable approaches to data which are not typical across countries**. Data audits are promoted by Estonia to a large extent. France aims to develop a system by which open data is submitted in real time and does not require a wait of several days to be publicly released. Luxembourg seeks to increase legal certainty for investors in data marketplaces by identifying innovative regulation. Finland's updated 2020 national AI strategy aims to foster data interoperability and sharing through several data-related actions.

b) Data and cloud strategies: beyond national AI strategies

Many countries have separate strategies since data and cloud are large topics which require further analysis and policy work. **21 countries already have or have committed to launch a national data strategy or action plan**.

12 EU Member States, plus Norway and Switzerland, have so far developed national cloud strategies. This is part of the goals of the Review of the Coordinated Plan, commonly agreed between countries and the European Commission, to foster innovative data-sharing environments based on open, interoperable, secure and resource-efficient cloud and edge solutions. These are Austria's Ö-Cloud initiative; Belgium's G-Cloud; Estonia's Government Cloud; France's cloud strategy for public administration; Greece's G-Cloud; Ireland's G-Cloud; Italy's Cloud for Public Administration Strategy; Lithuania's project on the government infrastructure consolidation; Luxembourg's Cloud Strategy for the Public Administration; Poland's Common State IT Infrastructure Programme (WIIP); Portugal's National Cloud Strategy for Public Administration; and Spain's cloud strategy for the state public administration. Denmark has recognised the need to establish a strategy for fostering data storage in the cloud to allow cheap access to massive computational power and storage capacity, and have published a guide that seeks to foster cloud uptake by public organisations. Further, Denmark has established GovCloud, which provides the central administration with a cloud service option. Norway and Switzerland also have a national cloud strategy, on cloud computing for the public and private enterprises, and for the federal administration, respectively.

Other countries have no strategy on cloud, but they do take actions and set up specific policies around the use and uptake of cloud computing, such as the Malta's Hybrid Cloud initiative procured by MITA, which is an example of how to enable access to cloud platforms for both the public and private sector, and Slovenia' State Cloud DRO, whose implementation is part of the eGOV strategy since 2018 and was launched before the national AI strategy.

In addition, all Member States signed a joint Declaration on Next Generation Cloud in October 2020 in which they agreed to work together towards deploying resilient and competitive cloud infrastructure and services across Europe. Member States agreed to focus joint actions on (1) combining private, national and EU investment in deploying competitive, green and secure cloud infrastructures and services; (2) defining a common European approach on federating cloud capacities; and (3) driving the take-up of more secure, interoperable and energy-efficient data centres and cloud services.

c) Recovery and Resilience Plans

As part of their Recovery and Resilience Plans (see references), 14 Member States have so far ring-fenced investments for supporting cloud uptake via public sector modernisation, business cloudification and the development of the next generation of advanced cloud and edge data processing solutions. Also, six countries are using their RRP to contribute to the IPCEI on Next Generation Cloud Infrastructure and Services (IPCEI-CIS). These Member States are France, Germany, Italy, Latvia, Slovenia and Spain. The corresponding budget ranges from EUR 1 to 2 billion in total.

EU initiatives

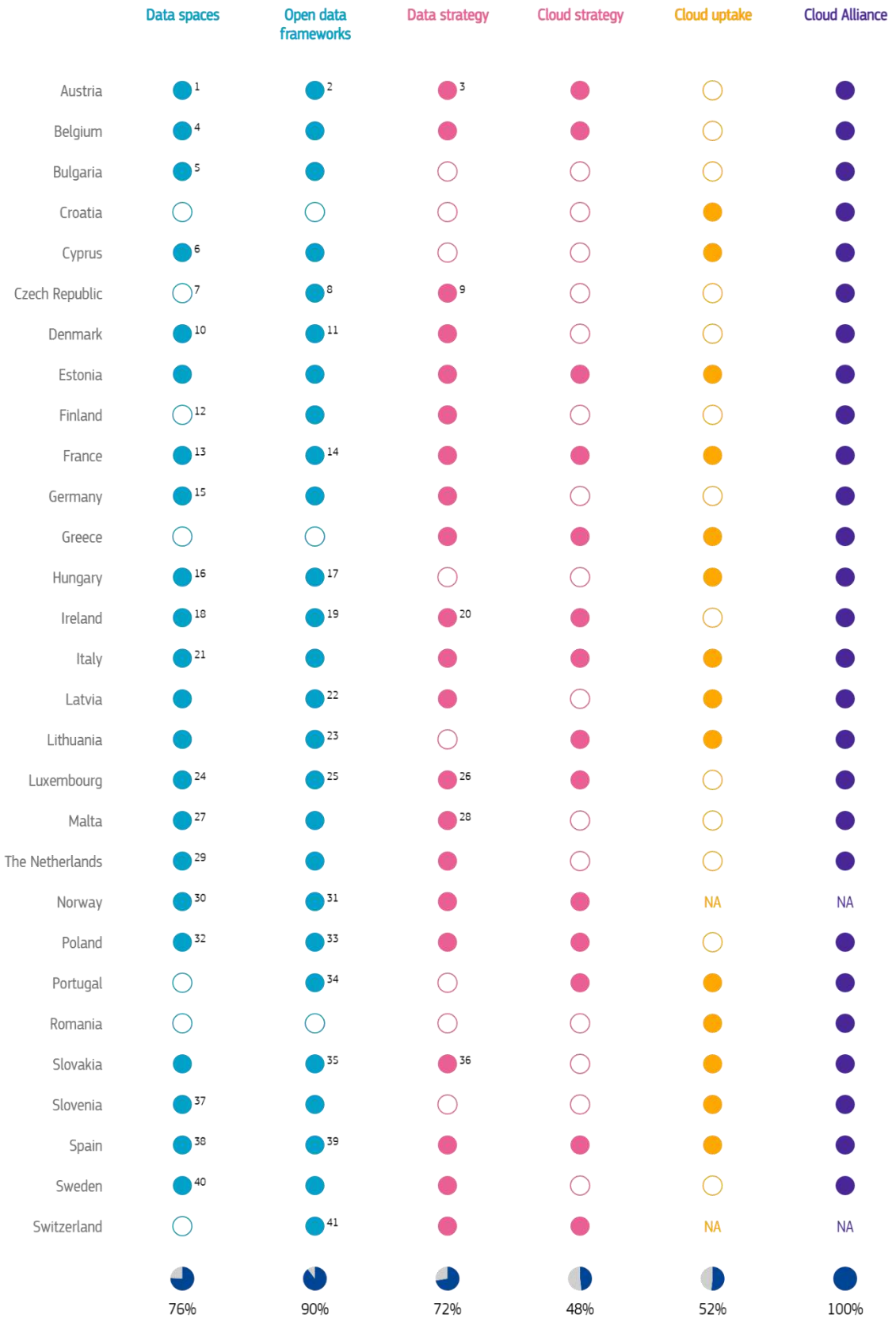
The European data strategy launched in February 2020 contributes to make the EU a leader in a data-driven society. It aims at creating a single market for data that will ensure Europe's global competitiveness and data sovereignty. Among other things it intends to invest EUR 2 billion in a European High Impact Project to develop data processing infrastructures, data sharing tools, architectures and governance mechanisms for thriving data sharing and to federate energy-efficient and trustworthy cloud infrastructures and related services

As a key pillar of the European data strategy, the Commission proposed a Regulation on harmonised rules on fair access to and use of data – also known as the Data Act – in February 2022. Its main objective is to make Europe a leader in the data economy by harnessing the potential of the ever-increasing amount of industrial data, in order to benefit the European economy and society.

With respect to next generation edge and cloud technologies, the European Alliance for Industrial Data, Edge and Cloud was launched in July 2021. It brings together businesses, Member States representatives and relevant experts with the objective to strengthen the position of EU industry on cloud and edge technologies.

Furthermore 12 Member States joined forces to create an Important Project of Common European Interest (IPCEI) on Next-Generation Cloud Infrastructure and Services (IPCEI-CIS) with the aim of developing a federated cloud and edge infrastructure and its associated platform, services and applications. IPCEI is a mechanism to pool public and private resources in areas where the market alone cannot deliver breakthrough innovation.

Table 2. Countries' efforts towards existing synergetic data and data processing activities along the Coordinated Plan



Source: Own elaboration by author, based on Recovery and Resilience Plans by country (see Bibliography), the 2nd edition of the AI Watch[17] report (2021), and direct feedback from Member States in the last stage of revision of the present report.

Note 1: Percentages exclude Norway and Switzerland from the statistical analysis when their respective boxes are "Not applicable" to the column's topic. Additional notes to the table are presented in the Box below.

Note 2: "Data spaces" (first column) refer only to those initiatives, policies and frameworks which *explicitly* refer to the notion of "data spaces". Data infrastructures, when mentioned, have not been identified as "data spaces".

Note 3: "Cloud strategy" refers to countries which have published a specific cloud strategy. It does not refer to those countries which have published any other type of roadmap, policy initiative and action on cloud (e.g., Slovenia has not published a national cloud strategy but has a State Cloud DRO framework).

Note 4: Please note that countries' participation in IPCEIs does not reflect the scope and degree of efforts that Member States are putting towards cloud update at the national level. Two IPCEIs are in preparation in so far (in Cloud and Microelectronics), while national initiatives on cloud are broader.

Note 5: "Cloud uptake" (fourth column) refers to the presence of investments and commitments to fund the use and uptake of cloud specifically in the Recovery and Resilience Facility plans, either under the "Scale-up" flagship, by channelling funds directly to the IPCEI-CIS, or under other forms of investments. Please note that this analysis only refers to RRPs adopted. Hungary, the Netherlands and Poland are not analysed as they have not adopted RRPs. Additionally, this information is based and aligned with the information as published in national RPP and Council Implementing Decisions. For further information on cloud plans led by Member States beyond the Recovery and Resilience Facility, please refer to section 3.1.2.b).

Note 6: Norway published a data strategy (in the form of a white paper to parliament) in 2021. For further information, please see: https://www.regjeringen.no/no/dokumenter/meld.-st.-22-20202021/id2841118/.

Box 2. Notes to Table 2. Countries' efforts towards existing synergetic data and data processing activities along to the Coordinated Plan

Structure of the table

The first two columns show the creation of data spaces and public data frameworks respectively as mentioned in national AI strategies, while columns three and four indicate which countries plan or already have dedicated data and cloud strategies. Column five highlights which countries include cloud uptake in their RRP's under the "Scale up" flagship area. Column six indicates which countries are part of the European Industrial Alliance for Industrial Data, Edge and Cloud.

Footnotes to the table

(1) Data circles are a concept developed by Data Market Austria for a specific data ecosystem (mobility, energy, industry 4.0, etc.) in which sectorial data providers, users, brokers, developers, or service providers engage in structured exchanges to address sector-specific challenges (e.g., ensuring security of supply, taking into account environmental concerns) through data-driven innovations. It also plans an incentive system for voluntary data exchange.

(2) Austria's national AI strategy aims to further develop the provision and re-use of administrative data, which includes an efficient implementation of the EU Open Data Directive at the national level. Austria is actively involved in the process of the European Open Science Cloud and FAIR's World Wide Web (Findable, Accessible, Interoperable, Reusable) data and services.

(3) The Digital Roadmap Austria sets out the goal to launch an Open Data Governmental Strategy.

(4) Belgium recognises the importance of facilitating access to data and making it available for citizens, businesses, public authorities, and researchers. At the federal level, the following policies have been deployed to facilitate free access to data and to support data sharing and processing: (i) the open data portal Data.gov.be provides access to 15,000 datasets across various categories and (ii) Statbel, the statistical institute of Belgium, provides free access to a hundred datasets, which can be used for commercial and non-commercial purposes. The Open Data Strategy is part of the Digital Agenda.

[17] Van Roy, V., Rossetti, F., Perset, K., Galindo-Romero, L. (2021) AI Watch – National strategies on Artificial Intelligence: A European perspective, 2021 edition. EUR 30745 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-39081-7, doi:10.2760/069178, JRC122684.

(5) Bulgaria's national AI strategy refers to create incentives for organisations to share data in the national Open Data Portal, as well as in private data spaces and platforms, and in the Bulgarian Open Science Portal maintained by NACID.

(6) The Cypriot Government is committed to the creation of a data ecosystem with guidelines and regulations about data interoperability and data exchange agreements. The national data environment will be reinforced through the further development of the National open data portal, and the creation of a National Research Data Portal.

(7) The Czech Republic's national AI strategy refers to data trust models, but not explicitly to data spaces.

(8) The Long-term objective is the creation of digital infrastructure and necessary processes for efficient provision of open data (government cloud, data platform, etc.) in accordance with the objectives of the Digital Czech Republic programme. In order to aggregate data in one place, store the data in a unified form, and above all ensure access to it by the private sector, including in the case of municipalities, their service organisations and subcontractors.

(9) This refers to the National Strategy of Open Access to Scientific Information and Data.

(10) The Danish Government is developing a strategy for access to the existing public health data ecosystem. To support researchers in accessing health data the Danish Government and Danish Regions have launched a common entry for health data.

(11) Fostering the Open Science Policy: the Danish Government's policy of Open Science is focused on three important elements – open access to scientific publications, research integrity and open research data.

(12) The Finnish Government has proposed a policy initiative called MyData service. It is a human-centred, open and compatible data management approach fostering data interoperability, sharing and protection of individual's rights on personal data.

(13) France's 2nd phase of its National AI Strategy: « 4 projets majeurs de mutualisation des données, inter ou intra-filières soutenus depuis 2019 dans les secteurs de l'agriculture (AgDataHub), de la logistique (IACargo), du traitement automatique de la voix (VoiceLab), accompagnés d'une plateforme générique d'IA « as-a-service ».”

Also, in the 1st phase of the National AI Strategy, the French Government supported data sharing in the private sector and has funded many AI Challenges (3rd season 2020) to help sponsors tackle data valorisation and problem resolution through AI in cooperation with start-ups and other innovators. It also funded several data hub projects to foster the setting up and development of sectoral data spaces (namely in agriculture, alimentation, logistics, health, sport), to be fully integrated in European data spaces.

(14) To encourage the creation of data commons fit for the AI age, including the provision of open data sets, and more real-time open data. This perspective is reflected in the National plan for open science, which aims to increase data portability. It is acknowledged that the right to data portability should be supported, allowing migration of data from one service ecosystem to another without losing data history.

(15) In Germany, the Federal Ministry of Health has recently established a working group to build a national health data space, especially for research and public health purposes on the national and European levels. There are other examples of support programmes of the German Federal Government to create data infrastructures to boost the development of AI applications, including: (i) mCloud, an open data platform that provides free access to data from the mobility, spatial, and weather forecasting sectors. The database is constantly updated by the German Federal Government with raw data and takes into account data from private providers from the mobility sector as well. It is primarily aimed at users from administration, research and the business sector; (ii) Mobility Data Marketplace (MDM), which offers suppliers and users of mobility data a neutral B2B platform to share, search and subscribe to traffic-relevant online data. The platform forwards the data supplied by the data suppliers unchanged to the data clients. With its defined standards for data exchange, MDM is nation's biggest volume of information on traffic flows, traffic jams, road works, mobility options, parking facilities and more; (iii) Mobilithek, which will merge the existing data platforms mCLOUD and MDM. Mobilithek will become the

National Access Point in the sense of the European ITS Directive. Launch planned for June 2022; (iv) Mobility Data Space (MDS), a non-profit joint venture that was established with the support of the German Federal Government and serves to mediate and technically link data supply and demand, especially in the B2B sector, by means of connectors (based on the International Data Space architecture). The MDS enables the secure, voluntary, sovereign data trade of private-sector data while fully respecting the property rights of the companies and thus, guaranteeing a level playing field. MDS and Mobilithek will be interlinked and will form a holistic data ecosystem. The MDS is one of the first important implementation projects within the European data infrastructure Gaia-X and is open for linking with further data spaces; (v) Smart Data Innovation Lab (SDIL), which offers researchers unique access to a large variety of big data and in-memory technologies. Industry and science can collaborate closely to find value in big data and generate smart data from it. Projects focus on the strategic research areas of Industry 4.0, energy, smart cities and personalised medicine; (vi) The Health Data Lab at the Federal Institute for Drugs and Medical Devices (BfArM). This will enable authorised institutions to analyse claims data from the statutory health insurance system for specified purposes, especially for scientific research purposes and the development of the healthcare system. As of 2023, insured persons will also have the option to voluntarily release pseudonymised and encrypted health data stored in the electronic health records to the Health Data Lab; (vii) Centre for Artificial Intelligence in Public Health Research (ZKI-PH) at the Robert Koch Institute. This aims to combine expertise in research into infectious diseases and non-communicable diseases with the methods of artificial intelligence.

(16) The establishment of the opportunity for the use of private data based on market conditions (Data market).

(17) Making the public data available in line with EU legislation (Portal for public data "Közadatportál")

(18) A public sector data catalogue was established at the beginning of 2021 and standards and guidelines for data sharing by public sector bodies will be issued over the course of 2021.

(19) Strategic actions: iii. Increase the availability of open government data for AI training and testing, including by holding an AI Open Data Challenge [DPER / CSO] iv. Identify public sector climate and environmental open datasets to encourage development of AI solutions for climate action [DPER / DECC, EPA, SEAI]

(20) Open Data Strategy and the Public Service Data Strategy 2019–2023.

(21) Regularly updating the guidelines for reusable Open Data for AI models with extensively large and annotated datasets (e.g., data for smart mobility). Policies will be the basis for Italian Participation in the Common European Data Space of the PA, envisaged by the European Data Strategy.

(22) These measures aim to foster the development of new information systems towards open data and to facilitate the path towards the creation of single data centres. In June 2017, Latvia has launched an Open Data Portal to harmonise data collection and encourage data sharing. As for data spaces, the 2nd AI Watch report highlighted the existence of data sharing initiatives of the data repository of the Latvian Environmental, Geological and Meteorological Centre (VSIA) containing meteorological radar images, measurements and forecast data to provide climate responses.

(23) The government highlights the existence of an open data portal Open.data.gov.lt. This portal provides an initial step towards the establishment of an open data ecosystem, but the current version is still limited in usability due to a large portion of data being uploaded in closed format.

(24) Identifying innovative regulation in the context of data marketplaces in order to increase legal certainty and transparency of data economy participants.

(25) Relaunching the government's open data policy with a new roadmap, taking into account the public sector's crucial role as a data provider for AI services development.

(26) Open Data Strategy.

(27) MITA (Malta's Information Technology Agency) has recently launched Malta Data Portal31, which included 41 registers and 200 data sets covering 10 sectors by September 2018 and will increase as the initiative is further developed. It aims to provide a one-stop shop for the discovery, viewing, downloading and online usage of data which is classified and has all the requirements of the open data definition. As a next step, The National AI Strategy will consider measures to increase the number of public data sets available, while ensuring that the interests of Maltese companies and individuals are protected.

(28) So far, there is a draft of the National Data Strategy

(29) Actions include: an inventory of data sharing solutions amongst others for AI and data markets, and the country's contribution to Common European Data Space (including for AI). As for open data frameworks, the case of Amsterdam's AI register (in partnership with the city of Helsinki) is highlighted, as these open AI registers track how algorithms are being used in the municipalities. A White Paper on the AI register was published on September 2020 to inspire other governments/organisations wanting to be transparent about their use of algorithms and AI

(30) SINTEF has enabled Norwegian companies to use the framework of International Data Spaces.

(31) Norway aims to promote and further expand open public data and data sharing between public sector agencies through initiatives such as National Data Directory on https://data.norge.no/, the Health analysis platform with national health data and geospatial data on Geonorge.no. In principle, all information that is lawfully published on public websites can also be made accessible as open data. Personal data that is exempt from public disclosure or that is subject to confidentiality must not, however, be made accessible unless specific reasons apply for doing so. Weather data from the Norwegian Meteorological Institute and traffic information from the Norwegian Public Roads Administration are examples of open data from the public sector. Also, Norway's national AI strategy commits to promoting and further expanding open public data and data sharing between public-sector agencies through initiatives such as National Data Directory on https://data.norge.no/, the Health analysis platform with national health data and geospatial data at Geonorge.no.

(32) Trusted data spaces (DataTrust, Virtual Data Storage).

(33) The strategy foresees the expansion of the platform containing open data collections of the public administration. In the same vein, virtual data warehouses will be created in which companies can share their industrial data in trustworthy and cyber secured data spaces.

(34) Creating the National Data Infrastructure, a centralised repository for administrative data. This action also provides guidelines about data sharing in the scientific community, as does the Open Data Policy of the Portuguese Foundation for Science and Technology (FCT).

(35) The strategy includes the following policy initiatives for the data economy: · Creating an Institute for trustworthy data to provide open access to high value databases from the public administration after controlling validity, constancy and credibility of the data; · The MIRRI will provide public administration with analytical tools for data management. So, the public administration will receive user-friendly SQL and machine learning tools for data simulations, visualisations and statistical calculations to facilitate policy making. With this help, end users in the public sector can run data analytics without technical issues on data management; · Setting up a Personal Information Management System (PIMS), a centralised data repository with data collected by the public administration about citizens. The PIMS will comply with data protection and data sharing regulations by allowing citizens to give their consent on these issues; · The Ministry of Environment is setting up a platform for sharing harmonised spatial data in compliance with the INSPIRE directive.

(36) In Slovakia, the Ministry of Environment is setting up a platform for sharing harmonised spatial data in compliance with the INSPIRE directive. The country also published the Slovak National Strategy for Open Science 2021–2028.

(37) Slovenia's national AI strategy sets out several goals on the use of data spaces and open data frameworks: creating national data spaces to develop AI in different areas (e.g., production, environment, mobility, health and medicine, finance, energy, agriculture, public administration, skills), and setting up a national platform with AI tools and algorithms developed in Slovenia; supporting the integration of data spaces at the EU level; raising awareness on risks and opportunities of sharing data across economy, public sector and research community.

(38) Slovenia has also established the national open data infrastructure Slovenia OPSI where all public data can be shared and used. These open data services, jointly with the State Cloud DRO, have been established before the national AI strategy. NpUI includes measures to assure proper technical infrastructure for AI development and use, based on available State cloud DRO, HPC Vega supercomputer (the first HPC within EuroHPC initiative) and Slovenia OPSI infrastructure.

(39) The creation of shared sectoral and industrial data and industrial data and decentralised and accessible repositories.

(40 To develop the regulatory framework for Open Data. Creation of an interdisciplinary Working Group on Open Data in the public sector, and the launch of the Data for the Common Good programme encourages the use and governance of open data.

(41) The AI Sweden programme makes datasets accessible via the Data Factory. It aims to provide horizontal resources to all research partners, ensuring that data sets are available across industries and application areas in order to accelerate AI innovation and applications. As for open data, the Swedish Agency for Digital Government (DIGG) is supporting open data policies to foster data-driven innovations and technology developments. Also, in October 2021 Sweden launched its data strategy for secure access to open data and the use of data as a strategic resource to enable increased access to data for, e.g., artificial intelligence and digital innovation.

(42) Switzerland aims to supporting data exchange infrastructures in the areas of Open Access to Publication and Open Research Data. These initiatives could link up with the European electronic computer infrastructure for open science (BEAT platform) and the European Open Science Cloud (EOSC). The country also has the Open Government Data Strategy 2019–2023.

3.1.3 Foster critical computing and data capacity

Without computing infrastructure, data will not generate added value. Data infrastructures are key for enabling the use of data for AI. In this realm, countries are contributing in two different ways: through nationally-led initiatives, and by supporting or relying on EU initiatives.

26 countries have either committed to or have already developed computing policies. The most typical action is to strengthen resources in already-existing computing centres at the national level. Other countries aim to create first-of-its-kind computing centres. 16 countries acknowledge the importance of the Recovery and Resilience Plan to boost these computing capacities.

Table 3 presents an overview of countries' contributions to the Coordinated Plan's goal on fostering computing capacity. It distinguishes between national and EU initiatives.

National initiatives

24 EU Member States, plus Norway and Switzerland, have committed to or have already developed computing policies.

a) Infrastructure

There are two main trends in the development of national integrated large-scale data management and High-Performance Computing infrastructure. **Most Member States tend to ensure** large-scale infrastructures **through centralised, one-stop national infrastructures**, such as Germany with its National Research Data Infrastructure Germany (NFDI). **Other countries create "platforms" which are co-ordinated by several ministries or public departments** at the same time, depending on the sector where the data is to be processed. This is the case of Hungary with its data market platform.

b) Computing and data policies

Most countries are now entering into the phase of advancing their existing computing capacities and making them more sophisticated. Portugal launched the Advanced Computing Portugal 2030 strategy, which outlines action lines to transform Portugal into an advanced computing service economy by 2030. Also, Slovenia works with the HPC Vega Supercomputer, the first High Performance Computer within the EuroHPC initiative. Czech Republic installed the IT4Innovations national supercomputing centre with the petascale HPC system Karolina in 2021, participates in the LUMI consortium aiming to build pre-exascale HPC systems and supports the EuroHPC research and innovation call. Other countries prefer to increase computing capacities, regardless of whether or not they have a computing centre. For instance, Hungary's Ministry for Innovation and Technology and the Governmental Information Technology Development Agency have the objective to increase the High-Performance Computing (HPC) capacity to 5 petaflops as of 2022. In other cases, some countries aim to create their first-of-its-kind computing centre: this is the case of Luxembourg, which has committed to developing the supercomputer MeluXina, aimed to rank in the world's top 30 supercomputers. MeluXina is funded via a joint investment of about EUR 30 million from the European Union and Luxembourg. Some countries benefit from hosting one of the eight EuroHPC supercomputers in their territory.

Second, there is an innovative approach where countries are genuinely contributing to the Coordinated Plan. All national AI strategies foresee that they will be able to strengthen their data capacities only if they first develop a strong *open data* governance framework, regardless of whether countries had computing capacities beforehand. Data governance is mainly reflected under the form of the figures of Chief Data Officer – as in Estonia and Spain – which ensures a permanent data oversight and management. Countries are increasingly proposing regulatory sandbox approaches to data management. Another area which is not mentioned in the Coordinated Plan but is fostered by some countries is the provision of funding for data audits. In this, Estonia and other countries such as Spain, are the leading a new approach to have control over personal and non-personal data through specific policies.

c) Stakeholders' engagement in computing and data policies

There are significant differences in the approach to interacting with stakeholders. **There is no single, prominent trend** on whether stakeholders are engaged in sector-specific data-sharing or data infrastructures, or if they are engaged in a whole-of-the-system discussion on how to share data regardless of the sector. While countries which lead sector-specific stakeholders' engagement include Denmark, Germany, Italy, Hungary and

Slovenia (the latter with the goal of raising awareness) are open to all stakeholders in all areas of data-sharing policy discussion.

These differences do not mean that one option is more effective than the other. Some countries will be able to speed up sector-specific demands and move them up to the chain due to inter-ministerial co-ordination, while in other countries demands may be channelled through a single voice. However, the challenge lies in Member States getting to know how they should best contribute to the goals of the 2021 Review of the Coordinated Plan, especially sector-specific data marketplaces and the interoperability with multi-country projects which cross over sectors.

d) Recovery and Resilience Plans

16 EU Member States have set out specific itemised budget, or at least have acknowledged the need to invest in computing capacities in their respective Recovery and Resilience Plans. 12 Member States will use RRF funds to contribute to the IPCEI on semiconductors. These are Austria, Belgium, Czech Republic, Finland, France, Germany, Italy, Latvia, Romania, Slovenia, Slovakia and Spain. It is important to note that not all countries earmark resources to this specific IPCEI. In some cases, the IPCEI on semiconductors is part of broader measures and it might be supported or not.

EU initiatives

Countries' participation is far restricted, if compared to the case of cloud and tapping into the potential of data.

22 Member States have signed the joint declaration for an Alliance on Microelectronics – for processors and semiconductor technologies – although this is clearly recognised as a goal to foster critical computing capacity in the 2021 Review of the Coordinated Plan.

Countries are limitedly pooling national public resources to bring innovation at the EU level where the market cannot deliver it alone. Four EU Member States (Austria, France, Germany and Italy) plus the United Kingdom are part of the **IPCEI on Microelectronics**, which was approved in December 2018. This IPCEI is composed of 32 companies.

Additionally, **the IPCEI on Microelectronics is on course to produce the expected EU-wide impact:** 32 direct partners are cooperating with up to 425 additional "indirect" partners from other countries in roughly 43 sub-projects. Likewise, technological knowledge is to be disseminated far beyond the five participating countries. Multi-country projects across regional-to-regional, national-to-national DIHs, or across European DIHs are analysed in the correspondent section.

Furthermore, a new IPCEI on Microelectronics and Connectivity has been pre-notified in December 2021 and will have a significant contribution on AI and AI computing. This IPCEI includes around 20 Member States[18] and more than 100 integrated projects.

Additionally, the Alliance on Processors and Semiconductor Technologies has more than 70 applications from companies and other legal entities in 15 EU Member States up to 23 February 2022, plus Norway and the United Kingdom, and submissions are still coming in.

Table 3. Countries' contributions to the Coordinated Plan's goal on fostering computing and data capacity

[18] Austria, Czech Republic, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Spain as direct participants, plus Belgium, Slovenia, Latvia as associate participants. Two additional prospective participants (Norway and Croatia) may join at a later stage.

Source: Own elaboration by author, based on Recovery and Resilience Facility by country, national AI strategies, countries' case studies from the 2nd edition of the AI Watch report (Van Roy et al., 2021), and direct feedback from Member States in the last stage of revision of the present report.

Note 1: The first column identifies which countries foresee computing policies as a driver of data processing and management in national AI strategies. The second column indicates which countries include processors and semiconductors for AI in their RRPs. The third column shows which countries have joined the new IPCEI (Important Project of Common European Interest) on Microelectronics and Connectivity. Percentages exclude Norway and Switzerland from the statistical analysis when their respective box are "Not applicable" (NA) to the column's topic.

Note 2: As for the IPCEI on Microelectronics and Connectivity, please note that Austria, Czech Republic, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Spain are direct participants, while Belgium,

Slovenia, Latvia are associate participants (up to 23 February 2022). Two additional prospective participants (Norway and Croatia) may join at a later stage.

Note 3: Please note that this analysis only refers to RRPs adopted. Hungary, the Netherlands and Poland are not analysed as they have not adopted RRPs. Additionally, this information is based and aligned with the information as published in national RPP and Council Implementing Decisions.

3.2 Make the EU the place where excellence thrives from the lab to the market

3.2.1 Collaboration with stakeholders

Member States are enhancing PPPs for AI, data, robotics, high-performance computing and other technologies in two ways: through nationally-created public-private partnerships; and through Horizon Europe-funded European Partnerships.

26 countries have set out plans to either create new National Public-Private Partnerships (PPPs) or strengthen the existing ones. It is important to say that in most cases national PPPs are not singularly devoted to AI technologies. These touch on several technology areas, and AI is part of them. There is no common pattern on how national PPPs are governed. Some Member States have centralised, one-stop schemes for all PPPs, while others have decentralised management of PPPs amongst several agencies. One significant policy development is that several countries are proposing bilateral PPPs with other EU countries. On the other hand, in terms of how countries support EU-funded European Partnerships, there is a strong support to the Key Digital Technologies Joint Undertaking (KDT JU) and the EuroHPC JU, which is seen as a driver and multiplier effect to strengthen respective national PPPs. Member States tend to work on Horizon Europe Cluster 4 "Digital, Industry & Space", fully devoted to AI research, and less in sector-specific clusters which may include AI.

Table 4 provides an overview of countries' contributions to the 2021 review of the Coordinated Plan's goal on collaboration with stakeholders. It distinguishes between national initiatives and EU initiatives.

National initiatives

26 countries have set out specific policies to address national Public-Private Partnerships on data, AI and related technologies. Most of them have already a specific PPP in progress, but they are devoted to convening private, research and public stakeholders into a same ecosystem on several technology areas, which include AI but are not limited or uniquely devoted to this technology. This is the case of Ireland's SFI Strategic Partnership Programmes, the Irish Research Council's Enterprise Partnership Schemes and SFI Industry Fellowship Programmes, and Collaborative Laboratories (CoLABs) in Portugal.

Additionally, in most cases the policy approach is to bring greater resources into existing PPPs to boost them and allow more coordination between stakeholders. To give an example, Germany's national platform "Plattform Lernende Systeme" (the Platform for AI) aims to increase resources. A few countries aim to create targeted programmes which will lead to new PPPs working specifically on AI topics. An example is Italy's goal to launch Italian AI 60-40 research-innovation calls, which will target large research projects in priority sectors with a participation of 60% from public labs and 40% from companies.

a) Governance models

There is no common pattern on how national PPPs are governed. There is a balance between the number of countries with **centralised platforms** from which PPPs are created, and those countries whose approach is decentralised and managed by several agencies depending on the sector. In the first case, countries channel the budget allocation and management of all PPPs through a single, one-stop "scheme". To give an example, France has set up in its 2021 Review of the national AI strategy the Grand Challenge "Confiance.AI", which co-finances over four years a large PPP "framework" through which smaller PPPs will get funding and institutional resources to be developed. The Netherlands does something similar through the Netherlands AI Coalition (NL AIC), a public-private partnership consisting of more than 400 participants which has received a share of EUR 276 million to fund the first phase of its project on AI, called the AiNEd Programme, to develop and accelerate AI applications. Sweden's innovation agency the Vinnova, channels most PPPs on AI or related digital technologies.

Ireland is a mixed case, as it has several "one-stop" frameworks[19] to channel PPPs, depending on the way stakeholders will engage with each other.

The second case – decentralised approach to PPPs – is managed through several agencies within the same country. This is the case with Estonia, which decentralises the approval, management, and execution of PPPs through several ministries and departments, depending on the topic which will be developed in the PPP on AI. Luxembourg allocates money to PPPs through several mechanisms, namely The Future Fund, Digital Tech Fund, and the Société Nationale de Crédit et d'Investissement (SNCI) bank. In Finland, Business Finland offers partnership funding for RDI projects in leading companies' ecosystem themes and in the platform-centred so-called Growth Engines, which are ecosystems of companies, research organisations and public actors.

b) Implementation

Some Member States have started proposing bilateral PPPs across two countries. France defines this with its Programme France-Québec DEEL, and also with the upcoming Franco-German public-private partnership for industrial AI ecosystems. France explicitly recognises that this bilateral PPP will be a driver to contribute to the Coordinated Plan. Czech Republic also defines as a goal to create bilateral and multilateral PPPs by 2027. It also aims, by 2035, to strengthen PPPs on AI in the Czech-German Strategic Dialogue, the Czech-French Strategic Partnership (for the digitalisation and AI development in start-ups), and the Slavkov Format alongside Austria and Czech Republic to cooperate on AI for the industry 4.0.

Second, all countries tend to govern PPPs at a public agency level on economic, technology or innovation affairs, but there are some exceptions at the highest level of decision-making. For example, Estonia has no one-stop PPP framework, but PPPs are constantly channelled through the Chief Information Officer (CIO) Office and the Chief Data Office. Also, Finland has committed to foster PPPs as one of the three key areas in its RDI Roadmap. The evolution of the research and innovation system is supported by the Research and Innovation Council chaired by the Prime Minister and there is extensive work by a parliamentary working group.

EU initiatives

There is a significant majority of countries showcasing the need to join EU-led PPPs. European PPPs, which are concerted research and innovation initiatives among the Commission, Member States, and private and/or public partners, are essential to define and engage collectively in supporting a roadmap for excellence and for wider diffusion of AI, through a legal structure to pool resources and to make research and innovation funding across the EU more efficient.

Of the three types of EU PPPs, Member States are mainly participating in the category of "institutionalised partnerships" (this is, between the Union, EU member states and/or industry), and less in "co-programmed partnerships" (this is, between the Commission and mostly private – and sometimes public – partners). No country pools national resources for AI or related technologies in the third type of EU PPP ("co-funded partnership").

As for institutionalised partnerships, Member States tend to work on public-private partnerships on AI mostly through the Horizon Europe Cluster 4 "Digital, Industry & Space", and less through other types of topic-specific clusters which incorporate some layers of application of AI technologies. This means the resources devoted to AI are mainly for developing AI technologies, and less for the application of AI to specific policies or sectors.

EuroHPC JU is the platform where most countries participate (28), as a way to benefit from the multiplier effect it has into their own national PPPs. The idea of EuroHPC as a driver for subsequent national PPPs on high-performance computing is explicitly acknowledged in the national AI strategies of Luxembourg, Poland, Portugal and Slovakia. Czech Republic does the same, but goes beyond and frames a specific deadline to create a future nationally-led PPP. **Other countries regard EuroHPC as a PPP which horizontally complements their own national PPPs**, as declared by Sweden, Norway, the Netherlands, Latvia, Italy and Finland. The latter dedicates an entire section in its AI strategy on the need to revamp national PPPs.

28 countries refer to the Key Digital Technologies Joint Undertaking (KDT JU) in their national AI strategies.

As for co-programmed partnerships on AI, although countries are not allowed to participate in them due to administrative rules, several Member States – Cyprus, France and Italy – have showed their interest in

[19] These are the SFI Strategic Partnership Programmes, Irish Research Council's Enterprise Partnership Schemes, and SFI Industry Fellowship (IF) Programme.

benefitting from these partnerships' proposal for countries to appoint national ambassadors or Points of Contact.

24 countries acknowledge the importance of these European partnerships, and 18 of them explicitly state the need to join them in their national AI strategies. Some Member States support the participation in partnerships such as EuroHPC and other JUs in their Recovery and Resilience Plans. This is the case of Italy under Component 2 of Mission 4.

Table 4. Countries' contributions to the Coordinated Plan's goals on collaboration with stakeholders

Source: Own elaboration by author, based on KDT JU Public Authorities Board (2021), HPC JU documents (2021).
Note 1: "P" stands for "planned" and refers to countries whose national AI strategy has shown an explicit commitment to create public-private partnerships on data and AI at the national level.

Box 3. Notes to Table 4. Countries' contributions to Coordinated Plan's goal on collaboration with stakeholders

Structure of the table

The first column refers to the existence of national Public-Private Partnerships on data and/or AI (or the plan to create them) as mentioned in national AI strategies. Columns two and three indicate which countries explicitly acknowledged the importance and the need to join European Partnerships in their national AI strategies. Columns four and five present countries' participation to the EU-wide Partnerships of Key Digital Technologies Joint Undertaking (KDT JU) and the European High Performance Computing Joint Undertaking (EuroHPC JU).

Footnotes to the table

(1) Austria: Existence. Data exchanges partnerships: Data Market Austria, Data Intelligence Offensive (focused on B2B or B2Science).

(2) Belgium: Existence by region. AI4Belgium coalition: Calls for G2G PPP on data-sharing and data-standards setting. Flanders Action Plan: No official PPP. Each sector has intra-sector consortiums, although they collaborate on specific "challenges" (City of Things project on smart cities in Antwerp). Wallonia: Project ARIAC within the DigitalWallonia4.ai programme gathers private and public organisations to foster the regional ecosystem. Brussels-Wallonia Federation: Trusted AI Labs (TRAIL).

(3) Bulgaria: The national strategy also mentions that the State Agency for Research and Innovation will develop a new set of policies that will encourage the development of applied research and innovation, as well as the strengthening of public-private partnerships. Furthermore, one of the measures to raise awareness and build trust includes inviting business to support an effective, focused and consistent discussion with the scientific community and public authorities. This is a prerequisite for the development of public-private partnership on the development and implementation of AI in Bulgaria, by creating a platform for public-private debate on AI and getting involved in organising discussions.

(4) Czech Republic: Collaborations between SMEs, start-ups and scientific research centres will receive support form specific programmes like the Knowledge Transfer Partnerships for the development of a mutually beneficial partnerships between the business community and research organisations. Also, the national AI strategy commits to increasing future bilateral and multilateral PPP (by 2027). Goal for bilateral PPP on AI (by 2035) in Czech-German Strategic Dialogue; Czech-French Strategic Partnership (digitisation and AI start-ups development), Slavkov Format (Dual Education and Industry 4.0).

(5) Denmark: Existence. PPP created in 2019 under the Digital Hub Denmark on AI & health data.

(6) Estonia: Existence. No "umbrella" PPP framework, but PPP are constantly channelled through the CIO Office and the Chief Data Office.

(7) Finland: Business Finland offers partnership funding for RDI projects in leading companies' ecosystem themes and in the platform-centred so-called Growth Engines, which are ecosystems of companies, research organizations and public actors.

(8) France: Existence. Grand Défi "Confiance.AI", co-financed PPP over 4 years with more than 40 partners including SMEs, start-ups, large companies and academics. Programme France-Québec DEEL. Upcoming Franco-German public-private partnership (industrial AI ecosystems).

(9) Germany: Existence. National platform "Plattform Lernende Systeme – the Platform for Artificial Intelligence". Upcoming Franco-German public-private partnership (industrial AI ecosystems).

(10) Ireland: Existence. SFI Strategic Partnership Programmes, Irish Research Council's Enterprise Partnership Schemes, SFI Industry Fellowship (IF) Programme.

(11) Italy: The national AI strategy aims to launch Italian AI 60-40 research-innovation calls: these calls target large research projects in priority sectors from which 60% for public labs and 40% for companies. (11) Latvia: Aims to increase number of PPP projects. Reference to PPP on AI for cancer diagnosis.

(12) Lithuania: Commitment. Refers twice to the commitment to create a PPP between AI companies and school children to encourage talent.

(13) Luxembourg: Existence. PPP with national and foreign companies (i.e., Nvidia). PPP to be financed through Horizon Europe, and also The Future Fund, Digital Tech Fund and the Société Nationale de Crédit et d'Investissement (SNCI) bank.

(14) Malta: Existence. No specific PPP framework, but PPP projects are funded through the R&I FUSION Programme, and promoted and visualised through Tech.mt.

(15) The Netherlands: The Netherlands AI Coalition (NL AIC), a public-private partnership consisting of more than 400 participants, channels PPP and received a share of EUR 276 million to fund the first phase of its project on AI, called the AiNEd Programme to develop and accelerate AI applications.

(16) Poland: Existence. Future Industry Platform.

(17) Portugal: Existence. Collaborative Laboratories (CoLABs). Aims to lead and propose an IPCEI on AI & energy. No PPP.

(18) Slovakia: Commitment. Aims to create a national PPP on High Performance Computing.

(19) Spain: Commitment. Aims to create Grand Challenges, and also platforms that foster collaborative research on AI and knowledge transfers, while promoting and exploiting synergies between universities and businesses by means of cooperation programmes like the Co-incident Programme.

(20) Sweden: Existence. Vinnova channels PPP on AI, data, HPC.

(21) Belgium: AI4Belgium coalition: importance, reference, and need to guarantee G2G public-private partnerships. Flanders Action Plan: No reference. Wallonia: Importance. No reference to European PPP. Region of Brussels: no reference.

(22) Cyprus: Importance and reference to European Partnership on AI, Data, and Robotics. Need to join it.

(23) Czech Republic: Importance and reference. Strong focus on time-framed goals for future nationally-led and bilateral PPP.

(24) Finland: Detailed reference. Dedicated section on the importance to revamp PPP in a more effective way.

(25) France: Continuous reference. The French national AI strategy acknowledges the need to foster European public-private partnerships in addition to the nationally led ones.

(26) Italy: Detailed reference to the European Partnership on AI, Data, and Robotics, as well as other Horizon Europe's clusters contributing to AI 1. Health, 3. Civil security for society, 5. Climate, energy and mobility, 6. Food and natural resources, and in all missions.

(27) Latvia: Reference and importance. Special reference to ECSEL JU.

(28) Luxembourg: Importance and specific reference to EuroHPC JU.

(29) Norway: Reference. Norway has already joined both Horizon Europe and DIGITAL, and has committed fully to EuroHPC.

(30) Portugal: Detailed reference. Strong support from European partnerships to develop Portuguese PPP. Aims to strengthen participation in joint undertakings: ECSEL, EuroHPC, Quantum Flagship.

(31) Slovakia: Reference to EuroHPC JU as driver for a national PPP.

3.2.2 Build and mobilise research capacities

Research excellence centres on AI contribute to boost AI research and innovation and to improve European competitiveness. This requires greater investments into research, and also increased cooperation, integration and synergies among research teams and industry within countries and across Europe. According to the 2021 Review of the Coordinated Plan on AI, the Recovery and Resilience Plans can also be used to strengthen national research centres.

Countries are contributing to this goal at different speeds and intensity. 17 countries already have a national research excellence centre working on AI, or at least with a specific portfolio on this topic among other technologies. Five countries have committed to launching one. This shows an upward trend. Some of those countries with a national research excellence centre (roughly 10) are singularly devoted to AI research. As for RRPs, the area of AI which receives most attention is basic research. 14 countries define AI basic research as a target. Rest of topics are less frequent: 10 countries include e-governance and public sector through AI as part of their RRPs; nine countries foresee actions on AI and education; also, nine countries set out initiatives to foster SMEs through AI; and the rest of topics are less frequent.

Table 5 provides an overview of countries' contributions to the 2021 review of the Coordinated Plan's goal on building and mobilising research capacities. It distinguishes between national initiatives and EU initiatives.

National initiatives

a) Research excellence centres in national AI strategies

17 countries have one or more **national research excellence centres** working on AI (see Table 5 for detail of number of centres). However, the trend is improving: another five countries have already committed to or are planning to launch a new national research excellence centre, although the level of speed differs.[20]

Having a national research excellence centre where there is research on AI does not mean that it is solely devoted to AI research or its applications. Of those countries with a national research excellence centre which has some line of work on AI, only around 10 countries have centres singularly addressing the topic of AI. For example, Bulgaria's national AI strategy has committed to creating a Bulgarian AI Research Centre of Excellence which will focus on the fields of neural networks, machine learning, natural language processing, semantic technologies and robotics. Czech Republic also aims to establish a Centre of Excellence in AI Research for basic and applied research, while Cyprus has committed to a new Centre of Excellence for applied research in AI. The Slovak Research Centre for Artificial Intelligence, Slovak.AI, highlights the importance of AI in solving major societal challenges such as climate change, safety, health and food security. It is remarkable that Slovenia has

[20] Belgium: At the federal level, the 2019 AI4Belgium Strategy includes the need to "create a confederation of Belgian laboratories" as well as "set up a country-wide AI lab to foster collaboration".
Bulgaria: The 2020 National AI Strategy, released in December 2020 commits to creating a establishing a Bulgarian AI Research Centre of Excellence. Currently, there are existing Centres of Excellence in ICT and Centres of Competence in ICT and Mechatronics which have done research on AI and robotics. However, they are not national centres on AI.
Cyprus: The AI research pillar is developed through CYENS COE[20], the Research Centre of Excellence in the area of ICTs focusing on Interactive media, Smart Systems and Emerging Technologies. However, it is not a research centre on AI. The National AI Strategy from January 2020 plans to create a specific Centre of Excellence for applied research in AI.
Czech Republic: The 2019 National Strategy underlined the establishment of a Centre of Excellence on AI as a short-term goal by the year 2021. In March 2020, the Czech Technical University in Prague, Charles University and Masaryk University signed a memorandum to start building a European Centre of Excellence in the field of AI for a more secure society. No news has been published since then.
Lithuania: The 2019 National AI Strategy includes the goal of establishing a national research centre in AI and increasing the financial support to AI research by developing new funding programmes with the aim of meeting the standards set out by the European Commission (i.e. increasing funding for AI research by 70% by the end of 2020).
Portugal: The National AI Strategy includes as one of its policy actions the establishment of a Centre of Excellence (CoE) for AI R&D which participates in the European endeavour to create a network of CoEs.
Slovenia: Draft AI strategy aims to create a public-private co-financing framework to support an AI Centre of Excellence on basic AI research.
Spain: The National AI Strategy includes the creation of a national *network* of excellence in AI across the country -not a national research centre.

the International Research Centre on Artificial Intelligence (IRCAI), which operates under the auspices of the United Nations Organisation for Education, Science and Culture (UNESCO) to develop AI-based tools, products and services and provides policy support to AI so that UNESCO Member States will attain the Sustainable Development Goals (SDGs) sooner. Additionally, Slovenia has committed to public co-financing to support the AI centre of excellence and basic AI research.

Other countries have a larger number of competence centres devoted to specific areas of application domains of AI technologies. In France, four Interdisciplinary Institutes of Artificial Intelligence (3IA) were created in 2019, namely Toulouse-ANITI, Nice-Côte d'Azur 3IA, Grenoble-MIAI and Paris-PR[AI]RIE. Germany has six Competence Centres for AI Research, each one of them specialised in a specific basic research area of AI. Also, Ireland has a "5+1" model: ADAPT, which is a SFI Research Centre for AI Driven Digital Content Technology, plus five SFI Centres for Research Training (SFI CRT) in Machine Learning (ML Labs), in Data Science, in Artificial Intelligence (CRT-AI), in Digitally Enhanced Reality (D-real) and in Advanced Networks for Sustainable Societies (Advance CRT). Additionally, Spain aims create a country-wide network of excellence in AI to maintain research and training programmes in cutting-edge knowledge areas on AI. Another nine countries plan to create a new centre singularly devoted to AI research. So far, other ten countries have no plans to create a centre exclusively devoted to AI.

b) Recovery and Resilience Facility Plans

Countries are boosting their national AI research capacities also by means of the RRP. The area of AI which receives most attention in RRPs is AI basic research, concretely by 14 countries which define it as a target. Other frequent topics are e-Governance and public sector through AI (10 countries), actions on AI and education (9 countries), and initiatives on SMEs through AI (9 countries).

Alongside these four topics, there are many more sectors in which countries plan to apply AI, but they are less typical across countries' RRPs (see Table 6). This is the case for the detection of money laundering and tax fraud in Estonia and Greece; language translation in Belgium and Spain; the tourism sector in Italy and Spain; and the use of AI for security-oriented issues on maritime and cyberattacks' early warning in France. It is important to mention that the use of AI to support the green transition as well as healthcare is in a limited way mentioned in the sections of the RRPs which are fully addressed to Artificial Intelligence. However, the reason is that green transition and healthcare have their own dedicated sections in the RRPs, and so the reference to AI is limited.

EU initiatives

Most member partners of EU-funded Networks come from countries with no national research excellence centres – or with small centres, except from the cases of France and Germany. However, it is important to stress that French and German stakeholders' part of these EU-funded networks are not "labelled" as national research excellence centres in their respective countries.

This may explain that EU-funded Networks are being envisaged by countries as, first, a window of opportunity to benefit from European tools and cooperation due to the lack of resources at the national level; and, second, a bridge for AI research centres in well-equipped countries with no "excellence" category, in order to move up to the chain and acquire higher levels of excellence through this EU-funded mechanism. As for countries' participation in EU-wide public-private partnerships on AI, see Table 5.

Table 5. Countries' contributions to the Coordinated Plan's goals on building and mobilising research capacities

	Research excellence centres on AI	AI4Media network	ELISE network	HumaneAI network	TAILOR network	VISION (CSA) network	European AI lighthouse: ELLIS centres	European AI lighthouse: CLAIRE centres
Austria	0	●	●	●	●	○	2	●
Belgium	P	●	●	●	●	○	1	●
Bulgaria	P [1]	●	○	○	●	○	○	●
Croatia	○	○	○	○	○	○	○	○
Cyprus	1 [2]	○	○	○	●	○	○	●
Czech Republic	P [3]	○	●	●	●	●	1	●
Denmark	1	●	●	●	●	○	1	●
Estonia	1	○	○	○	○	○	○	○
Finland	1	○	●	●	●	○	1	●
France	4 [4]	●	●	●	●	●	1	●
Germany	9 [5]	●	●	●	●	●	9	●
Greece	○	●	○	●	●	○	○	●
Hungary	1	○	○	●	○	○	○	●
Ireland	6 [6]	●	●	●	●	●	○	●
Italy	5 [7]	●	●	●	●	●	4	●
Latvia	○	○	○	●	●	○	○	●
Lithuania	P	○	○	○	●	○	○	●
Luxembourg	○	○	○	○	●	○	○	●
Malta	○	●	○	○	○	○	○	○
The Netherlands	1	●	●	●	●	●	3	●
Norway	1 [8]	○	○	○	●	○	○	●
Poland	2	○	●	●	●	○	○	●
Portugal	P	●	●	●	●	○	1	●
Romania	○	●	○	○	○	○	○	●
Slovakia	1 [9]	○	○	○	●	○	○	●
Slovenia	1 [10]	○	●	●	●	○	○	●
Spain	1 [11]	●	●	●	●	○	1	●
Sweden	1 [12]	○	●	●	●	○	○	●
Switzerland	4	●	●	●	●	○	2	●
	59%	52%	55%	66%	83%	21%	41%	90%

Source: Own elaboration by author, based on 2nd edition of the AI Watch report (Van Roy et al., 2021), national AI strategies, countries' RRPs, and direct feedback from Member States in the last stage of revision of the present report.

Note 1: Please note that this analysis only refers to RRPs adopted. Hungary, the Netherlands and Poland are not analysed as they have not adopted RRPs. Additionally, this information is based and aligned with the information as published in national RPP and Council Implementing Decisions.

Box 4. Notes to Table 5. Countries' contributions to the Coordinated Plan's goals on building and mobilising research capacities

Structure of the table

The first column refers to the existence or commitment to have a national research centre of excellence on AI or related technologies. Figures indicate the number of "national research excellence centres". The letter "P" shows which countries have committed to creating a national research excellence centre on AI in their national AI strategies. The rest of columns shed light on country's participation into EU-wide initiatives on research capacities. The column on ELLIS centres identifies the number of centres which each country has at its disposal, if any.

Footnotes to the table

(1) Bulgaria: The national AI strategy aims to create a Bulgarian AI Research Centre of Excellence to bring together scientific organisations and higher education institutions with proven excellence in AI research. Research will focus on the fields of neural networks, machine learning, natural language processing, semantic technologies, robotics.

(2) Cyprus: The Cypriot Government devotes particular attention to policy actions fostering research and innovation, including the creation of a Centre of Excellence for applied research in AI, and the formation of new financial support and funding schemes. The establishment of a special Task Force for Researchers is also considered to help the AI Expert Group in developing AI policies.

(3) Czech Republic: The national AI strategy aims to create the Centre of Excellence in AI Research to support basic and applied research in the field of AI. The Digital Czech Republic Programme will fund this centre with resources from the City of Prague ad private partners.

(4) France: 4 Interdisciplinary Institutes of Artificial Intelligence (3IA) were created in 2019: Toulouse-ANITI, Nice-Côte d'Azur 3IA, Grenoble-MIAI and Paris-PR[AI]RIE. There are 3 other major education and research centres specialised on data science, AI and Robotics: Paris-Saclay-Institut Data-IA, Institute Polytechnique de Paris-Hi! and Paris-Sorbonne-SCAI.

(5) Germany has created six Competence Centres for AI Research to strengthen excellence and competitiveness and to become a leading country for AI research. To support their expansion and their development into a national research network on AI the ministry has doubled the funding of the competence centres until 2022. As mentioned in the Updated AI strategy (p. 12), "the plan is to dovetail the existing centres at the universities in Berlin, Dresden/Leipzig, Dortmund/St. Augustin, Munich and Tübingen and the German Research Centre for Artificial Intelligence with other application hubs to be established to form a network of at least twelve centres and hubs". As of 2022, the five competence centres for AI research that are situated at universities are permanently supported.

(6) Ireland: Ireland has one SFI Research Centre for AI Driven Digital Content Technology (ADAPT), plus five SFI Centres for Research Training (SFI CRT) in Machine Learning (ML Labs), in Data Science, in Artificial Intelligence (CRT-AI), in Digitally Enhanced Reality (D-real) and in Advanced Networks for Sustainable Societies (Advance CRT). Most of these centres are co-funded by SFI and the industry and are organised as public-private partnerships between academia and industrial players. The aim of the centres is to build on research excellence and to provide cohorts of PhD researchers with the skills and knowledge required to address the future challenges of an ever-changing work environment.

(7) Italy: The Italian AI research ecosystem counts on a wide range of national centres of excellence like the Artificial Intelligence and Intelligent Systems Laboratory (AIIS) of the Italian Interuniversity Consortium for Informatics (CINI), the Italian Institute of Technology (IIT), and the Institute for Calculation and Networks for High Services (ICAR) of the National Research Council (CNR). In April 2021 the first laboratory dedicated to Pervasive Artificial Intelligence Laboratory (PAI Lab) was inaugurated in Pisa.

(8) Norway: The Norwegian Centre for Research-Based Artificial Intelligence Innovation (SFI NorwAI) was launched in 2020. It is a new research centre on AI and big data. The purpose of the centre is to develop cutting-edge theories, methods and technologies for efficient and responsible use of data-driven AI in innovative industrial solutions. NorwAI is run as an integral and complementary part of the Norwegian Open AI Lab (NAIL), both of which are formally hosted by the Department of Computer Science at NTNU. New centres will be awarded the category of research excellence centre throughout 2022. Out of the 36 finalists, several are centres focusing on AI research.

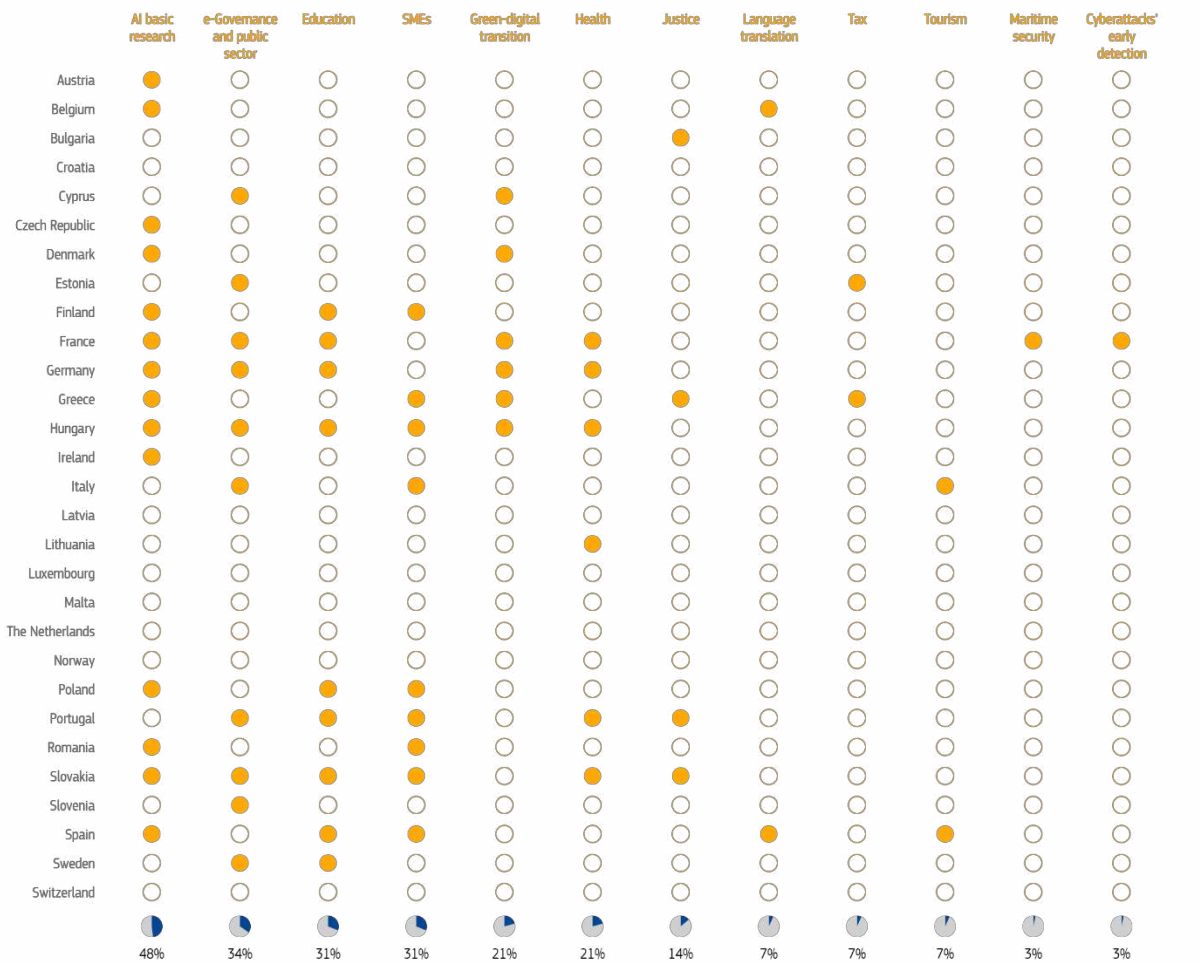
(9) Slovakia: The Slovak Research Centre for Artificial Intelligence, Slovak.AI was created in 2019 to support excellence in the field of AI by bringing together all relevant stakeholders such as businesses, research communities and governmental institutions. The platform highlights the increasing importance of AI in solving major societal challenges such as climate change, safety, health and food security. Additionally, the National Security Authority and the MIRRI are establishing a national competence and coordination centre for cyber security to develop new technologies like encryption and to evaluate the use of AI in automating security procedures.

(10) Slovenia: The International Research Centre on Artificial Intelligence (IRCAI) operates under the auspices of the United Nations Organisation for Education, Science and Culture (UNESCO) to develop AI-based tools, products and services and provides policy support to AI so that UNESCO Member States will attain the Sustainable Development Goals (SDGs) sooner. Additionally, Slovenia has committed to creating to public co-financing to support AI centre of excellence and basic AI research.

(11) Spain: The national AI strategy commits to further expanding the National Centre of supercomputing in Barcelona (BSC). Also, the country aims to create a Spanish network of excellence in AI to maintain research and training programmes in cutting-edge knowledge areas on AI.

(12) Sweden: AI Sweden is organised as a national centre for applied AI research and innovation with almost 70 partners from the industrial and public sectors, research institutions and the academic world.

Table 6. Preferred topics on AI research in the Recovery and Resilience Facility plans, by country



Source: Own elaboration by author, based on countries' Recovery and Resilience Plans (RRPs), and direct feedback from Member States in the last stage of revision of the present report.

Note 1: The table shows only information from RRPs and not from national AI strategies.

Note 2: Please note that this analysis only refers to RRPs adopted. Hungary, the Netherlands and Poland are not analysed as they do not have RRPs adopted. Additionally, this information is based and aligned with the information as published in national RPP and Council Implementing Decisions.

3.2.3 Tools and environments to test and experiment AI technologies

Bringing innovation from the lab to the market to ensure the broad uptake and deployment of AI technologies is key. Testing and Experimentation Facilities (TEFs) are essential to support the suppliers of AI for the deployment and uptake of AI technologies. The continued implementation of Digital Innovation Hubs (DIHs) across the EU since 2016 with the "Digitising European Industry", and the recent call for European Digital Innovation Hubs (EDIHs) to be implemented in 2022 across all Member States under the "Digital Europe" programme, are important ecosystems where companies interested in using AI for their business and production may "test before invest". AI-on-demand platforms and AI marketplaces can also play a major role in supporting SMEs in adopting and developing AI.

26 countries have either committed to creating or have already set up national testbeds and similar facilities on AI. The main topics of priority for these national initiatives on AI testbeds are: mobility and transport (10 countries), healthcare (8), agriculture and farming (7), Smart City and communities (5) and manufacturing (4). All these clusters are aligned with the "prioritised sectors in TEFs" drawn from the 2021 Review of the Coordinated Plan, except for "mobility and transport", which is not included by the Review and receives significant attention at the national level (see Box 1 for more information about priority sectors in testing and experimentation facilities). Meanwhile, eight countries have already created or plan to set up an AI marketplace, although the scope of these marketplaces differ, and resources are still at a low level. As for EDIHs, Member States have pre-selected, at the national level, the entities that will be able to participate in the EDIH call which is to be implemented throughout the year 2022. For the pre-selection of these entities Member States defined their national policy and priorities in terms of digital transformation.

EDIHs are mainly mentioned in Recovery and Resilience Plans. AI-on-demand platforms receive little attention in national strategies and policies. Additionally, several policy developments at the national level are highly remarkable including growing regulatory sandboxes, "Free Zones of Technology" and cross-border facilities and similar testbeds.

Table 7 presents an overview of countries' contributions to the Coordinated Plan's goals on establishing tools and environments to test and experiment AI technologies.

National initiatives

a) Testing and experimentation facilities and regulatory sandboxes

TEFs are the area where national action is most developed, although still most cases are commitments to implement TEFs. 26 countries have either national testbeds or similar facilities on AI, or have committed to create them in their national AI strategies.

Regulatory sandboxes and the setting up of facilities and similar testbeds at universities tend to be the most important actions for implementation at the national level, although approaches differ. For the case of universities, Denmark's example shows how the country has created performance contracts with seven Research and Technology Organisations (GTS institutes) that provide hands-on technological support to Danish enterprises for start-up establishment and development.

14 countries[21] already have or plan to create regulatory sandboxes for AI or other related technologies. In some countries, the reason why regulatory sandboxes are set up is explicitly acknowledged in their national AI strategies. Some countries point out that sandboxes will help ensure legal certainty and business security within the country when using AI facilities and testbeds. To give some examples, Bulgaria has committed to support innovation laboratories to test AI applications at the company level; Malta launched the Technology Assurance Sandbox in May 2021, including AI and other digital technologies; and Italy's *Sperimentazione Italia* aims to increase by 30% the AI products and services tested via authorised controlled experimentations. Another argument to set up a regulatory sandbox for AI testbeds in their national AI strategies is that this is a tool to potentially attract international investors, as Estonia does with its Digital Testbed Framework. This topic on regulatory sandboxes is of interest as the implementation of regulatory sandboxes remains a competence of Member States.

[21] These are Cyprus, Czech Republic, Estonia, France, Germany, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Norway, Portugal, Spain, plus the Flanders region. For further information, see Table 7.

On the other hand, there are other policy initiatives which are particularly developed in some countries. This is the case of the commitment to create **cross-border facilities and similar testbeds for autonomous vehicles** across France, Germany and Luxembourg. Portugal already put in place an initiative to recognise "**Free Zones for Technology**" (FZT), which are physical environments, geographically located in a real or quasi-real environment, to support testing with adapted regulatory regimes, with the support and monitoring of the respective competent authorities, to promote a culture of experimentation in Portugal. Portugal is also cofounding the AI TEF through the recently deployed initiative to create a network of testbeds. The "National Network of Test Beds", funded by RRP, aims to create the conditions for the companies to develop and test new products and services and accelerate the digital transition process, via a physical equipment with a strong digital component or a virtual/digital simulator.

Additionally, there is an **innovative "cross-technology" TEF** in Poland addressing cyber threats to AI systems.

b) National AI marketplaces

Eight countries explicitly bring a commitment to local, regional and/or national AI marketplaces: Austria, Belgium (specifically the Wallonia-Brussels Federation in Belgium, whose TRAIL Factory marketplace is under development), Finland, France, Germany (the market of ideas by the Civic Innovation Platform), Hungary (which aims to develop a national AI marketplace with specific timeframes), Ireland (decentralised AI-powered electric vehicles (EV) marketplaces), and Latvia.

EU initiatives

a) European Digital Innovation Hubs (EDIHs)

All Member States fully support[22] the importance and need to establish a network of **European Digital Innovation Hubs** (EDIHs), previous Digital Innovation Hubs (DIHs) were initiatives at the national level. Member States have pre-selected, at the national level, the entities that will be able to participate in the EDIH call which is to be implemented throughout the year 2022. The first restricted call for EDIHs opened on 17 November 2021, to enable selected EDHIs to start their operations towards September 2022. For the pre-selection of these entities, Member States defined their national policy and priorities in terms of digital transformation. For example, Croatia commits to at least three EDIHs. Cyprus allocates a specific investment package for EDIHs to help SMEs. Italy defines how to foster awareness-raising and communication to SMEs on the importance of EDIHs. Finland's publication of its list of seven national candidates to become EDIHs by 2022 shows a diversity of topics ranging from services founded on AI basic research to mobility and transport, geolocation, manufacturing, healthcare, or robotics. The Czech Republic nominated six candidates from the field of digitalisation of industry, research and implementation of AI technologies, cybersecurity and other areas.

17 countries include the need to create these mechanisms in their RRPs, mainly EDIHs and to a lesser extent testing facilities and similar testbeds, although most of them are not specific in their RRPs. There are few exceptions which, in line with the Coordinated Plan's objective, specify details. For example, Cyprus sets out specific investment packages for these mechanisms. Czech Republic makes reference to the timeline to set up these EDIHs and testbeds. Portugal has proposed a network of 30 testbeds and 17 DIHs, out of which 16 of them assume in their strategy the ambition to join the European Network (EDIH). Spain plans to allocate EUR 37.6 million to support the development of 25 DIHs. Croatia commits to itemised budgets for at least three EDIHs, one DIH, and testbed resources through the European Centre for Innovation, Advanced Technologies and Skills Development (ECINTV)).

b) Testing and Experimentation Facilities (TEFs)

The European Commission introduced AI Testing and Experimentation Facilities (TEFs) in the Digital Europe programme. Through this programme, the Commission seeks to co-fund with Member States a limited number of specialised large-scale reference sites which will offer a combination of physical and virtual facilities to support technology providers testing their latest AI-based soft-/hardware technologies in real-world environments.

[22] Alongside national AI strategies, see: Miörner, J., Rissola, G., Sörvik, J. and Wernberg, J., Putting Digital Innovation Hubs into Regional Context. A European survey, Rissola, G and Kalpaka, A. (Eds.), EUR 29845 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-10951-8, doi:10.2760/339108, JRC117910.

Table 7 analyses how each country has set out nationally-led facilities or similar testbeds for AI experimentation. Table 8 and Table 9 provide more information about Member States' initial expression of interest in sectorial AI Testing and Experimentation co-funding across the EU.

Box 5. Priority sectors in Testing and Experimentation Facilities

The cluster that has received greater attention at the national level for AI facilities and similar testbeds is "mobility and transport". This is important to point out as this cluster is not highlighted as a high-priority sector by the 2021 Review of the Coordinated Plan. Concretely, 10 countries have it or have included this commitment in their national AI strategy.

Other clusters that receive attention at the national level for AI testbeds and facilities and do align with the "prioritised sectors" of the 2021 Review of the Coordinated Plan are: health (by eight countries); manufacturing (8); agri-food (7); and smart communities (7). The use of AI TEFs for the energy sector at the national level is also highlighted by seven countries.

Additionally, 20 countries joined an initial expression of interest in November 2021 to co-fund EU-wide Testing and Experimentation Facilities in some of the aforementioned high-impact sectors (see Notes 3 and 4 in Tables 8 and 9 for further detail), and this list has had recent additions by some Member States (see notes in Tables 8 and 9). Some countries support both the creation of nationally led AI testbeds and the co-funding of EU-wide TEFs for the same clusters. Manufacturing is the cluster that has received the greatest interest by Member States (16) to develop co-funded AI TEF across the EU. The cluster of Smart City and Smart Communities has also been the subject of significant interest (15). Other areas with solid interest by roughly half of the total of countries for co-funded AI TEFs across the EU are health (14); and agriculture and farming (11). Additionally, countries have also participated in workshops[23] led by the European Commission on sectorial testing and experimentation facilities for high-impact sectors.

Other clusters which are labelled as "high-impact sectors" by the Coordinated Plan but receive less attention in terms of national AI testbeds and facilities are climate and energy and the public sector. An example of a country doing so is Denmark's investment fund for testing, scaling and encouraging the uptake of AI in three areas within the public sector: healthcare, public administration and the green transition.

For the remaining topics countries tend to differ in their preferred additional sectors for their national facilities and similar testbeds. This adds up value to the 2021 Coordinated Plan, one of whose goals is to encourage Member States to "define relevant new priorities for additional TEFs beyond the current sectors" defined by the European Commission. Main "additional sectors" tend to be TEFs for foreign language translation, tourism and culture, justice, education, early detection of cyberattacks, and the financial sector (alongside climate and energy and the public sector). For example, France included a new TEF for energy and green solutions for the housing sector in its reviewed national AI strategy. Germany also has a testing environment at the Reality Lab for Artificial Intelligence in Civil Protection.

[23] For further information, see:
- Online info-day for Digital Europe Programme calls on sectorial Testing and Experimentation Facilities (December 2021): https://digital-strategy.ec.europa.eu/en/library/online-info-day-digital-europe-programme-calls-sectorial-tefs
- Workshops on Sectorial Testing and Experimentation Facilities for Artificial Intelligence under the Digital Europe Programme (July 2021): https://digital-strategy.ec.europa.eu/en/library/2021-workshops-sectorial-testing-and-experimentation-facilities-artificial-intelligence-under
- Workshops on reference testing and experimentation facilities for Artificial Intelligence in the Digital Europe Programme (February 2020): https://digital-strategy.ec.europa.eu/en/library/workshops-reference-testing-and-experimentation-facilities-artificial-intelligence-digital-europe

Table 7. Countries' contributions to the Coordinated Plan's goals on establishing tools and environments to test and experiment AI technologies

Source: Own elaboration based on national AI strategies, 2nd edition of the AI Watch report (2021), countries' National Recovery and Resilience Plans, and direct feedback from Member States in the last stage of revision of the present report.

Note 1: In the RRFs column on Recovery and Resilience Plans, NA means Not Applicable, as Norway and Switzerland are not EU Member States.

Note 2: Please note that this analysis only refers to RRPs adopted. Hungary, the Netherlands and Poland are not analysed as they do not have RRPs adopted. Additionally, this information is based and aligned with the information as published in national RPP and Council Implementing Decisions.

Box 6. Notes to Table 7. Countries' contributions to Coordinated Plan's goals on establishing tools and environments to test and experiment AI technologies

Structure of the table

The first column refers to the existence, or at least the commitment in their national AI strategies to create, facilities and testbeds on AI at the national level. The second column identifies which countries have created AI marketplaces in their national AI strategies, or have at least committed to or acknowledged the importance of doing so. The third column includes information on which countries have planned or launched a European Digital Innovation Hub (EDIH).

Footnotes to the table

(1) Austria: Commitment to create testbeds, pilot factories and Smart Factory Labs for SMEs in the national AI strategy. As for AI marketplaces, Austria's national AI strategy acknowledges the existence of Data Market Austria for specific data ecosystems (which is not an AI marketplace as such), but shows a special interest in marketplaces for on-demand solutions in mobility and AI. No territory level is defined.

(2) Belgium: As for testbeds, Belgium has a Royal decree on tests with automated vehicles (2018), although it is important to remark that it does not set out a TEF on this topic. The AI4Belgium report demands the creation of one. Additionally, Flanders has a Sandbox Vlaanderen, and in its Action Plan has committed to strengthen digital experimentation labs (no TEFs). Both the WalloniaDigital4.ai project and the Brussels Federation make no reference to testbeds. As for AI marketplaces, the Wallonia-Brussels Federation is setting out the TRAIL Factory marketplace (under development). In the Recovery and Resilience Plan, Belgium foresees testing and experimentation facilities in: AI applications in the energy cluster; AI technologies to optimise production chain; and industrial AI research.

(3) Bulgaria commits to create a TEF specifically on AI, as well as to finance innovation laboratories to test AI applications at the company level. Currently, the Sofia Tech Park is a testbed for innovation systems, but not on AI. As for AI marketplaces, Bulgaria's national AI strategy acknowledges the existence of Centres of Competence, funded by OP SESG, which also aim to support applied research and the integration of science with business. The national AI strategy also aims to create Virtual Labs and expand financial mechanisms (no concrete reference to AI marketplaces is made). In the Recovery and Resilience Plan, Bulgaria's Pillar 3 of economic recovery will be devoted to support the development of two to three DIHs on a regional basis.

(4) Cyprus: Reference to the creation of regulatory sandboxes on AI in the national AI strategy.

(5) Czech Republic: Reference to the creation of regulatory sandboxes on AI in the national AI strategy. In 2021, Czech sectorial priorities on the national level changed. The main AI Testing and Experimentation sectorial priority is "manufacturing" now.

(6) Denmark sets out various TEFs mechanisms: an investment fund for testing, scaling and encouraging the uptake of AI in the public sector, with a particular focus on healthcare, public administration and the green transition; and performance contracts with seven Danish GTS institutes that provide expertise to promote businesses uptake of new technologies. In March 2022, an interactive guide for Danish TEFs was launched on the public business guide website "virksomhedsguiden.dk" following a mapping on most Danish TEFs. This mapping was made by industry and academia. This interactive guide shows examples of testing and demonstrations facilities in which many of them provide technical and digital support including AI. A previous mechanism (which no longer exists) was Sprint:Digital, which included a testbed focused on SMEs. Sprint:Digital was an initiative that is no longer active, and which was launched under the (still existing) programme SMV:Digital. SMV:digital is a national programme supporting the digital transformation, automation and e-commerce in Danish enterprises, and developed by Danish Business Authorities in 2018.

(7) Estonia: Regulatory sandboxes for testing. There is an existing Digital Testbed Framework to attract international investors.

(8) Finland: While it is not exactly an AI Marketplace, Finland counts on an AI maturity tool, which has been in use since 2019 to help organisations increase their business opportunities by identifying their most important areas for improvement in AI.

(9) France's testbeds: TEF for energy and green solutions for housing and innovation sandboxes (acknowledged by the 2nd phase of the national AI strategy). The Recovery and Resilience Plan makes reference to TEFs on AI to optimise energy and green solutions.

(10) France's AI marketplaces: The Teralab Institute provides technological resources and a whole ecosystem of expert companies to remove scientific and technological obstacles faced by organisations wishing to exploit their data and accelerate experimentation and technology transfer.

(11) Germany: The updated national AI strategy acknowledges the existence of digital testbeds, regulatory sandboxes, pilot and flagship AI projects, as well as the existence of the testing environment at the Reality Lab for Artificial Intelligence in Civil Protection. Additionally, the Civic Innovation Platform serves as a market for ideas. It connects stakeholders which publish their ideas to find partners for AI related projects from civil society, the public, academic and private sectors.

(12) Hungary: The national AI strategy commits to the accreditation of ZalaZone as a European testing environment, as well as the accreditation of the agrarian model farms as a European testing environment. As for marketplaces, the national AI strategy commits to the development of a national AI marketplace by following a first step of creating an inventory of infrastructure.

(13) Italy's national AI strategy refers to the regulatory sandbox called "Sperimentazione Italia" to test AI applications. Italy also plans to create testbeds to test AI methodologies, and to increase by 30% the AI products and services tested via authorised controlled experimentations. Additionally, the national AI strategy foresees the promotion of communication and awareness-raising campaigns on the benefits of AI products and services by reaching at least 80% of Competence Centres and Digital Innovation Hubs.

(14) Latvia: Several value chain ecosystems are currently developed by the Ministry of Economics. Three strategic value chain ecosystem pilots are being implemented – on Smart materials, Biomedicine and Smart city – to enhance state-of-the-art research and innovation in these fields. These priority areas are based on Latvia's Smart specialisation strategy. The ecosystems bring together innovation actors from private, public and academic sectors. AI is a key enabling technology to facilitate the implementation of above-mentioned ecosystems.

(15) Luxembourg: The national AI strategy commits to creating TEFs and regulatory sandboxes. It also acknowledges the existence of a project on cross-border testbeds across France, Germany and Luxembourg for autonomous vehicles, and the creation of cross-border datasets. As for DIHs, these are mainly managed through Luxinnovation, which in turn supports the creation of start-ups. Also, the Recovery and Resilience Plan foresees to develop a national testbed to be integrated into the EuroHPC Joint Undertaking.

(16) Malta: On the one hand, the Technology Assurance Sandbox was launched in May 2021, including AI and other digital technologies. It is aimed at providing a safe environment for individuals or companies developing solutions based on Innovative Technologies such as Blockchain and Artificial Intelligence or solutions deployed in critical environments, to enable the correct nurturing of such solutions in line with recognised standards. On the other hand, following the launch of the National AI Strategy, six public sector pilot projects targeting traffic management, healthcare, education, customer service, tourism and utilities have been initiated. Of these, the pilot projects initiated by the Ministry for Education and Employment (MEDE) and the servizz.gov Agency are at an advanced stage, and it is envisaged that they are finalised by the end of 2023. The pilot projects initiated with the Malta Tourism Authority (MTA) and the Ministry for Energy, Enterprise and Sustainable Development (MESD) are at tendering stage, while the pilot project initiated with the Central Procurement & Supplies Unit Malta (CPSU) within the Ministry for Health (MFH) is still to start. Through Artificial Intelligence, these pilot projects aim to enhance the digitalisation of various sections within the public sector in Malta.

(17) The Netherlands: No committed TEFs in the national AI strategy. However, there is an Experimental Law on self-driving vehicles since July 2019. The Netherlands Organisation for Applied Scientific Research (TNO) connects the Dutch field labs and hubs with the European AI Digital Innovation Network.

(18) Norway: First, Norway's national AI strategy acknowledges the existence of the Norwegian Catapult Scheme for testing control. Second, Norway has also committed to the creation of a regulatory sandbox for specific legislation for data protection in the AI testing in controlled environments. Third, the country participates in the TEF scheme and, fourth, is part of the EDIH scheme. Two Norwegian consortia have applied to become EDIHs.

(19) Poland: NASK Public Research Institute has testbeds for testing and experimenting cyber threats to AI systems, and on standardising and certifying cyber security procedures for AI systems. On the other hand, as for DIHs, the Future Industry Platform coordinates these DIHs. Additionally, the Recovery and Resilience Plan makes reference to regulatory sandboxes for TEFs.

(20) Portugal: The national AI strategy highlights the importance of Portugal-created Free Zones for Technology (FZT), which are physical environments, geographically located in a real or quasi-real environment, spaces to support testing with adapted regulatory regimes with the support and monitoring of the respective competent authorities in order to promote a culture of experimentation in Portugal. The goal is to promote a culture of experimentation in the country. As for DIHs, Portugal acknowledges the need to extend collaborative laboratories (CoLabs) and Digital Innovation Hubs (DIHs). As for EDIHs, out of 17 DIHs selected, Portugal pre-selected 16 EDIHs that will have access to the restricted EDIH call. Additionally, regarding testbeds, the tender for the submission of applications for the National Testbeds Network under the national RRP was published in April 2022 and provides for national co-financing within the scope of the European Test and Experimentation Facilities (TEF) network, co-financed under DEP.

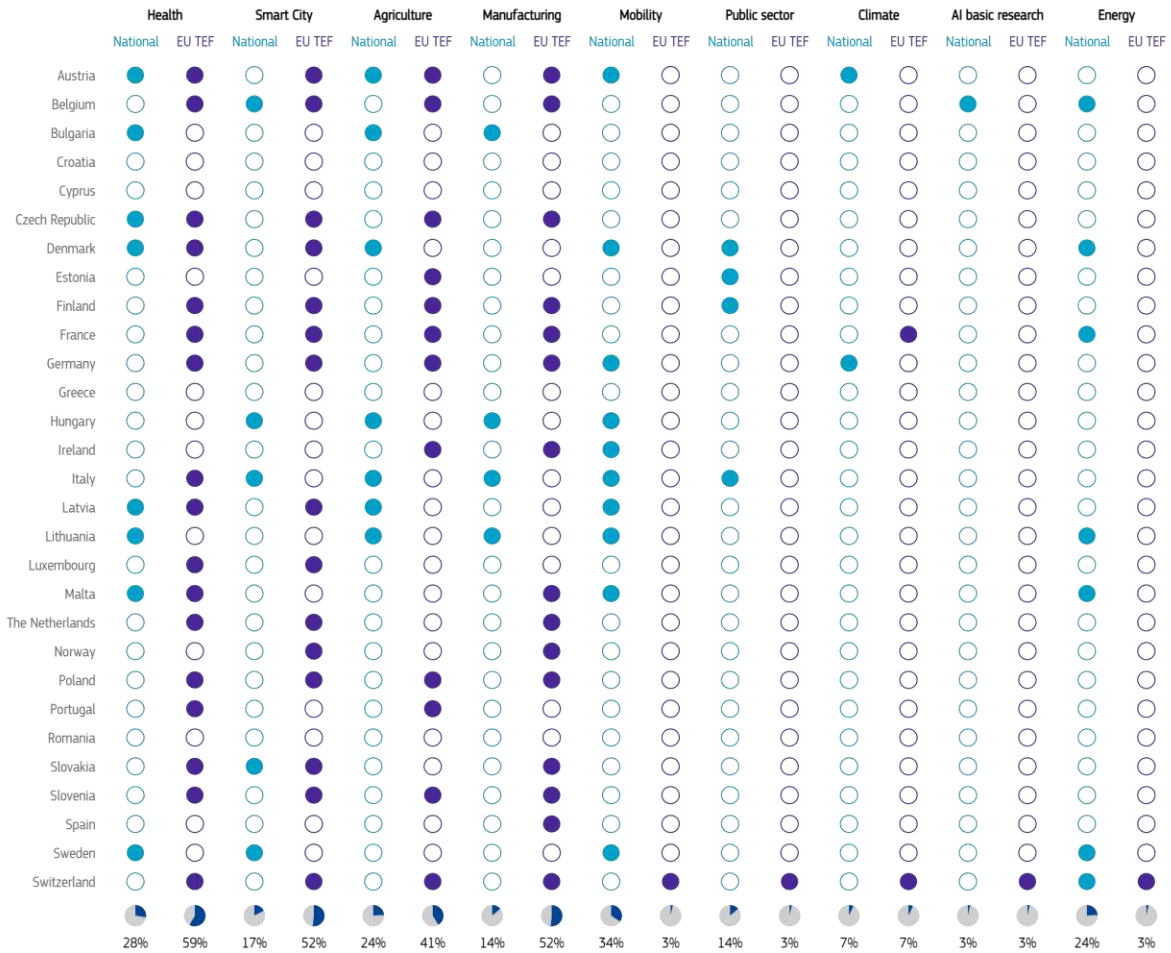
(21) Slovenia: The Slovenian NpUI highlights the importance of testing and experimental facilities to aid the development of AI tools and algorithms. The Edge-AI infrastructure has been developed for the Factory of the Future (FoF) digital twin demonstration centre at the Faculty of Mechanical Engineering (University of Ljubljana) within the FoF Strategic Research and Innovation Partnership.

(22) Spain: The national AI strategy commits to increasing testbed areas and regulatory sandboxes, such as the Sandbox Financial Act or the Sandbox foreseen in the Sustainable Mobility Act.

(23) Sweden: The national AI strategy acknowledges that Vinnova is the national coordinator for testbeds and demonstration activities. The Recovery and Resilience Plan commits to increase the number of testbeds.

(24) Switzerland: The country recommends the creation of testbeds for cybersecurity and the energy sector. To increase the use of AI in cybersecurity, The National Cybersecurity Centre (NCSC), and the Federal Department of Defence, Civil Protection and Sport (DDPS), in cooperation with the Federal Department of Foreign Affairs (FDFA) and the EAER, are launching a study to evaluate the potential of a Swiss AI test centre in this field. In the energy sector, the Federal Office for Energy offers a Pilot and Demonstration Programme to promote the development and testing of new technologies, including AI-related projects.

Table 8 Comparison between preferred clusters to be sectorial AI Testing and Experimentation at both the national level and as co-funded EU TEFs



Source: National AI strategies (see references), the document "Member States' initial expression of interest in sectorial AI Testing and Experimentation Co-funding" (link), and direct feedback from Member States in the last stage of revision of the present report.

Note 1: This table analyses which sectors are identified as of high priority in the case of the development of testing and experimentation facilities on AI at the national level. The analysis on which sectors are of high impact for the whole ecosystem of public policies on AI (not only testbeds) is analysed in Table 14.

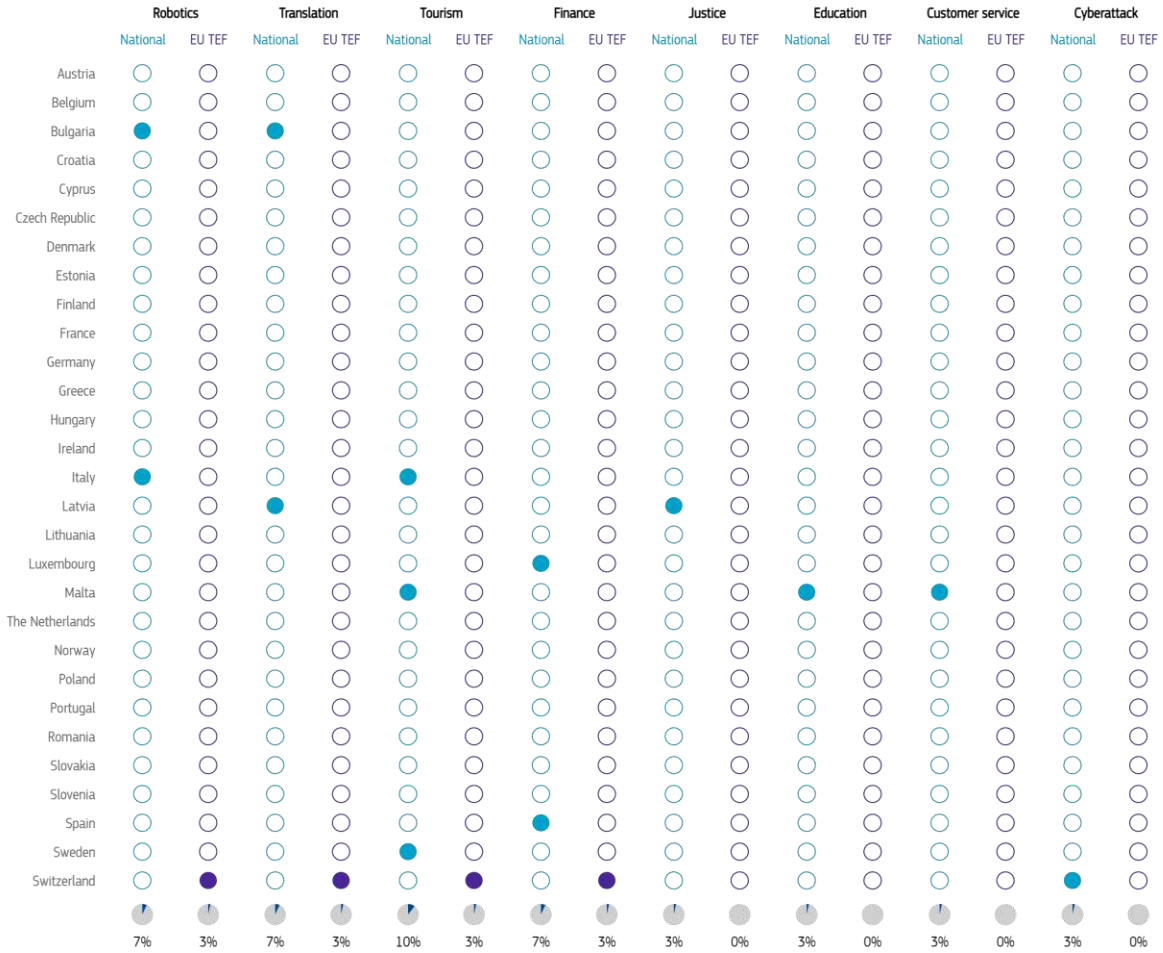
Note 2: The columns labelled as "National" highlights countries' actions to set up sectoral Testing and experimentation facilities at the national level based on information from national AI strategies. The column indicated as "EU TEFs" refers to Member States' initial expression of (potential) interest to participate in sectorial AI Testing and Experimentation *co-funding* between countries and the European Commission. This information is based on the initial expression of interest expressed in November 2021, plus additional direct feedback from several Member States during the last stage of the final revision of the present report. These new additions to the original table referred in the source are from Denmark, Norway and Portugal. Please note that Member States are not bound by this list in co-funding the sectorial AI TEFs mentioned. For a binding commitment, applicants need to contact the respective national contact points. Source: see link.

Note 3: As for Member States' initial expression of interest in sectorial AI TEFs between countries and the European Commission, the official publicly available expression of interest shows that Czech Republic, Finland, Latvia, Luxembourg, the Netherlands, Norway, Poland, Slovenia, Spain and Sweden have explicitly acknowledged that they have "interest in all sectors". Portugal also confirms its interest in all sectors, according to direct feedback provided by Portugal's officers in the latest stage of revision of the present report. The columns show information only about sectors which have been explicitly marked as being of "special interest", if any (the typical nomenclature is as follows: "interested in all sectors, but especially"). Also, based on this initial expression of interest from November 2021, several countries have explicitly argued that they are interested in certain sectors, but there is no political commitment yet. These countries are Finland, Slovakia and Slovenia. Building upon the content of the document, there is no data on the table from Bulgaria, Croatia, Cyprus, Estonia, Greece, Hungary, Lithuania and Romania because they did not publish an initial expression of interest in the document by November 2021. Switzerland is not included in the document on countries' initial expression of interest in sectorial AI Testing and Experimentation Co-funding.

Note 4: The analysis only refers to RRPs adopted. Hungary, the Netherlands and Poland are not analysed as they have not adopted RRPs. Additionally, this information is based and aligned with the information as published in national RPP and Council Implementing Decisions.

Note 5: "Smart City and Smart Communities" and "Mobility and Transport" are differentiated labels because there are variations in the nomenclature provided by each country. The cluster of "Smart city and smart communities" is tagged when a country explicitly states it. The cluster of "Mobility and Transport" is tagged when a country explicitly states it, or when a country refers to mobility generally speaking, without concretely referring to smart cities and smart communities.

Table 9 Comparison between preferred clusters to be sectorial AI Testing and Experimentation at both the national level and as co-funded EU TEFs (continued table)



Source: National AI strategies (see references), the document "Member States' initial expression of interest in sectorial AI Testing and Experimentation Co-funding" (link), and direct feedback from Member States in the last stage of revision of the present report.

Note 1: This table analyses which sectors are identified as of high priority in the case of the development of testing and experimentation facilities on AI at the national level. The analysis on which sectors are of high impact for the whole ecosystem of public policies on AI (not only testbeds) is analysed in Table 14.

Note 2: The column labelled as "National" highlights countries' actions to set up sectoral Testing and experimentation facilities at the national level based on information from national AI strategies. The column indicated as "EU TEFs" refers to Member States' initial expression of (potential) interest to participate in sectorial AI Testing and Experimentation *co-funding* between countries and the European Commission. This information is based on the initial expression of interest expressed in November 2021, plus additional direct feedback from several Member States during the last stage of the final revision of the present report. These new additions to the original table referred in the source are from Denmark, Norway and Portugal. Please note that Member States are not bound by this list in co-funding the sectorial AI TEFs mentioned. For a binding commitment, applicants need to contact the respective national contact points. Source: see link.

Note 3: As for Member States' initial expression of interest in sectorial AI TEFs between countries and the European Commission, the official publicly available expression of interest shows that Czech Republic, Finland, Latvia, Luxembourg, the Netherlands, Norway, Poland, Slovenia, Spain and Sweden have explicitly acknowledged that they have "interest in all sectors". Portugal also confirms its interest in all sectors, according to direct feedback provided by Portugal's officers in the latest stage of revision of the present report. The column shows information only about sectors which have been explicitly remarked as of "special interest", if any (the typical nomenclature is as follows: "interested in all sectors, but especially"). Also, based on this initial expression of interest from November 2021, several principles have explicitly argued that they are interested in certain sectors, but there is no political commitment yet: these countries are Finland, Slovakia and Slovenia. Building upon the content of the document, there is no data on the table from Bulgaria, Croatia, Cyprus, Estonia, Greece, Hungary, Lithuania and Romania because they did not publish an initial expression of interest in the document by November 2021. Switzerland is not included in the document on countries' initial expression of interest in sectorial AI Testing and Experimentation Co-funding.

Note 4: Please note that this analysis only refers to RRPs adopted. Hungary, the Netherlands and Poland are not analysed as they have not adopted RRPs. Additionally, this information is based and aligned with the information as published in national RPP and Council Implementing Decisions.

Note 5: "Smart City and Smart Communities" and "Mobility and Transport" are differentiated labels because there are variations in the nomenclature provided by each country. The cluster of "Smart city and smart communities" is tagged when a country explicitly states

it. The cluster of "Mobility and Transport" is tagged when a country explicitly states it, or when a country refers to mobility generally speaking, without concretely referring to smart cities and smart communities.

3.2.4 Fund and scale innovative ideas and solutions for AI

Start-ups and scale-up hubs contribute to AI excellence and innovation.[24] That is why Member States are intensifying their national actions to support these innovation ecosystems, either by creating national hubs, facilitating information exchange, or supporting them through their Recovery and Resilience Plans.

25 countries have already committed to, or intend to set out, plans to create policies on start-ups and SMEs growth in their national AI strategies. Evidence shows that there are no common policy trends across countries on how to foster start-ups and scale-ups. The main funding mechanism is direct funding to support a concrete number of start-ups through the whole business cycle. The second most typical action is to support the transition from academic research into start-ups or accelerators. Other innovative funding mechanisms are growing in some countries as it is the case of *ad hoc* seed investment schemes and venture capital mechanisms. With regards to how the Recovery and Resilience Facility may be harnessed to support start-ups and scale-ups, nine countries refer to "AI start-ups" in their RRPs.

Table 10 provides an overview of countries' contributions to the Coordinated Plan's goals on funding and scaling innovative ideas and solutions for AI.

Main funding mechanisms and particularities

The main funding mechanism is direct funding to support a concrete number of start-ups through the whole business cycle (from early stage to AI deployment and implementation). This happens for instance in Lithuania, whose AI Boost Initiative aims to help 50 start-ups to develop at least 20 types of AI solutions prototypes. This is also the case with StartIA project at DigitalWallonia4.ai in Belgium, or with Germany's Gruender Platform and its targeted funding mechanism called "German Accelerator Programme".

The second most prominent policy action is the **support to transition from academic research into start-ups or accelerators**. France leads this trend with Inria's goal to multiply by ten the number of *deeptech* start-ups by 2026, as set out in the second review of the national AI strategy. It devotes a specific allocated budget of EUR 40 million to this effect. Italy's national AI strategy has set up a model of "AI 60-40 calls", aiming to transfer research knowledge into business models as start-ups and accelerators. At least 10% of these calls should create new AI start-ups.

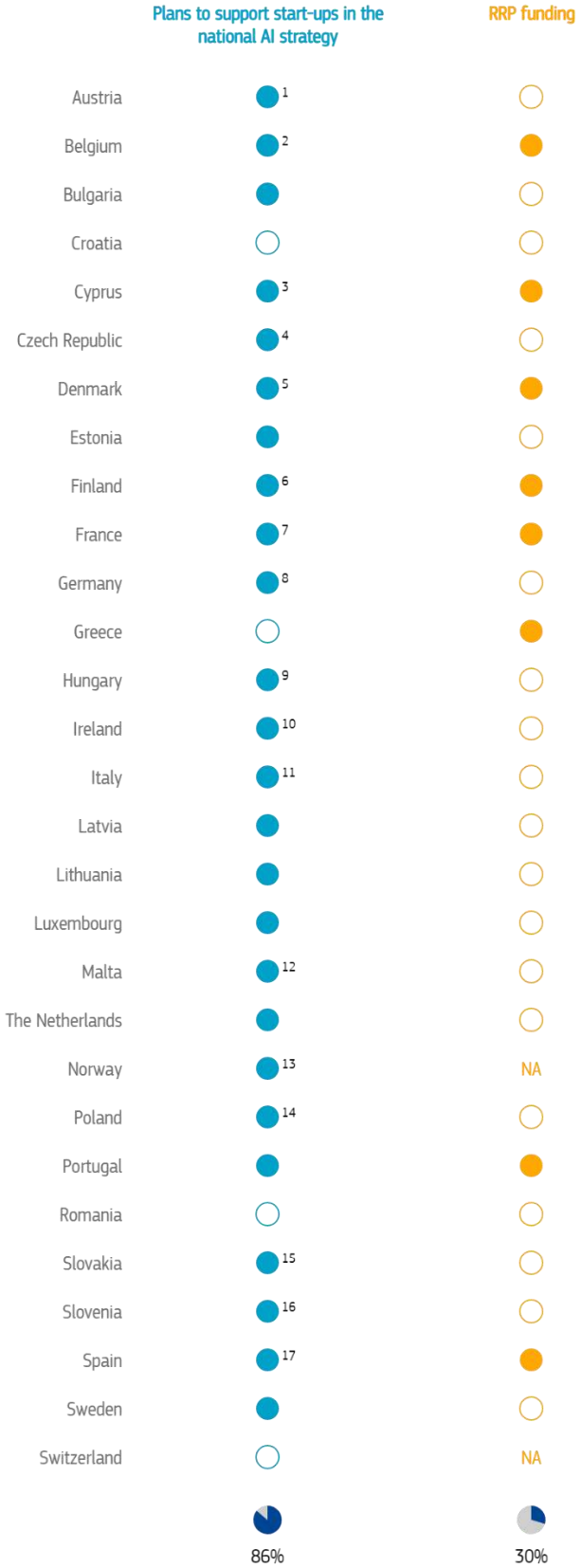
There are other innovative funding mechanisms which are not typical across countries including ***ad hoc* seed investment schemes, and venture capital mechanisms often addressed to scaling start-ups.** Five countries have created *ad hoc* seed investment schemes (France's *Tech Seed*, Malta's TAKEOFF Seed Fund Award, Poland's investment *crowdfunding*, Spain's Seed Capital Schemes, and the Netherlands's Innovation Credit and Seed Capital Scheme), and Portugal has committed in its Recovery and Resilience Plan to create Seed Investment Funds for technology-related start-ups (not explicitly mentioning AI technologies). As for public-private venture capital which supports the scaling-up of companies, some examples are Germany's Tech Growth Fund, the Netherland's Dutch Venture Initiative, Poland's National Venture Capital Fund, Spain's Next Tech Fund, and France's Tech Seed.

Recovery and Resilience Plans as a driver to foster start-ups and scaling-up

8 countries refer concretely to "AI start-ups" in their RRPs. Overall, countries which include it do so by specifically allocating a concrete investment package to the issue – see, for example, Belgium, Cyprus, Denmark, Finland, France, Greece, Hungary, Portugal and Spain. Portugal also refers to start-ups, but does not explicitly refer to AI or *deeptech*. The latter is included in the StartUp Portugal programme.

Table 10. Countries' contributions to the Coordinated Plan's goals on funding and scaling innovative ideas and solutions for AI

[24] For more information about the strengths and weaknesses of the Artificial Intelligence and Blockchain ecosystems in Member States, we refer to a recent report of DT2 Invest. The report provides a SWOT analysis of support measures taken in 10 Member States and highlights funds raised by AI and Blockchain scale-ups.



Source: Own elaboration based on the 2nd edition of the AI Watch report (Van Roy et al., 2021), national AI strategies, and direct feedback from Member States in the last stage of revision of the present report.

Note 1: NA means Not Applicable, as Norway and Switzerland are not EU Member States. They are Associated Countries.

Note 2: Please note that this analysis only refers to RRPs adopted. Hungary, the Netherlands and Poland are not analysed as they do not have RRPs adopted. Additionally, this information is based on and aligned with the information as published in national RPP and Council Implementing Decisions.

Box 7. Notes to Table 10. Countries' contributions to the Coordinated Plan's goals on funding and scaling innovative ideas and solutions for AI

Structure of the table

The first column refers to the existence of plans to support start-ups in each country's national AI strategy. The second column identifies which countries include financial mechanisms to support start-ups in their respective Recovery and Resilience Plans (RRP).

Footnotes to the table

(1) Austria: DIH-AI4P (AI for Production) supports SMEs and start-ups in developing, implementing and anchoring their specific digitisation projects, particularly in the field of Artificial Intelligence. It also gives easy access to the AI know-how, technology and infrastructure. The RRP includes investment packages for the digitalisation of more than 15,000 SMEs and 7,000 larger companies (EUR 101 million), but not specifically on AI.

(2) Belgium has several existing projects. A6KE6K – Hub d'innovation et de formation numérique et technologique (created under the RRP); DigitalWallonia4.ai, whose Wallonia Innovation and Growth (W.I.N.G) fund supports start-ups. The last was launched in 2016 and, since then, more than 60 start-ups have already been eligible for funding totalling around EUR 7 million of financial support. In Wallonia, StartIA also supports early-stage start-ups launch. In Flanders, the Imec.start programme provides financial support and facilities for start-ups.

(3) Cyprus: The national AI strategy plans the establishment of a national AI accelerator programme. The RRP sets out two main lines of investment, one for funds, and one for talent attraction through the Start-up VISA Scheme to attract international innovators.

(4) Czech Republic: It aims to support start-ups through three DIHs (IHAI, mobility, ESA). Also, the national AI strategy highlights prg.ai, which is an AI ecosystem of start-ups and accelerators. Additionally, the country plans to develop ups through bilateral partnerships (Czech-French Strategic Partnership).

(5) Denmark has two measures on start-ups and SMEs growth. First, investment for AI businesses: The Danish Growth Fund will launch a pilot project in the form of an investment pool of EUR 3.1 million over four years targeting companies with a business model based on AI. It will take the form of co-investments with private investors; second, SMV:Digital: has been put in place to advance the digital transition and e-commerce capabilities of Danish SMEs. In 2021, the grant scheme was extended to include subsidies for SMEs to invest in new hardware and software. More than 1200 enterprises benefitted from the programme during 2021.

(6) Finland's Startup Permit aims to attract international start-ups outside from the EU. The RRP seeks to foster AI start-ups in the Investment P2C2I5.

(7) France: The 2nd phase of the national AI strategy aims to multiply by 10 the number of *deeptech* start-ups until 2026; and support the transition from academic research into start-ups or accelerators (EUR 40 million, out of which EUR 25 million will be publicly funded). France's Tech Seed is also seen as a driver towards this goal. The RRP includes both subsidies and grants through Bpifrance for *deeptech* start-ups.

(8) Germany has various mechanisms to foster AI start-ups. These are: whole-of-business cycle support from initial stage to final application in start-ups (Gruender Platform); advisory and funding services for AI start-ups growth (EXIST programme focusing on university spinoffs); funding initiative to secure market entry: StartUpSecure; targeted funding programme: within the international German Accelerator Programme; and venture debt through the Tech Growth Fund.

(9) Hungary aims to create an AI Accelerator Centre with funds and tenders. The RRP has five plans related to AI start-ups: creation of a network of "Early adopter" partners; development of AI-specific accelerators; development of AI-specific investment funds; sector-specific start-ups grants; and a new Digital Agricultural Innovation Centre to incubate start-ups.

(10) Ireland: The Government agencies Enterprise Ireland and IDA Ireland will continue supporting enterprises in working with AI, through R&I funding and assistance. The RRP acknowledges that digital challenges for Ireland include digital technologies in businesses, in particular for Irish SMEs that should adopt other e-business technologies. The plan supports the digitalisation of businesses, mainly of SMEs in Ireland (EUR 85 million). There is no specific reference to AI for start-ups and SMEs.

(11) Italy places a strong focus on public procurement to start-ups for AI-based GovTech solutions. Also, the national AI strategy plans to create "AI 60-40 calls": large projects on priority sectors with 60% of academia and 40% of companies aiming to transfer research knowledge to business models as start-ups and accelerators. At least 10% should be devoted to creating new AI start-ups. Additionally, the national AI strategy also plans to increase the number of AI start-ups by 30% with respect to 2021; to improve the average revenues of AI start-ups by 50% in the domestic market and 30% in export; to improve the number of scale-ups; to detect and support scale-ups and unicorns.

(12) Malta: The national AI strategy sets out several mechanisms to foster AI start-ups. These are: regular funding to help the early start-up of AI businesses (accelerator YouStartIT); seed funding/First official equity funding stage through the TAKEOFF Seed Fund Award; favourable tax conditions through the reform of the Seeds Investment Scheme; and talent attraction with the launch of a Start-up visa for people outside from the EU.

(13) Norway: Innovation Norway supports companies in developing their competitive advantage and enhancing innovation. In recent years, Innovation Norway's portfolio has seen a growth in the number of digital projects. In 2020 the number of ICT projects tripled compared to 2019. In terms of AI, it has established the Tech City Executive Accelerator (TEA) initiative providing international scaling and support for companies oriented towards AI and IoT. Also, the Industrial Development Corporation of Norway (Siva) is a governmental corporation that aims to unleash the national innovation capability through support from incubators, business gardens and accelerator schemes (e.g., Norwegian Catapult scheme). Additionally, the StartOff programme supports start-ups in getting projects for public sector agencies.

(14) Poland plans investment crowdfunding, a National Venture Capital Fund whose first target audience are start-ups, the creation of an accelerator for start-ups entry market, and training activities for start-ups and scaling-up.

(15) Slovakia: The national AI strategy commits to creating investment opportunities for start-ups, funded by the MIRRI (Ministry of Investments, Regional Development, and Informatisation of the Slovak Republic). It also aims to create a manual to deploy AI and hands-on support to start-ups using AI.

(16) Slovenia: Support mechanisms across all Technology-readiness levels are in place.

(17) Spain: The national AI strategy foresees the creation of several mechanisms. These are: the creation of Seed Capital Schemes for AI start-ups; Joint Venture Capital Next Tech for high-growth AI start-ups; and the creation of a new Start-Up Act with favourable tax conditions, also for AI start-ups, which has already been launched. The RRP includes EUR 4.6 billion investments to promote the digitalisation of industry and SMEs, investments in artificial intelligence, digitalisation of tourism and culture systems.

3.3 Ensure that AI works for people and is a force for good in society

3.3.1 Nurture talent and improve the supply of skills necessary to enable a thriving AI ecosystem

The ICT skills gap is a key challenge to the development of AI in Europe. It is necessary to facilitate the acquisition of broad computing skills and further the understanding of AI for all citizens. There is a need for professionals with specialised AI skills, and also a working age population which does not work on AI and technical aspects but needs to have a deeper understanding of AI basics or the social and economic impacts of AI in the workplace.

All Member States with a national AI strategy dedicate a section to the AI skills dimension. While all countries include measures for higher education institutions, most (but not all) also address both primary and secondary levels. The pre-school level is included by a few countries, too.

Most countries making policy changes in primary and secondary schools do so through targeted, mandatory measures. Meanwhile, higher education institutions experience either incentive mechanisms to increase its AI skilling, or – to a lesser extent – some mandatory measures.

With regards to upskilling, the three areas which have received most attention are retraining courses for workers whose job is at risk of automation, teachers' training, and public servants. The first group of people is the one receiving the most targeted, tailored measures. As for the two other groups – teachers' training and public servants – national initiatives are not often targeted.

Regarding gender equality, which is set as a goal in the Coordinated Plan, policies are mainly carried out by northern, western and some central European countries.

Finally, the impact assessment of overall skill policies is shaped by a few countries, mainly in the form of public laboratories or specific plans.

As for the Recovery and Resilience Plan, some countries address how to foster human capital through AI (e.g., Spain's National Plan on Digital Competences), although it is difficult to isolate the specific contribution of RRP measures to AI-specific skills competences.

Table 11 presents countries' contributions to the Coordinated Plan's goals on improving skills supply for society as a whole and targeted groups.

National initiatives at several education levels

All countries incorporate skilling and reskilling initiatives for higher education institutions. The landscape changes in primary and secondary education levels, where many countries (but not all of them) are implementing measures. A few countries – Estonia, Luxembourg and Poland – incorporate computational thinking skills at the preschool level – an aspect which is not explicitly mentioned in the 2021 Coordinated Plan. Some countries differentiate between formal, informal and non-formal education (each one with its own definitions). In the countries making this distinction, AI skilling measures tend to be larger for formal education.

Higher education institutions are subject to two different actions. First, the creation of **incentive mechanisms** to help universities increase the number of programmes and subjects on AI through larger funding and resources if they wish to. For example, Bulgaria aims to expand bachelor and master's programmes on AI, plus adequate conditions to increase attractiveness of PhDs. France is promoting a model of "AI+X" tracks (law, biology, humanities, among others), to go beyond pure AI programmes. Malta has set out the Pathfinder Digital Scholarship Fund, which is aimed at incentivising the studies in AI. The call from 2021 awarded a total of 13 individual candidates, with a disbursement plan covering from 2021 till 2023. Second, a **few mandatory measures** include new courses on AI for non-typical degrees working on this issue. In Germany there is a policy measure which aims to create at least 100 professorships on AI. Poland plans to create "cross-technology" PhDs combining cybersecurity and AI.

Most countries making policy changes in primary and secondary schools tend to do so through targeted, mandatory measures. This is for example the case in Finland, which promotes "modular" education programmes over time based on assessment of needs and impact. Slovenia has a model of "targeted research projects" to showcase of use of AI in teaching various classes (history, music, geography, etc.) in primary and secondary schools. Also, Denmark has set out a four-year test programme which assesses how technology understanding is taught at primary and secondary schools from a methodological perspective. In 2021, the Danish digitalisation partnership recommended the government to make the understanding of technology a mandatory competence in primary and secondary education. Austria directly implements a change in the content of subjects, transforming the mandatory "Digital Basic Education" exercise into a compulsory subject in secondary education, for at least four hours per week. Malta has not implemented new mandatory courses but has planned "Challenges" for primary school and AI training at the secondary level.

As for **AI skilling in non-formal and informal education**, a few countries undertake policy measures in this regard. Bulgaria seeks to validate non-formal learning to allow easier access to job offers, while France is undertaking a process of labelling and certification of alternative learning methods through initial and part-time continuing education, summer or winter schools, free online courses for all people, and executive programmes. Sweden's Agency for Economic and Regional Growth together with the Swedish Higher Education Authority analyse the evolution of the supply of competencies in advanced digital technologies in both the short and long

terms, and make recommendations about it. The work aims to improve the supply of such competencies and improve statistics and forecasts of future needs in the Swedish labour market.

Some countries have launched specific strategies, plans and roadmaps to further digital skills. This is the case with Spain's National Digital Skills Plan, and Portugal's national initiative on digital skills. Slovenia has adopted a Law on Digital Inclusion to provide subsidies for computers and computer-related learning and training for young people and the elderly. Luxembourg's Digital Skills Bridge and Talent Attraction Strategy sets out policy programmes to fit at-risk jobs with new labour market needs.

Upskilling in three main sectors: at-risk professional profiles, teachers and public servants

With regards to upskilling, the three areas which have received most attention are retraining courses for the sections of the working age population whose jobs are at risk of automation, teacher training and public servants.

The sections of the working age population whose jobs are at risk of automation are receiving the most targeted, tailored measures. At least 11 countries have set out *targeted* measures to address this issue. There are three main policy trends. First, the launch of national strategies, plans and programmes, as is the case in Germany (both the Skilled Labour Strategy and the National Skills Strategy), Malta (National Reskilling Programme), the Netherlands (STAP Scheme and Longlife Development), and Spain (National Digital Competence Plan). Second, incentive mechanisms, which usually apply to companies. Examples include Ireland's Enterprise Partnership Schemes, and Norway's support to firms enabling employees to enter into a PhD to learn new AI skills on some topic of interest for their company. Third, a range of other targeted measures such as vouchers for personalised training (Finland), adaptive PhDs for the reskilling of people that are experts in other technologies (Poland), and a set of policies in Ireland which include apprenticeships, SOLAS programmes,[25] and Skillnet Ireland training programmes.

With regard to the two other groups – teacher training and public servants – national initiatives are not often targeted.

At least 12 countries have established AI policies applicable to teacher training, although these tend to be broad packages of digital skills, with some exceptions which are more specific. For example, Austria plans to provide certification schemes, didactic innovation learning, and an AI marketplace with products for teaching, methodological options, and research projects. Other countries prioritise MOOCs on how to learn AI basics which these two groups may benefit from (e.g., Cyprus and Italy).

Regarding **public servants, at least nine countries plan to carry out training on AI.** For instance, the Netherlands have committed to a non-mandatory, national online course on AI. Slovakia sets out the type of training which will be given to public servants: proof of concepts, national vocabulary of existing and emerging AI terms, and main AI regulatory trends. Luxembourg has developed a dedicated course developed with an expert on AI ethics based on actual AI-services inside the Luxembourg administration. Luxembourg's strategic vision for AI has led to the creation of an AI4Gov inter-ministerial committee which aims to provide State officials with the practical experience necessary for mastering the process of acquiring cutting-edge AI technologies. The ultimate goal is to establish expertise within the State and position the civil service as a driving force for innovation.

Inclusion and diversity: limited policies for gender and other issues

Gender equality policies are mainly carried out by northern, western and some central European countries. Spain is the only country that includes disability inequality and geographical diversity as two areas to address. Eastern European countries tend to pay stronger attention to the socioeconomic gap which leads to high drop-out rates in STEM studies.

Overall, there is **no definition of special groups or areas to be addressed** through special inclusion and diversity measures across all Member States' national AI strategies.

[25] Ireland's SOLAS programme supports, through a range of education and training programmes, a varying cohort of learners who are interested in: upskilling to enter the workforce or progress in their existing career; progressing into further or higher education; undertaking an apprenticeship or traineeship; or developing their literacy or numeracy skills.

Assessment of effectiveness and impact of skilling measures

A few countries have created mechanisms to assess and evaluate the effectiveness and impact of their overall policies on AI skilling. Half of these countries[26] have committed to doing so through a governance model based on "public laboratories or observatories on the future of work", such as Austria, France's Labor AI lab, and Malta. The remaining countries committing to this assessment undertake it through different organisations: for instance, Slovenia will systematically assess and review the impact of computational thinking under the Ministry of Education, Science and Sport. The organisation in charge of this assessment is the RINOS group, which analyses the need for inclusion of computer and informatics content in primary and secondary schools. The RINOS group has already provided several reports that have been taken up by the Ministry in order to update the curriculum accordingly. The RINOS group has recently extended its scope to also assess the impact of requirements on kindergarten-level activities. Switzerland's State Secretariat for Economic Affairs (SECO) monitors the challenges and addresses emerging issues within the existing competencies in AI. By the end of 2022, it will publish a report on the monitoring of the impact of the digital transformation on the labour market.

[26] Austria, France and Malta, and an approximate approach in the case of Finland.

Table 11. Countries' contributions to the Coordinated Plan's goals on improving skill supply for all society and targeted groups

Country	Initiatives on the future of work and skills	Skilling and reskilling measures in national AI strategies	Upskilling measures in national AI strategies	AI modules on humanities, social sciences	Specialised programmes for target groups (judges, lawyers…)	Inclusion and diversity measures for ICT/AI skills
Austria	To launch a dialogue between businesses and employees for a human-centred design of future AI-based jobs. To consider setting up an Observatory for AI to monitor AI-induced changes in work and labour market, and to propose policy options.	Mandatory changes: Transform the mandatory "Digital Basic Education" exercise into a compulsory subject in secondary education. At least 4 hours per week. AI focus in vocational training.	Sector-specific targeted measures. Financial incentive mechanism for companies to participate in university spin-offs and benefit from know-how.	Two-way: Integration of humanities, social sciences and culture in technical contexts and, conversely, the use of digital technologies and cultural techniques in non-technical training.	Voluntary: For teachers: Certification schemes, didactic innovation learning. AI marketplace with products for teaching, methodological possibilities, and research projects.	Gender equality policies in all AI actions: mentoring programmes, women talent pool and scholarships, and gender equality-driven AI design (to refrain biases). Targeted measures to reduce drop-out rates in STEM.
Belgium	Reforms at primary, secondary and tertiary levels of education.	Voluntary, or ad hoc for primary and secondary schools. Targeted measures for university and PhD. *See 2nd edition of the AI Watch report.	Voluntary, ad hoc: Large-scale MOOCs. Training programmes.		Targeted initiatives: Teachers Coaching and guidance of schools Public administration officers	Gender: campaigns, ambassadors.

Country	Initiatives on the future of work and skills	Skilling and reskilling measures in national AI strategies	Upskilling measures in national AI strategies	AI modules on humanities, social sciences	Specialised programmes for target groups (judges, lawyers…)	Inclusion and diversity measures for ICT/AI skills
Bulgaria	Managed by the Ministry of Education and Science.	No acknowledged plans for primary and secondary school. Expand bachelor and master's programmes on AI, plus adequate conditions to increase attractiveness of PhDs.	Specialised requalification schemes for at-risk professional profiles. Validation of non-formal learning.	To improve students' competencies in ethical issues on ICTs. Two-way.	Teachers	Targeted measures to increase enrolment to STEM subjects.
Cyprus	Integration of soft skills in students' curricula, such as interpersonal communication and problem-solving skills. MOOCs for citizens in general.	Creation and upgrade of higher education programmes in AI.	Tailor-made training programmes for further training and lifelong learning for the workforce. Also, the Cyprus Human Resource Authority (AnAD) can provide information and incentives to employers for upgrading the workforce skills and competencies in digital and AI-related fields.	Integration of soft skills in students' curricula, such as interpersonal communication and problem-solving skills.	Teachers: (1) digital skills and (2) use of digitalisation to improve educational methods.	Education reforms will aim to support new technological skills, particularly in STEM subjects.

Country	Initiatives on the future of work and skills	Skilling and reskilling measures in national AI strategies	Upskilling measures in national AI strategies	AI modules on humanities, social sciences	Specialised programmes for target groups (judges, lawyers…)	Inclusion and diversity measures for ICT/AI skills
Czech Republic	Several strategies have a role in ICT skills: Czech Industrial Strategy foresees a governmental programme to support innovative academic programmes entirely on AI. Strategy for the education policy of the Czech Republic up to 2030+: teachers' learning. National AI strategy.	Mandatory for primary, secondary, and higher education: Creation of new programmes and courses.	Voluntary, ad hoc: Systematic promotion of updated jobs by means of career guidance, worker mobility and reskilling opportunities.	Study of AI impacts at faculties in social sciences and humanities.	Teachers: learning AI and digital technologies, and how this may affect learning methods.	Foreign language: teach AI degrees fully in English to improve talent competitiveness.
Denmark	The government has set up a vocational adult education and training working group to advise new forms of vocational education programmes to	Four-year test-programme to assess how technology understanding is taught at primary and secondary schools. In 2021, the Danish digitalisation partnership	Vocational education training.	Two-way.	Teachers: Teaching models to be evaluated in the test programme. Specific investment package for upskilling.	Increase enrolment in STEM courses.

Country	Initiatives on the future of work and skills	Skilling and reskilling measures in national AI strategies	Upskilling measures in national AI strategies	AI modules on humanities, social sciences	Specialised programmes for target groups (judges, lawyers…)	Inclusion and diversity measures for ICT/AI skills
	target the upcoming needs of the labour market. The Government will set up a centre for the application of IT in vocational education teaching, and will support vocational courses, among others in AI.	recommended the government to make technology understanding a mandatory competence in primary and secondary education.				
Estonia	Awareness raising through the Technological Compass offered by the Estonian Education and Youth Board.	Mandatory upgrades in preschool, primary and secondary levels. Increase of higher education programmes. Upgrade of the ProgeTiger Programme.	Public awareness campaigns. Training courses and instructional materials. MOOCs. *Estonian lifelong learning strategy 2020 (published in 2014).		Public officers: upskilling.	
Finland	Competence and Innovations Committee: established under the Artificial Intelligence Programme to	"Modular education programmes" to address incompatibilities between current skills and new skills requirements.	Voucher for personalised trainings for working-age upskilling. Elderly: MOOCs options.	Communication and social skills. Masters and Bachelor programmes at university	Promotion of "Elements of AI" for all people. During its EU Council Presidency in December 2019, Finland offered the Elements of AI online	Elderly Gender equality

Country	Initiatives on the future of work and skills	Skilling and reskilling measures in national AI strategies	Upskilling measures in national AI strategies	AI modules on humanities, social sciences	Specialised programmes for target groups (judges, lawyers…)	Inclusion and diversity measures for ICT/AI skills
	support education reforms.			providing courses in AI.	course to all Member States for free.	
France	Creation of the "Labor AI", a public laboratory on the future of work to make proposals.	Less focus on primary and secondary schools. Higher education proposal: the AI strategy will continue to provide financial incentives to higher education and research institutions to increase the provision of initial training at all levels, intermediate and expert, and dual programmes.	Strong focus on higher education: Labelling and certification of alternative learning methods: initial and part-time continuing education, summer or winter schools and executive programmes. Creation of bachelor, masters and PhDs. Incentives.	Two-way	One of the goals of the current AI Education plan is to enhance a model of "AI+X" tracks (law, biology, humanities, etc.) beyond "pure AI" programmes.	Digital literacy for all citizens through free online courses.
Germany	Continuation of a Skilled labour strategy: skilled labour monitoring system to identify increase and decrease of labour demand in the future.	Focus on formal training. Creation of at least 100 Professorships on AI.	Continuation of a National Skills Strategy. Custom-fit counselling and training (Hubs for Tomorrow) across regions.	Two-way.	Working age population, educators, trainers, and general public.	

Country	Initiatives on the future of work and skills	Skilling and reskilling measures in national AI strategies	Upskilling measures in national AI strategies	AI modules on humanities, social sciences	Specialised programmes for target groups (judges, lawyers…)	Inclusion and diversity measures for ICT/AI skills
	So-called "Hubs for tomorrow" support companies (especially SMEs) and their employees with custom-fit counselling and innovative learning approaches in order to shape change.		INVITE competition projects (digital ecosystem for continuing education and training). Formation of regional Centres of Excellence for Labour Research studying and organising labour.			
Hungary	All levels, from an early age.	Mandatory courses for primary and secondary levels. Introducing games for improving high-level mathematical and logical skills from an early age and identifying talented children and teenagers. Targeted measures for higher education: reach up to 300 people with a PhD degree involved in an AI research topic.	Personalised learning methods for at-risk groups.	Social sciences for engineers.	Manager-level at companies. Public officers. Teachers.	All society: AI Challenge to train 100,000 people in the basics of AI.
Ireland	Review of employment criteria	Encourage coordinated approach among higher	Targeted measures:	Two-way	No target groups.	Gender

Country	Initiatives on the future of work and skills	Skilling and reskilling measures in national AI strategies	Upskilling measures in national AI strategies	AI modules on humanities, social sciences	Specialised programmes for target groups (judges, lawyers…)	Inclusion and diversity measures for ICT/AI skills
	for critical AI-related skills. (NAS)	education institutions on AI.	apprenticeships, SOLAS programmes, Skillnet Ireland training programmes and enterprise partnership schemes.			
Italy		Mandatory: One targeted measure for school curriculum (content and methodological changes). Four targeted measures to increase PhDs.	Online courses in AI (e-learning platforms). Tax credits for the participation costs of SMEs' management in AI executive courses. Consolidation of the vouchers for advice on digital innovation from specialised managers. Promotion of trainings on AI and related technologies within the public administration		Teachers Public officers	Gender Government: specific PhDs on AI for the public sector will be created.

Country	Initiatives on the future of work and skills	Skilling and reskilling measures in national AI strategies	Upskilling measures in national AI strategies	AI modules on humanities, social sciences	Specialised programmes for target groups (judges, lawyers…)	Inclusion and diversity measures for ICT/AI skills
			and covering at least half of the civil servants in 3 years maximum.			
Latvia	Integration of AI courses at all levels. Expected education system reform to be announced.	The Ministry of Education plans to improve skills in the field of natural language processing, especially in master's and PhDs programmes.			Expert level and management level specialists	
Lithuania		Mandatory AI basic courses for primary and secondary levels. Larger curriculum of master's and PhDs.		AI-related courses for at-risk degrees of automation	Teachers	Citizens: MOOCs (Massive Open Online Courses). Lithuanian Government recommends modernising STEM teaching subjects.
Luxembourg	Luxembourg aims to map the current education offer and to integrate AI courses in those disciplines that are subject to benefit most from AI.	Mandatory class on computational thinking for preschool and primary school.	Policy programmes to fit at-risk jobs with new labour market needs: Digital Skills Bridge and Talent	National approach to digitalisation: critical thinking, creativity, communication, collaboration & coding.	Dedicated course for civil servants developed with an expert on AI ethics based on actual AI-services inside the Luxembourg administration.	Social scientists at risk of jobs automation.

Country	Initiatives on the future of work and skills	Skilling and reskilling measures in national AI strategies	Upskilling measures in national AI strategies	AI modules on humanities, social sciences	Specialised programmes for target groups (judges, lawyers…)	Inclusion and diversity measures for ICT/AI skills
			Attraction Strategy. Learning opportunities in AI for the labour force as offered by AI academy Luxembourg (training modules for decision makers, technical professionals, data scientists & engineers), Lifelong-learning.lu (platform with trainings in IT and telecommunicatio n), and the Elements of AI course, among others.		Elements of AI as open course for all citizens.	
Malta	Set up of a think tank/laboratory to assess the impact of AI on work.	Early and primary school: Challenges, no mandatory course. Secondary school: AI trainings.	National Reskilling Programmes. Promotion of access to training for the workforce through the	Strong focus on learning from social sciences and humanities to AI and the way round.	Teachers (through the Malta Union of Teachers)	Citizens: MOOCs.

Country	Initiatives on the future of work and skills	Skilling and reskilling measures in national AI strategies	Upskilling measures in national AI strategies	AI modules on humanities, social sciences	Specialised programmes for target groups (judges, lawyers…)	Inclusion and diversity measures for ICT/AI skills
		New masters and PhD programmes. Pathfinder Digital Scholarship Fund: aimed at incentivising the studies in AI. The call from 2021 awarded a total of 13 individual candidates, with a disbursement plan covering from 2021 till 2023.	Investing in skills programme. eSkills Malta Foundation can provide advice on reforms in the ICT educational offerings and AI-related courses for professionals.			
The Netherlands		Formal education and training reforms are foreseen through policies targeting increased digital literacy in primary and secondary education and providing more opportunities to develop skills and competencies in data science in higher education (National Data Science Trainee programme).	Multi-annual programme (STAP Scheme and Lifelong Development).		Civil servants, public offers: national online course on AI (non-mandatory).	
Norway	Vocational training initiatives funded by the Regional Investment Fund will	Formal education and training reforms are foreseen through policies targeting increased	Awareness campaigns on the	Two-way.		Citizens: MOOCs.

Country	Initiatives on the future of work and skills	Skilling and reskilling measures in national AI strategies	Upskilling measures in national AI strategies	AI modules on humanities, social sciences	Specialised programmes for target groups (judges, lawyers…)	Inclusion and diversity measures for ICT/AI skills
	target more closely the future (digital) needs of the labour market. Further training and lifelong learning are fostered with the STAP-scheme – a EUR 200 million investment to create training opportunities in AI and digital skills for individuals – and with a multi-annual programme for the improvement of Lifelong Development, with a focus on digital skills. A report to the Storting – Norway's Parliament – on skills reforms and lifelong learning (in Norwegian only). The report outlines a concrete action plan and policy initiatives to close the gap between what the labour market needs	digital literacy in primary and secondary education and providing more opportunities to develop skills and competencies in data science in higher education (National Data Science Trainee programme).	importance of learning AI. PhD on AI for people already working at companies (fitting companies' interest with the topic).			

Country	Initiatives on the future of work and skills	Skilling and reskilling measures in national AI strategies	Upskilling measures in national AI strategies	AI modules on humanities, social sciences	Specialised programmes for target groups (judges, lawyers…)	Inclusion and diversity measures for ICT/AI skills
	in terms of skills and the skills that employees already have.					
Poland		Revision of curricula for preschool, primary and secondary. "Implementation PhDs": programmes which combine AI and other technologies (including those related to cybersecurity). Its main objective is to prepare a dissertation that will help a given company to function. Implementation PhDs are an alternative way of obtaining a doctoral degree designed for people who - while wanting to develop their scientific careers - do not want to give up their careers outside academia.	Reskilling of people expert in other technologies to add the layer of AI (through adaptive PhDs).	Critical thinking, empathy and interpersonal skills	Public administration	Citizens: MOOCs, for public awareness.

Country	Initiatives on the future of work and skills	Skilling and reskilling measures in national AI strategies	Upskilling measures in national AI strategies	AI modules on humanities, social sciences	Specialised programmes for target groups (judges, lawyers…)	Inclusion and diversity measures for ICT/AI skills
Portugal		Trainings in AI from early age to higher education. Since 2019, public higher education institutions have launched about twenty graduate and postgraduate degrees on data science and AI. Specific courses have also been introduced in ongoing "classical" postgraduate degrees. In 2020, higher education institutions have launched several executive programmes, advanced courses, summer or winter schools on AI-related.	Regional/local Networks for Digital Qualification. Executive programmes, advanced courses, summer or winter schools on AI-related.	Two-way. Especially social sciences degrees will learn AI.	Public sector. Teachers.	
Slovakia	Digitalise education by 2030. Setting up of expert group to coordinate educational activities on AI.	If reform is to happen, there will be mandatory courses on AI across all education levels.	Reform of education system to train employees in AI.		Public sector: proof of concepts, national vocabulary of existing and emerging AI terms, and main AI regulatory trends.	

Country	Initiatives on the future of work and skills	Skilling and reskilling measures in national AI strategies	Upskilling measures in national AI strategies	AI modules on humanities, social sciences	Specialised programmes for target groups (judges, lawyers…)	Inclusion and diversity measures for ICT/AI skills
Slovenia		Mandatory courses at primary and secondary levels, and targeted research projects to prepare AI related showcase of use of AI in teaching various classes (history, music, geography, etc.). Systematic review and assessment of effectiveness, at primary and secondary level (now extended to kindergarten level).	Training programmes For lifelong learning to assure inclusion and diversity.	Showcasing AI use cases across social sciences classes (history, economy…). Inter-disciplinary programmes.	Public sector Law on Digital Inclusion provides subsidies for computers and computer-related learning and training to youth and elderly.	Citizens: awareness trainings through MOOCs.
Spain	National Digital Competence Plan (January 2021) to transform and reform the education system.	Introducing the foundations of computational thinking, critical and creative thinking at primary and secondary levels.	Strategic plan for vocational training of the education system 2019–2022	Promotion of joint programmes on STEM-H (Humanities).	Teachers: from early education cycles to train on AI and ICTs.	Gender equality Disability and social exclusion
Sweden		Focus on higher education and reskilling.	Voluntary training: MOOCs and need-based courses.	Social sciences including teaching on the use of AI		Gender equality
Switzerland	The State Secretariat for Economic Affairs	Reform at all levels of education (undefined	Trainings (undefined			

Country	Initiatives on the future of work and skills	Skilling and reskilling measures in national AI strategies	Upskilling measures in national AI strategies	AI modules on humanities, social sciences	Specialised programmes for target groups (judges, lawyers…)	Inclusion and diversity measures for ICT/AI skills
	(SECO) monitors the challenges and addresses emerging issues within the existing competencies in AI.	whether mandatory or voluntary).	whether mandatory or voluntary).			

Source: Own elaboration based on 2nd edition of the AI Watch report (Van Roy et al., 2021), national AI strategies, specific programmes related to skills policies, and direct feedback from Member States during the last stage of revision of the present report.

Note 1: The expression "two-way" refer to countries where there are education curricula both on the impact of AI for students in social sciences and humanities, as well as on the nexus of social sciences and humanities with students specialising in AI and related technologies.

3.3.2 Develop a policy framework to ensure trust in AI systems

Trust is essential to facilitate the uptake of AI technologies. Standards will also play a significant role in the new framework by ensuring that AI providers develop trustworthy ad compliant solutions.

24 countries have already developed (or have at least committed to developing) their own national policies on standards, mainly in the form of early-stage assessments or roadmaps. For instance, the Estonian Government has developed a national metadata standard and data quality framework, which will be implemented in a combination of guidelines and mandatory binding legislation. Finland proposes to pilot environments of an international standard that facilitate access to world class infrastructures and data resources. Ireland has secured, through the ADAPT Centre, in collaboration with NSAI, over EUR 1 million in EU funding to recruit and train the next generation of international standards experts.

A second, less significant trend involves countries that have taken the role of "norms entrepreneurs" for standards at the international or the EU level, or which aim to strongly engage with international bodies and EU networks. These include Denmark (which has acquired new roles for the Secretariat of the upcoming European focus group that is to identify the needs for standardisation within artificial intelligence) and Malta (whose national AI strategy emphasises the importance to collaborate with international organisations on emerging standards and norms in AI. This goes along with the provision of a common definition on AI aligned with the one provided by the EU High-Level Expert Group on AI. Luxembourg also aims to actively promote and adopt international standards in the field of open data and to facilitate interoperability between data catalogues, such as the Data Catalogue Vocabulary Application Profile for data portals in Europe. The Norwegian government has supported Standard Norway in establishing a shadow committee for ISO/IEC SC 42 Artificial Intelligence.

Overall, all countries stress they are waiting for any EU standardisation policy (resulting from the AI Act) to be defined, as it will become the framework countries will commit to.[27] Some of countries which have explicitly acknowledged this are Czech Republic,[28] Hungary, Italy,[29] the Netherlands, Portugal, Slovakia and Spain.

Table 12. Member States' national initiatives on standards and AI

[27] Stefano NATIVI, Sarah De Nigris, AI Standardisation Landscape: state of play and link to the EC proposal for an AI regulatory framework, EUR 30772 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-40325-8, doi:10.2760/376602, JRC125952.

[28] Czech Republic aims to fall back on the EU's upcoming standardisation policy and the existing Cyber Security Act to develop certification and standardisation in the field of cyber security of AI products, systems and services and prevention of their abuse.

[29] To ensure common standards in terms of form, structure and granularity on Data and AI Software and Services as well as compliance protocols with national and EU regulations.

Source: Own elaboration by author based on national AI strategies and the 2nd edition of the AI Watch report (2021), and direct feedback from Member States during the last stage of revision of the present report.

Box 8. Notes to Table 12. Countries' contributions to the Coordinated Plan's goals on developing a policy framework to ensure trust in AI systems

Structure of the table

The column refers to the existence, commitment to, or acknowledge of the importance of standardisation policy for AI in each national AI strategy. Specific particularities may be identified in this box.

Footnotes to the table

(1) Austria: The Federal Government, together with European and international partners, will promote standardisation of AI applications in the relevant fora in order to create a secure framework for the development, operation and use of trustworthy AI applications.

(2) Belgium: Arranging private-public partnerships and G2G collaborations to share and work on using data together and setting data standards.

(3) Bulgaria: The national AI strategy foresees the setting up of clusters of experts in priority areas (such as health and agriculture) to establish standardisation approaches and to ensure interoperability and compliance to FAIR principles.

(4) Cyprus: The Cyprus Organisation for Standardisation (CYS) will establish a National Commission constituting of technical experts from the public and private sectors to monitor and evaluate the work of International and European Committees on AI. It will also be responsible to apply and introduce AI standards in all sectors of the Cypriot economy.

(5) Czech Republic: Development of certification and standardisation in the field of cyber security of AI products, systems and services and prevention of their abuse following the European Cyber Security Act.

(6) Denmark: An independent, voluntary labelling scheme, the D-Seal, has been established to award companies that fulfil eight criteria regarding data governance, cybersecurity and AI. The seal was supported by the Danish government and is driven as an independent and private organisation. Also, in order to gain real influence on European standardisation work, the government has successfully acquired responsibility for the secretariat of the upcoming European focus group that is to identify the needs for standardisation within artificial intelligence. With the secretariat in Denmark, Danish businesses will be able to make a strong impact on the work. In particular, the Strategy for Denmark's digital growth seeks to support the development of international standards for small and collaborative robots (cobots).

(7) Estonia: The Estonian Government has developed a national metadata standard and data quality framework, which will be implemented in a combination of guidelines and binding legislation.

(8) Finland: National AI strategy proposes to pilot environments of an international standard that facilitate access to world class infrastructures and data resources.

(9) France: A national AI standardisation strategy has been set up, implemented by national normalisation agency AFNOR. It aims at enhancing participation of all kinds of enterprises (large companies, SMEs, start-ups) into European and international bodies.

(10) Germany: The Federal Government is supporting the presentation of the current status of norms and standardisation nationally and internationally and identifying and structuring future standardisation needs. The German standardisation institute Deutsche Institut für Normung e.V. (DIN) and the German Commission for Electrical, Electronic and Information Technologies in DIN and VDE (DKE) have worked with business leaders, trade associations and leading scientists to compile a comprehensive standardisation roadmap for AI, including ethical issues, on behalf of the Federal Government and presented this at the 2020 Digital Summit. This forms the basis for a subsequent implementation programme, which, building on the roadmap, is to initiate specific standardisation projects.

(11) Hungary: Standardisation of AI processes in the public sector. Also, alignment with EU-led standardisation policies.

(12) Ireland: Solid expertise in AI standardisation. The ADAPT Centre, in collaboration with NSAI, has secured over EUR 1 million in EU funding to recruit and train the next generation of international standards experts.

(13) Italy: To ensure common standards in terms of form, structure and granularity on Data and AI Software and Services as well as compliance protocols with national and EU regulations.

(14) Lithuania: To ensure that Lithuania's data meets the requirements of international standards. To guarantee research data used for AI systems meets the requirements of the European Union's FAIR Data Management in Horizon 2020 project – this will enable research data to be "findable, accessible, interoperable and reusable (FAIR)".

(15) Luxembourg: Actively promoting and adopting international standards in the field of open data and facilitating interoperability between data catalogues, such as the Data Catalogue Vocabulary Application Profile for data portals in Europe.

(16) Malta's AI strategy emphasises the importance to collaborate with international organisations on emerging standards and norms in AI. This goes along with the provision of a common definition on AI aligned with the one provided by the EU High-Level Expert Group on AI.

(17) The Netherlands acknowledges that it will align with the EU-wide proposal.

(18) Norway's AI strategy emphasises the importance to collaborate with international organisations on standards and norms in AI. The country aims to align with the EU-wide standardisation proposal. Also, the Norwegian government has supported Standard Norway in establishing a shadow committee for ISO/IEC SC 42 Artificial Intelligence.

(19) Poland has its own initiatives on standardisation. The Polish Government will support mutual recognition of interoperability standards and certification or compliance procedures of trustworthy AI.

(20) Portugal: Aligned with EU's standardisation approach. Also seeks sector-targeted standards.

(21) Slovakia: The national AI strategy acknowledges to support the EU's certification and standardisation schemes.

(22) Slovenia: The national AI strategy devotes specific support to Slovenian firms and institutions that develop standards in the field of AI. Besides targeting research and innovation on AI standards, the Slovenian Government also promotes collaborations with national, EU and international standardisation organisations.

(23) Spain: The national AI strategy acknowledges to be aligned with the EU's standardisation approach.

3.3.3 Promote the EU vision on sustainable and trustworthy AI in the world

The opportunities that AI brings transcend borders, and related challenges need to be addressed globally. The Coordinated Plan describes how the EU will support establishment of a global playing field for a human-centric, sustainable, secure, inclusive, trustworthy and ethical use of AI.

Member States are contributing to this approach through national actions and initiatives with other countries, either on a bilateral or multilateral basis.

All Member States plus Norway and Switzerland are working to promote themselves internationally. The most common action is to promote international partnerships to attract foreign talent, investors and research organisations (27 countries). As for international outreach efforts, 24 countries acknowledge in their national AI strategies the importance to participate in international organisations working on AI. Some less frequently used initiatives are the creation of awareness campaigns on the use of AI (22 countries) and the outlook to AI through

the lens of human rights, development policy and humanitarian affairs (16 countries). Additionally, it is remarkable to point out some policy particularities which are less typical across countries. Some Member States aim to engage the city level into international initiatives on AI, and a few countries talk about the importance of engaging with their global diasporas in the development of trustworthy AI around the world.

Table 13 presents countries' contributions to the Coordinated Plan's goals on promoting the EU's vision on AI globally.

Nature of Member States' international promotion

27 countries are carrying out or plan to promote economic-oriented international partnerships to attract foreign talent, investment and research organisations as a driver to enhance their economic growth. Main actions tend to be outreach activities to promote universities and research centres' international visibility (AI4Belgium, Digital Wallonia International Project, Hub Brussels Initiative); or the increase of international attractiveness of companies to investors (such as Spain's Talent Hub in Spain to attract foreign talent, scientists, or foreign investment with social impact). Luxembourg aims to attract investors, but also to project itself as a "living country testbed for TEFs" (Testing and Experimentation Facilities). There is also a visa facilitation initiative to enable foreign talent to easily settle down in a country. Several countries have already implemented this policy: for example, Finland has launched its Startup Visa Permit and Talent Boost; Malta and France have established a special visa policy; Portugal launched the "StartUP Portugal" initiative in 2017; and Spain has created a programme for the accreditation of non-EU educational certificates.

On the other hand, fewer countries (16) undertake outreach activities on, or at least make a reference to, the nexus between AI and human rights, development policy and humanitarian affairs. For example, national AI strategies from Austria and Norway both commit to increasing efforts to link international human rights law with AI. Slovenia capitalises IRCAI (the UNESCO International Research Centre on AI which is based in the country) to support Sustainable Development Goals. Slovakia aims to strengthen its current participation in the Ad Hoc Committee on AI to address gender and algorithmic biases, although the national AI strategy does not indicate if this strengthening means adding more representatives or is aimed at positions of responsibility.

As for international outreach efforts, 24 countries acknowledge in their national AI strategies the importance of participating in international organisations working on AI. There are also initiatives on the creation of awareness campaigns on the use of AI (in 22 countries) and the human rights , development policy and humanitarian affairs perspectives on AI (16 countries).

Another common policy approach is to explicitly mention[30] countries that EU Member States will partner with in dialogues or political frameworks, although these tend to be intra-European. This is the case of Lithuania, which aims to strengthen ties with neighbouring Latvia, and Estonia, to set up shared initiatives through the Cooperation Scheme on AI[31]. Czech Republic looks forward to strengthening bilateral established partnerships[32] with France, Germany and Slovakia. Poland aims to strengthen the Visegrad Region through the Digital Tri-seas Initiative (D3Seas). France and Germany have established a permanent bilateral cooperation framework, and these two countries are planning to set up, jointly with Luxembourg, a cross-border TEF (Testing and Experimentation Facility) on self-driving vehicles. It is remarkable that Finland has created five thematic working groups to set out concrete measures and key performance indicators, one of which specifically focuses on EU and international affairs. Also, Portugal and Spain signed a memorandum of understanding in October 2021 to work together towards developing the Recovery and Resilience Plan in four strategic areas, one of them being capacity building for digital infrastructure with three projects of major significance. These are the development of a research network in the field of artificial intelligence; articulating the different digital hubs to make the Iberian Peninsula a major innovation platform; and the development of common projects in the field of digitalisation and Public Administration. Internationally, Germany, Portugal and Slovenia aim to increase ties on

[30] Germany will do so through "Smart Africa", which supports policy recommendations for these countries through the lens of SDGs. Portugal's national AI strategy commits to working with African countries. Slovenia does not cover any international partnership with another country, but channels its "international development policy" on SDGs through the UNESCO-affiliated International Research Centre on AI (IRCAI).

[31] Nordic and Baltic countries have established the Cooperation Scheme on AI, to cooperate on artificial intelligence to secure digital skills, access to data based on common standards, ethical guidelines for artificial intelligence, and to promote development of the technology in Europe.

[32] Czech Republic aims to strengthen bilateral established partnerships (Czech-German strategic dialogue on research, development and innovation; Czech-French Strategic partnership on digitisation; and Czech-Slovak partnership on education and industry 4.0).

AI development with African countries. To give another example, Slovenia aims to cooperate with Japan to support high-tech in Slovenian companies. Also, Germany's MFA funded a project on "International AI Governance" to create a network of think tanks and international standardisation and regulatory bodies.

Few countries mention the importance of "AI diplomacy". Only France and Poland commit themselves to taking a geopolitical stance on the issue in order not to lag behind in global AI supply chains. Germany wants to strengthen its contact with stakeholders in Silicon Valley. Denmark has a Tech Ambassador's Office, and Estonia has an Ambassador-at-Large. Ireland plans to create an AI Ambassador post to lead a national conversation around the role of AI in our lives, emphasising an ethical and compliant approach. Slovenia is also opening the contact point in Silicon Valley in order to strengthen the research and business ties with the most advanced stakeholders in US. This means that just a small number of Member States are supporting the 2021 Coordinated Plan's goal to anchor AI in diplomacy and development policy. Furthermore, these countries do not necessarily link their "diplomatisation" of AI to the goals of the 2021 Coordinated Plan, except for France and Denmark which do it to some extent and mention it explicitly.

Participation in international organisations and groups

23 countries have committed themselves to or are part of working groups in international bodies, the outliers being countries with no national strategy or with a strong focus on internal AI growth. 20 countries participated in the stakeholders' ONE-AI group hosted by the OECD up to 23 February 2022. It is important to remark that the number of countries in the ONE-AI group has grown in recent years, which suggests the Coordinated Plan's goal to increase this participation is on the right track. Another initiative, the Global Partnership on AI (GPAI), has been launched by Canada and France, and gathers a total of 25 countries, out of which 12 are Member States, plus the EU's representation. The GPAI aims to foster international cooperation building on the OECD Recommendation on Ethical Guidelines for Artificial Intelligence.

International policy particularities

Value is placed on the **engagement with global diasporas** with a dual goal: first, to engage their nationals which live abroad in the development of their place of origin as a solid country on AI; second, to collaborate with these diasporas in the promotion of their own country abroad. Ireland and Lithuania have adopted this policy.

The **municipal level is also contributing to support EU's international image as a promoter of trustworthy AI**. It is the case of the Cities Coalition for Digital Rights, an alliance composed of Amsterdam, Barcelona and New York aims to protect digital rights, including within the use of AI.

Table 13. Countries' contributions to the Coordinated Plan's goals on promoting the EU's vision on AI globally

Source: based on national AI strategies, national Recovery and Resilience Plans, the 2nd edition of the AI Watch report[33] (2021), and direct feedback from Member States during the last stage of revision of the present report.

[33] Van Roy, V., Rossetti, F., Perset, K., Galindo-Romero, L. (2021) AI Watch – National strategies on Artificial Intelligence: A European perspective, 2021 edition. EUR 30745 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-39081-7, doi:10.2760/069178, JRC122684.

Box 9. Notes to Table 13. Countries' national initiatives to promote the EU's AI vision globally

Structure of the table

The three first columns refer to international outreach activities on softer policy areas. The first identifies which countries mention the need to foster AI through a human rights, humanitarian or development policy perspective with other countries in their national AI strategies. The second column refers to countries which are, or have committed to, implementing awareness campaigns. The third column indicates which countries aim to participate in international organisations working on AI issues. The fourth column is related to how countries aim to partner with other stakeholders, be it talent, foreign research organisations, private actors such as investors, or other countries.

Footnotes to the table

(1) Belgium: The Belgian Chamber of Representatives adopted a resolution in 2018 to have a preventative ban on fully automated weapons ("killer robots").

(2) Bulgaria: The national AI strategy aims to create awareness campaigns on the benefits and risks of AI (mass surveillance, manipulation, disinformation). The country also wants to involve Bulgarian academic institutions in international organisations such as the RDA.

(3) Czech Republic: The national AI strategy acknowledges the importance of strengthening bilateral established partnerships, namely the Czech-German strategic dialogue on research, development and innovation; the Czech-French strategic partnership on digitalisation; and the Czech-Slovak partnership on education and industry 4.0. Also, the national AI strategy commits to increasing networking opportunities through the country's participation in Working Groups of international organisations (OECD, United Nations).

(4) Denmark: The national AI strategy highlights several mechanisms including the existence of a Technology Diplomacy framework (namely the Tech Ambassador and TechDiplomacy offices around the world). It also aims to strengthen the established Nordic-Baltic Cooperation on AI. With their declaration "AI in the Nordic-Baltic Region" the Nordic and Baltic countries have agreed to cooperate on artificial intelligence to secure digital skills, access to data based on common standards, ethical guidelines for artificial intelligence, and to promote development of the technology in Europe.

(5) France: The 2nd phase of the national AI strategy aims to strengthen the established Franco-German cooperation on AI. The national AI strategy is also grounded in geopolitical concerns over the development and use of AI. France is one of the two founding countries of the GPAI and is currently co-chair of its Steering Committee. It is the only EU country with a dedicated strategy on military AI.

(6) Germany: The national AI strategy suggests a programme to strengthen cooperation and exchange between German and US stakeholders, especially in Silicon Valley. AI is also part of Germany's programme on Sustainable Development Goals. Additionally, there is a Germany Ministry of Foreign Affairs-funded project on "International AI Governance" which convenes think tanks and international standardisation and regulatory forums as well as technical standard-setting bodies. Furthermore, Germany supports AI in the Global South through "Smart Africa".

(7) Hungary: The national AI strategy commits to creating at least 15 instances of cooperation in international research projects in technological fields, from which two in defence technologies and five in international AI patents. Hungary also aims to increase awareness in public, vocational and higher education (in the latter, establishing a mandatory introductory course).

(8) Ireland: The national AI strategy sets out a specific funding package to recruit and train the next-generation of international standards experts (EUR 1 million, ADAPT Centre). Ireland also aims to engage with the Irish global diaspora on AI. Ireland plans to create an AI Ambassador post to lead a national conversation around the role of AI in citizens' lives, emphasising an ethical and compliant approach.

(9) Italy: The national AI strategy seeks to promote communication and awareness-raising campaigns on the benefits of AI products and services by reaching at least 80% of trade associations, 30% of trade association members, and 80% of Competence Centres and Digital Innovation Hubs.

(10) Lithuania: The national AI strategy aims to engage with the diaspora.

(11) Malta: An awareness campaign will be launched for public officers to build capacity, knowledge and understanding of what AI is, why it is important, and the benefits of public sector adoption.

(12) Norway: The national AI strategy acknowledges the importance of international human rights law, and aims to engage with the Council of Europe, United Nations, OECD and Nordic-Baltic Cooperation through the Nordic Council of Ministers.

(13) Poland: According to the national AI strategy, Poland will "engage in geopolitical competition to place businesses and research centres based in Poland in the (…) global supply chains". It also aims to develop the Visegrad region and north-south under the Digital Tri-seas Initiative (D3Seas).

(14) Slovakia: It participates in the Ad Hoc Committee on AI (AHCAI) to address gender and algorithmic biases.

(15) Slovenia: The International Research Centre on Artificial Intelligence (IRCAI) operated under the auspices of UNESCO is based in Slovenia. IRCAI develops AI-based tools, products and services and provides policy support to Sustainable Development Goals.

(16) Spain commits to increasing awareness campaigns on Artificial Intelligence. Spain has been the first European country to launch a Charter of Digital Rights.

(17) Switzerland: It is actively involved in international discussions on AI-specific international law and international human rights law. It aims to strengthen international cooperation for cybersecurity and AI. The FDFA has set up the Office of the Special Envoy for Cyber Foreign and Security Policy. This targeted multilateral cooperation regularly discusses the influence of AI.

3.4 Building strategic leadership in high-impact sectors

The 2021 Review of the Coordinated Plan on AI defines seven high-impact sectors or strategic priority areas which were jointly developed with Member States. This section analyses how countries individually set out their own high-impact sectors for AI and compares it to those identified by the 2021 Coordinated Plan. A country is considered to have identified a sector as of "high-impact" when there is one of the following in its national AI strategy: a dedicated section or chapter on such a topic; a specific list of most important clusters; the presence of a certain sector in strategic axes or pillars of the national AI strategy; or when a specific sector – even if not highlighted – has been given more than five mentions throughout the national AI strategy, either by means of specific policies or budgets.

Additionally, this report further analyses how countries address AI for sustainability, as it is a new sector introduced by the latest 2021 review of the Coordinated Plan on AI and has significant policy relevance. This report also provides a brief summary on the importance of AI as a trailblazer for the public sector.

3.4.1 High-impact sectors in the national AI strategies

The 2021 Review of the Coordinated Plan defines seven topics as high-impact sectors for AI's leadership and excellence: climate and environment; health; robotics; the public sector; law enforcement, migration and asylum; mobility; and agriculture.

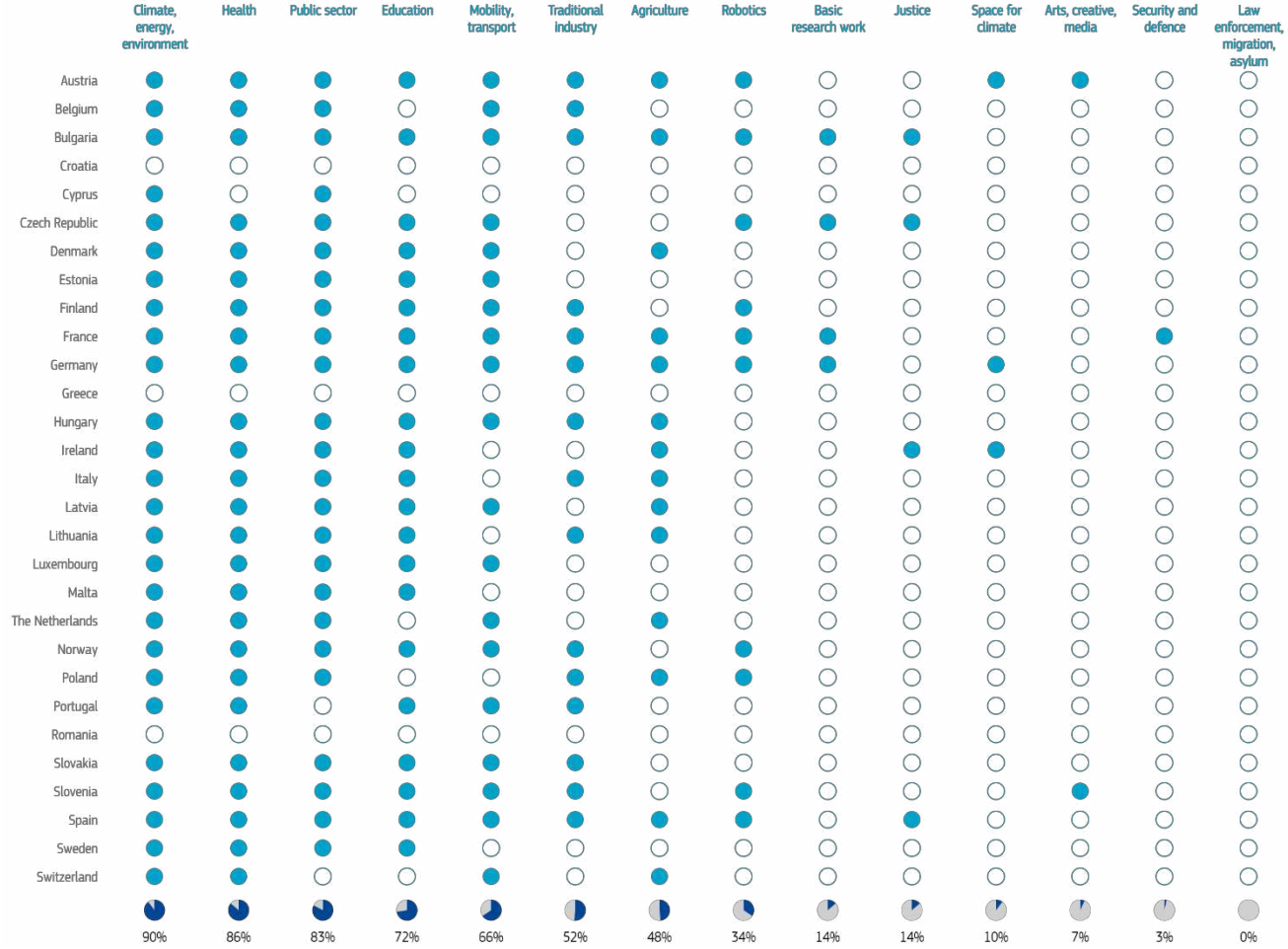
Countries' national AI strategies slightly differ from the Coordinated Plan's approach.[34] Concretely, climate and environment as well as health remain at the top tier of priorities. Of countries with a national AI strategy, 26 of

[34] Most national AI strategies provide a list of the priority sectors for the development and uptake of AI.

them acknowledge the strategic relevance of AI responses to climate, and health is seen as a priority by 25 of them. The public sector receives the same attention as of high-priority (25).

Education is regarded as a high-impact sector by 21 countries at the national level. It is important to point out that the Coordinated Plan does not acknowledge it as a high-impact sector. Mobility and transport (20) and manufacturing in the traditional industry (15) receive strong attention at the national level, although these are not defined as of high-priority by the Coordinated Plan. For instance, agriculture – which is highlighted by the Coordinated Plan – is seen as a high-priority sector at the national level by 15. **Robotics (10) and basic research work on AI (5) receive little attention.** Other specific clusters are given a high priority at the national level by a lesser number of countries. This is the case for justice (4); use of AI in space for climate action (3); arts, creative and media (2); security and defence (2); and the cluster of **"law enforcement, migration, asylum". It is important to remark that the Coordinated Plan on AI frames law enforcement as a high-priority sector**, and only Slovenia has dedicated a specific section to it, concretely through the strategic goal 6 "Enhancing security through AI", which addresses the use of AI for enhancing public safety – including areas such as law enforcement, and cybersecurity. It derives from the need for clear ethical and legal environment also for these areas, so that use of AI has clear and beneficial results that public can trust. Table 14 highlights the priority sectors as mentioned in each country's national AI strategy

Table 14. Comparison of priority sectors by each country's national AI strategy



Source: Own elaboration based on the 2nd AI Watch report (Van Roy et al., 2021), national AI strategies up to December 2021, and direct feedback from Member States up to 18 April 2022.

Note: The column "Security and defence" refers to the use of AI as a driver to leadership in geopolitics globally (foreign affairs), while "law enforcement, migration, asylum" refers to home and internal affairs, as acknowledged by the 2021 Review of the Coordinated Plan on Artificial Intelligence. The column "Space for climate action" identifies which countries give a specific relevance to the use of AI in space to climate responses. These countries are already part of the first column on "climate and environment".

3.4.2 Bring AI into play for climate and environment

Climate and the environment are defined as the first high-impact sector for EU's strategic leadership in the 2021 Review of Coordinated Plan.

All countries acknowledge the importance of AI for green transition, and a group of forerunners is already implementing measures. The "AI and sustainability" category was only recently brought into the policy agenda. This explains why some countries are still in the early phase and starting, and others with most recent national AI strategies have set out further developed measures, such as Spain's National Programme for Green Algorithms, or the fact that Finland's Artificial Intelligence 4.0 programme has "sustainability" in the title. Finland's goal is to make industrial assets sustainable, with capacity for renewal, technological leadership and solutions that enable increasing the carbon footprint by 2030. More than half of the countries are planning or implementing policy measures that reinforce AI's role in sustainability and climate efforts. 12 countries[35] have already implemented some targeted measures to address the issue. Five countries are devoting large blocks of measures to fostering AI and sustainability, promoting environment data use by AI systems and climate-specific testing facilities and similar testbeds (France), Action Plans (Germany), a comprehensive inter-ministerial governance model (Ireland), or other measures (in Denmark and Estonia). 11 countries[36] acknowledge the importance of AI for the environment, but do not set out any roadmap or policy steps.

A common policy trend is the creation of environmental datasets, with each country focusing on its own areas of climate interest.[37]

It is important to remark that **these environmental datasets tend to be government-led**. Stakeholders' engagement for the creation of data assessment guidelines remains limited to a few countries.

As for the **type of stakeholders' engagement on AI for sustainability**, **there is no common policy across countries**. While smaller or less populated countries tend to work with clusters – in Austria, the Luxembourg Tech Cluster, or Norway's Cluster for Applied AI – bigger countries or those with a highly advanced AI industry opt for the setting up of large roadmaps, or at least an early-stage assessment of what might be deployed for green-AI projects, such as France, Germany, or Poland in the cyber-AI nexus.

Also, 14 countries have existing DIHs working on a specific portfolio of climate responses through AI and related technologies, although the scope differs.

Additionally, eight countries comply with the goal set in the Coordinated Plan for Member States to create university curricula on AI for sustainability issues. Norway does so comprehensively (with the creation of educational programmes); Finland plans university curricula for AI and environment; Belgium proposes optional online courses; and Estonia and France promote workshops and exercises.

Finally, **impact assessment of AI impact on climate and energy is an issue which is articulated by just a few countries,** such as Spain (through its National Programme on Green Algorithms), and France (with its national research excellence centres and its "AI and ecological transition" roadmap).

Table 15 presents an overview of countries' contributions to the Coordinated Plan's goals on AI solutions for climate and environment.

Table 15. Countries' contributions to the Coordinated Plan's goals on AI solutions for climate and environment

[35] Norway, Austria, Belgium, Finland, Hungary (although it defines 'Green AI' as a transformative programme), Spain, Sweden, Switzerland, Luxembourg, the Netherlands, Poland and Italy (although Italy's measures are highly limited, but they rely on Horizon Europe funds, what shows a strong interest).

[36] Bulgaria, Croatia, Cyprus, Czech Republic, Latvia, Lithuania, Poland, Slovakia and Slovenia. Malta and Greece have no indicative measures.

[37] For example, Estonia has developed an ice map based on satellite data, while Portugal's AIRCentre makes AI-powered data predictions on the Atlantic Ocean.

Source: Own elaboration by author, based on national AI strategies, the 2nd edition of the AI Watch report (Van Roy et al., 2021), and direct feedback from Member States in the last stage of revision of the present report.

Box 10. Notes to Table 15. Countries' contributions to the Coordinated Plan's goals on AI solutions for climate and environment

Structure of the table

The first column refers to the existence of DIHs or EDIHs on AI solutions for climate and environment, or at least the acknowledgment of their importance in the national AI strategies. The second column identifies which countries have included any potential plan on higher education curricula and other training on "AI for climate, green, sustainability" in their national AI strategies or Recovery and Resilience Plans. Additional information is included in this box on two main areas: first, which national efforts on AI for sustainability have been mentioned in national AI strategies, including cross-border projects and outreach efforts, if any; second, countries which have defined deployment guidelines and standardised assessment methodologies alongside stakeholders on the nexus between AI and climate, environment and sustainability.

Footnotes to the table

(1) Austria: The "AI for Green" programme promotes research-intensive technologies in the field of AI. The fields of application include both climate protection (mitigation) and adaptation to the consequences of climate change. There is no EDIH on this nexus. However, DIH-Innovate.at works on forecasts & simulation with a special focus on the agriculture, wood, forest and energy industries. Additionally, Austria's national AI strategy commits to prepare a masterplan for the most promising applications of AI to combat climate change and present it in the next version of the AI strategy AIM AT 2030. The nexus between AI and climate is also part of the Mission Innovation (MI) Initiative. Austria has two clusters related to technologies (not necessarily AI) and climate solutions: the Vienna Scientific Cluster (VSC-4), and the Green Tech Cluster.

(2) Belgium: There is an EDIH Digital Construction, one of its six themes being sustainable development and resilience. As for educational curricula, there are optional online courses directed to the secondary education (KIKS project, Flandes). Belgium has set out some further policies on this topic, namely Circular Manufacturing Initiative (Flandes); Flanders AI Research Programme (Energy-efficient AI systems); Brussels Smart City Initiative; and TremplinAI programme (DigitalWallonia4.ai). It is also developing AI-powered satellite image processing for climate change-driven events.

(3) Bulgaria: There is no EDIH and no plans on higher education curricula. However, the national AI strategy acknowledges the need to foster data gathering for oversight and assessment in agriculture (NAS). The Bulgarian Strategic Centre for Artificial Intelligence (SCIA) also works on climate solutions.

(4) Croatia: BlueDIH works on the blue-green sector (water management, sea cleanness through AI).

(5) Cyprus: The KOIOS Centre of Excellence is devoted to the supervision, control and security of critical infrastructures, which are inextricably linked to smart environments.

(6) Denmark: The national AI strategy acknowledges that Denmark participates in European cooperation on space data, particularly on the weather, environment and climate. Additionally, Denmark has made a set of recommendations on the use of AI and data for 13 climate partnerships. An investment fund is deployed to fund some testing and scaling projects in the use of AI for the green transition, as well as for the public administration and healthcare. Finally, the Danish Meteorological Institute is in the process of making their data available for reuse. This is expected to be completed by the end of 2022.

(7) Estonia has set out educational workshops and exercises on green AI (TalTech). Additionally, Estonia's national AI strategy commits to the creation of assessments on data quality, trainings on how to compile data, guidance materials (including responsible development and sustainable management of AI solutions, and methodology for impact assessment). There are also several highly advanced AI/ML projects for ice mapping based on satellite data, remote monitoring of forest resources, and species identification.

(8) Finland: WellLake EDIH is focused on maritime and water issues through a range of digital solutions (i.e. not just AI). Also, 5STAR eCorridors (DIH) works on the Federation, Interoperability and Verification of Electronic data sharing in multimodal Sea/Truck/Air/Rail logistics in eCorridors. Additionally, the Finnish Environment Institute, part of the Ministry of Environment, has set out environmental policy guidelines for the collection of environmental data suitable for decision-making. Also, Business Finland – Growth Initiatives has established earmarked funding for climate-AI projects.

(9) France: The 2nd phase of the national AI strategy identifies the climate-AI nexus as one of the three strategic axes to position France globally. There is a specific chapter devoted to fostering greener AI and promoting the dissemination of ecological data. Also, France aims to set up frugal AI TEFs in key areas of the ecological transition (EUR 120 million including EUR 60 million of public funding), and is part of several European H2020 programmes (Perf-AI). As for higher education curricula, there are workshops, classes and exercises in the 3IA centres. 3IA Côte d'Azur works on smart territories, and PRAIRIE-Paris does so with overall climate solutions. Additionally, the country aims to release performance assessments of ecological data.

(10) Germany: There are flagship projects for the Environment, Climate, Nature and Resources (KI-Leuchttürme). Also, there is an Action plan for Digitalisation and AI in Mobility touching on climate issues.

(11) Hungary: Climate-driven AI is one of the seven Transformative Programmes in the national AI strategy.

(12) Ireland: The national AI strategy acknowledges to have established several mechanisms to work on collaborative projects on AI and climate under four main public departments. These are the Sustainable Energy Authority of Ireland (SEAI); the Environmental Protection Agency (EPA); the Disruptive Technologies Innovation Fund (DTIF); and the Science Foundation Ireland (SFI).

(13) Latvia: The DIH "Ventspils High Technology Park" has some projects on energy efficiency.

(14) The Netherlands: The KNMI DataLab aims to facilitate and coordinate innovations in the fields of climate change, weather forecasting and seismology.

(15) Norway: AI solutions for climate is one of the main goals in the national AI strategy. Also, the strategy seeks to create educational programmes to support the green transition. Additionally, State-owned institution ENOVA has created a fully autonomous transport chain with specific guidelines over the control of AI-related technologies to emit fewer greenhouse gasses, improve local air quality and produce less noise. Also, the two DIHs GCE NODE in Agder and SINTEF have specific areas devoted to climate and environment through the use of AI and related technologies.

(16) Portugal has developed AI Moonshot Challenge, as well as AIR_DataNet (AIRCentre), which makes data predictions over the Atlantic Ocean.

(17) Spain: ITECAM is a DIH with a line of work on climate and the environmental. Also, the Measure 20 of the national AI strategy aims to develop the National Programme for Green Algorithms.

(18) Sweden: The DIH Future Position X: FAIRTRANS is a project on a fair transition to a fossil-free society. Also, Vinnova (Sweden's innovation agency and national AI funding coordinator) has completed 2 calls (2020 and 2021) on AI and climate, in collaboration with Formas (a government research council for sustainable development), The Swedish Energy Agency and the Swedish National Space Agency. In the 2021 call, projects for SEK 65 million (approx. EUR 6.5 million) were funded with a total public funding of SEK 50 million (approx. EUR 5 million). Vinnova, together with other public agencies, is planning for a new innovation programme related to the twin transition, where AI and data will be key components.

(19) Switzerland: The DIH Lifehub.swiss works on life sciences (although not necessarily through AI). Also, Switzerland has set out the Swiss Hub for Energy Data report, as part of a national energy data infrastructure. The Federal Office of Environment plans open environment datasets to be used for AI applications.

3.4.3 Make the public sector a trailblazer for using AI

The importance of the public sector is recognised by the European Commission that included a specific proposal on making *"the public sector a trailblazer for using AI"* in the 2021 Review of the Coordinated Plan on Artificial Intelligence. The European Union aims at becoming a strategic leader in the use of AI for the public sector.

AI has the potential to be an extremely useful – or disruptive – technology for the modernisation of the public sector itself. In fact, AI might become a strong enabler for seeking efficiency and effectiveness in the management and delivery of public services. For example, it has the potential to (i) automate simple and repetitive cognitive activities freeing-up labour time for more high-value activities; (ii) augment the predictive capabilities, enhancing data-driven decision-making; or finally (iii) support user-centric service personalisation, increasing the effectiveness of public service delivery. Evidence of the potential of AI for the public sector is provided by the fact that public organisations are starting to adopt many different AI systems in different areas, such as control and monitoring, resource planning, data validation, document digitalisation, law enforcement and service provision and delivery.

The AI Watch has published various policy reports on AI in the public sector and engaged with Member States to learn and discuss about challenges and best practices to foster the uptake of AI in the public sector in:

- Policy reports including use cases[38] and policy recommendations;[39]
- Peer-learning workshops and reports presenting workshops' proceedings.[40]

Use cases in the public sector

In 2020 the AI Watch presented the first exploratory landscaping of the use of AI in the public sector. Overall, 230 cases of AI in the public sector have been collected and analysed. Looking at the data, there are two types of AI that appear more frequently: (i) chatbots or digital assistants; and (ii) systems providing some sort of intelligent, data-based predictions and simulation, through the recognition and visualisation of patterns in (big) socioeconomic data. One of the main takeaways from this first research is that there is a large variety of ways of using AI solutions in the public sector. However, many of the projects analysed were just in the pilot or testing phase, even though there was already a significant portion of cases effectively implemented and used in the daily public services operations in 2019 and 2020. Some of the collected cases have been also published in open data in the JRC data catalogue.[41]

In 2022, the collection expanded to more than 600 use cases of AI in the public sector in the EU. The collection will available in open data. Moreover, a policy report will go deeper into a shortlist of selected cases and, based on several interviews, it will shed light on those intangible elements and critical aspects that can be observed only with a deep look in real-life projects. Finally, the report will present the results of the research conducted on the policies and interventions related to the public sectors that EU Member States included in their AI national strategies.

Policy recommendations

The 2020 report described above identified and published some critical challenges for AI implementation, including: (i) the generation of a critical mass of public investments; (ii) the availability of widely shared and suitable datasets; (iii) the improvement of AI literacy and skills in the involved staff; and (iv) the threats associated with the legitimacy of decisions taken by AI algorithms alone. Starting from these challenges, a

[38] Misuraca, G. and Van Noordt, C., AI Watch – Artificial Intelligence in public services, EUR 30255 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-19540-5, doi:10.2760/039619, JRC120399.

[39] Molinari, F., Van Noordt, C., Vaccari, L., Pignatelli, F. and Tangi, L., AI Watch. Beyond pilots: sustainable implementation of AI in public services, EUR 30868 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-42587-8, doi:10.2760/440212, JRC126665.

[40] - Van Noordt, C., Misuraca, G., Mortati, M., Rizzo, F. and Timan, T., AI Watch – Artificial Intelligence for the public sector, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-19438-5, doi:10.2760/25756, JRC120315.
- Van Noordt & Pignatelli (2020), Report of the 2nd Peer Learning Workshop on the use and impact of AI in public services, 29 September 2020, European Commission, Ispra, 2020, JRC122366.
- Van Noordt, C., Alishani, A., Manzoni, M., Tangi, L., Gattwinkel, D. and Pignatelli, F., AI Watch. Artificial Intelligence for the public sector. Report of the "3rd Peer Learning Workshop on the use and impact of AI in public services", 24 June 2021, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-41530-5, doi:10.2760/162795, JRC126501.
- Manzoni, M., Medaglia, R. and Tangi, L., AI Watch. Artificial Intelligence for the public sector. Report of the "4th Peer Learning Workshop on the use and impact of AI in public services", 28 October 2021, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-46347-4, doi:10.2760/142724, JRC127944.

[41] Joint Research Centre Data Catalogue – Selected AI cases in the public sector – European Commission (europa.eu).

forthcoming report of AI Watch[42] presents 16 policy recommendations clustered in four areas of intervention, accompanied by a number of actions to foster the implementation of AI in the public sector at different operational levels. Recommendations and actions presented are intended to support forward-looking managers, practitioners and innovators throughout the public sector governance chain at multiple levels (European, national and local levels). It is the first endeavour at the European level to outline possible avenues to promote AI in support of public services.

Peer-learning workshops

The AI Watch organised a series of peer-learning workshops in 2020 and 2021 to engage with EU Member States and relevant stakeholders. The workshops were an opportunity to co-create, share and discuss the ongoing research and to report experiences of public administrations that are dealing with AI implementation. The first workshop discussed the current state of AI in the public sector, and showed how AI is being widely experimented with across European countries. The second one focused on the impacts of the COVID-19 crisis on the development and uptake of AI in public services. In the third one, the AI Watch and some MSs presented initiatives and analyses on the uptake of AI. Finally, in the fourth one, an interactive event took place for discussing a validating the policy recommendations that will be published in the forthcoming report.

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[42] Manzoni, M., Medaglia, R., Tangi, L., van Noordt, C., Vaccari, L., & Gattwinkel, D. (2022). AI Watch. Road to the adoption of Artificial Intelligence by the public sector. EUR 31054 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-52132-7, doi: 10.2760/288757, JRC129100.

4 Investments in AI

The latest *AI Watch report on EU investments in AI* (Dalla Benetta et al., 2020)[43] estimates that in 2019 the EU invested between EUR 7.9 and EUR 9 billion in AI (i.e. 40–45% of the annual investment target of EUR 20 billion as set by the Communication on Artificial Intelligence for Europe (COM(2018) 237 final). The report presents combined public and private AI-related investments into four investment assets: Skills, R&D, Data and equipment and Intangible assets. The majority (53%) of EU AI investments relate to labour and human capital. Expenditures on AI-related Data and equipment account for 30%.

At the level of Member States, the highest absolute investments came from the largest countries (i.e., France and Germany), while in terms of AI investment per capita, Nordic countries and Ireland were the top investors. Over the period 2018–2019, AI investments in the EU grew approximately by EUR 2.1–2.5 billion (i.e., about 39%). If the EU maintains this growth pace, by 2025 the AI investments may reach EUR 22.4 billion and surpass the EUR 20 billion target by over 10%.

While the above statistics are estimates based on Eurostat data, many national AI strategies present planned or budgeted investment figures. Numbers vary greatly and are difficult to compare, as they are presented according to different timeframes and coverage. The following information is based on budget, which is contained in some countries' national AI strategy and Recovery and Resilience Plans, as well as previous information in the 2nd edition of the AI Watch report (Van Roy et al., 2021).

AI investments in Member States and Norway

Austria: The national AI strategy does not provide an overall budget estimation. There is information on two lines of action. As for AI applications for the environment, a targeted funding of EUR 4 million for Austria Wirtschafts service (AWS) was awarded in 2020 and 2021 in order to increase the number of trusted, innovative small projects in Austria (where small projects were supported up to EUR 200,000). A second itemised budget is state support to research activities in institutions and universities: a total of EUR 910 million was distributed between 2012 and 2020 through the Austrian Research Promotion Agency (FFG).

Belgium: The Flemish AI Action Plan, which was released in 2019, foresees an annual budget of EUR 32 million for its implementation, broken down as follows: EUR 15 million dedicated to the implementation of AI within companies, EUR 12 million allocated to basic research, and EUR 5 million to supporting measures (training, ethical and legal aspects related to AI adoption, and outreach activities). This funding is complemented with other policy instruments of both FWO (funding for HEIs) and VLAIO (funding for enterprises). In 2020 FWO invested about EUR 15 million and VLAIO some EUR 45 million in AI related projects. The same amounts are expected for the following years.

In the Walloon Region, the DigitalWallonia4.ai programme has an annual budget of EUR 18 million, including also the industry 4.0 and the regional digital strategy "Digital Wallonia".

The Brussels region has already invested around EUR 44 million in AI since 2017. There is an itemised budget on the regional innovation funding body Innoviris, which has been playing a major role in the support of AI-related research and innovation effort through a strong development of its support programmes with a dedicated budget of EUR 22 million.

Belgium's Recovery and Resilience Plan includes two specific investment packages on AI. First, the Brussels' region aims to set up a project for the development of an AI institute to address societal challenges with a budget of EUR 9.91 million. Second, the Wallonia Federation plans to create a centre for technological innovation and training (with a budget of EUR 86.8 million) which includes a section on AI.

Bulgaria: The national AI strategy does not include specific budget figures. However, it defines the funding governance model (pp. 52–53):

National and regional sources:

[43] Dalla Benetta, A., Sobolewski, M. and Nepelski, D., *AI Watch: 2020 EU AI investments*, EUR 30826 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-41492-6, doi:10.2760/017514, JRC126477. This report will be updated in Q1 of 2022. Please note that this report does not reflect actual budgets but provides AI investment estimations in the public and private sector based on Eurostat data.

- Public funding of basic research and support for higher education should be provided through the Ministry of Education and Science, as well as through projects of Bulgaria's Research Fund.
- Applied research and innovation should be managed by the new State Agency for Research and Innovation (SARI).
- The National Innovation Fund may also finance projects on innovative solutions based on AI.
- The development of prototypes for experimentation in public organisations can be financed by regional funds, for example through partnerships in the cluster "Sofia City of Knowledge".

Programmes 2021–2027, funded by European funds:

- Projects to support Centres of Excellence and Centres of Competence have already been approved in the "Education Programme" and "Research, Innovation and Digitalization Programme for Smart Transformation" for the period 2021–2027.
- Partial financing of AI programmes has also been approved through the Technical Assistance Programme, the Strategic Plan for Agriculture and Rural Development, the Regional Development Programme and the Human Resources Development Programme, for the period 2021–2027.

Czech Republic: There is no definite estimate provided in the national AI strategy. However, since the adoption of the national AI strategy in 2019, there have been several projects supported by the Technological Agency of the Czech Republic, Czech Science Foundation, and other agencies for EUR 120 million in total. Additionally, since the release of the 2019–2030 Innovation Strategy, which includes a roadmap to improve the innovation system as for the strategic management (e.g., education and research) through AI and other technologies, "The Country for the Future" (CFF) programme by the Ministry of Industry and Trade is the implementation tool for the Innovation Strategy has allocated a budget of CZK 6.1 billion (approx. EUR 232.6 million) to support innovative companies, digital services and R&D-based innovations.

Denmark: The national AI strategy contains 24 initiatives and has earmarked DKK 60 million (EUR 9.2 million) for 2019–2027. This is a supplement to the DKK 295 million (EUR 45.4 million) allocated in the Finance Act 2019 (annual national budget) from the research reserve for exploring new technological possibilities and digital technologies and for a national centre for research into digital technologies.

Some specific itemised budgets are as follows. First, the investment fund on AI and other technologies will have a total investment budget of DKK 410 million (EUR 63.1 million) for 2018–2022, including a funding package for 2019–2022 of EUR 27 million for testing, scaling and encouraging the uptake of AI in the public sector, with a particular focus on healthcare, public administration and the green transition. Second, the national AI strategy defines that total public research budget for 2019 was DKK 23 billion (EUR 3.1 billion). Third, the creation of the Digital Research Centre Denmark (DIREC) was supported by the Innovation Fund Denmark with DKK 100 million (approx. EUR 13.4 million).

Additionally, Denmark's Recovery and Resilience Plan provides a specific budget package for the digitalisation of the public sector with AI and other technologies which includes an investment fund for 2022–2025 of DKK 142.8 million (18.9 million EUR).

Estonia: The government invested at least EUR 10 million euros over the 2019–2021 period for the implementation of AI strategy in its different directions. For 2022–2023 the government will invest at least EUR 20 million euros for the implementation of AI strategy in its different directions.

Finland: The Finnish government provides investment figures for various flagship policies. This is the case of the AI Business Programme, which has been allocated EUR 200 million over a four-year period. The Finnish Centre for Artificial Intelligence (FCAI) was granted EUR 8.3 million in flagship funding for 2019–2022. Also, to foster the digital infrastructure for research purposes, the Ministry of Education and Culture has developed a research infrastructure development programme for data management and computing with research and innovation actors in 2017–2021. The development programme foresaw an investment of EUR 37 million in data management and computing infrastructures and related services.

The Recovery and Resilience Plan shows a breakdown of itemised budgets: Corporate digital economy – RTE programme, EUR 14 million; Virtual Finland programme, EUR 9 million; Accelerator programme for spearhead technologies, EUR 25; Improving the Residential and Commercial Property Information System, EUR 14 million; Enhancing the effectiveness and transparency of RRP-based reforms and investments by improving information systems, administration, oversight and inspections.

France: Initially, the first phase of the national AI strategy allocated around EUR 1.5 billion over the period 2018–2022. The second phase earmarks a total of EUR 2.22 billion to be spent on AI over the next 5 years (period 2021–2025), including EUR 1.5 billion in public funding and EUR 506 million in private co-financing. Of this EUR 1.5 billion, training accounts for more than half of the effort (50%), innovation and economic support measures for 40%, and measures for scientific research and transfer for almost 10%.

The public funding will come from the 4th Programme on Future Investments (PIA4) with a budget of EUR 648 million, the France 2030 investment plan (on AI training with a budget of more than EUR 700 million) and other public provisions (including budget appropriations from ministries and operators, European funding and local authorities) with a budget of EUR 288 million.

The Recovery and Resilience Plan sets out itemised budgets on digital technologies, including AI. EUR 460 million will be devoted to the digitalisation of professional training through the Skills Investment Plan.

Germany: The German government initially earmarked EUR 3 billion for the implementation of the German strategy in 2019–2025; which was subsequently increased to EUR 5 billion.

Ireland: The national AI strategy sets out cross-border cooperation in the area of AI R&I. For example the Government is making EUR 500 million in new capital funding available out to 2025 through the Shared Island Fund, in order to foster new investment and development opportunities on a North/South basis.

Italy: The national AI strategy includes budget figures which will be directly used from the Recovery and Resilience Plan, and state budget. In this strategy, EUR 14.650 million will be funded through the RRP, and EUR 215 million will be provided by state budget.

Latvia: The Ministry of Interior plans to spend approximately EUR 1.5 million on digitalisation with a focus on AI.

Lithuania: The national AI strategy acknowledges that there are a few channels for receiving financial investment for AI projects and start-ups. In the period between 2015 and 2018, public sector investment in AI was more significant than private sector with a total of EUR 26.5 million and EUR 3.2 million respectively. In total 39 different AI projects received funding from Ministry of Economy and Innovation initiatives, totalling EUR 12.5 million since 2016. When combined with private capital brought in, the total value of projects for the last three years was over EUR 20 million.

Another itemised budget is a call for proposals by MITA to support the development of green industry innovation. The call foresaw investments from EUR 10,000 to EUR 2 million per project. The innovation areas include bio-technologies, new products from recycled materials, environmental technologies and technologies to modernise production processes while reducing their negative impact on the environment, such as digitisation, automation, robotisation, according to the 2nd AI Watch report.

Luxembourg: The national AI strategy acknowledges that the Ministry of the Economy has allocated approximately EUR 62 million in 2018 for AI-related projects through R&D grants, while granting a total of approximately EUR 27 million in 2017 for projects based on this type of technology. The Luxembourg National Research Fund (FNR), for example, has increasingly invested in research projects that cover big data and AI-related topics in fields ranging from Parkinson's disease to autonomous and intelligent systems – approximately EUR 200 million over the 2013–2018 period. Based on the 2nd AI Watch report, the infrastructure MeluXina is funded via a joint investment of about EUR 30 million from the European Union and Luxembourg.

Malta: Some itemised budgets are provided by the 2nd AI Watch report. First, the Maltese strategy announced a public investment of EUR 1 million per year to organise promotion campaigns and outreach programmes to highlight the benefits of AI. Also, the R&I FUSION Programme[44] has a budget of EUR 2.2 million. The seed funding grants scheme (Business START) provides EUR 1 million per year.

Netherlands: The Dutch strategy mentions in an annex that the yearly governmental budget for AI innovation and research is estimated at EUR 45 million per year. In 2019 this budget was EUR 64 million. In 2020 the Netherlands funded an additional EUR 23.5 million for the Public Private Partnership the Dutch AI Coalition. In April 2021 an investment programme was granted to maximise the possibilities of AI for the Dutch economy and society by investing an additional amount of maximum EUR 276 million in the upcoming years.

[44] Malta's areas of Smart Specialisation (ICT as an Enabler, ICT Based Innovation, Tourism Product Development, Aviation and Aerospace, Health, Resource Efficient Buildings, High Value-Added Manufacturing, Aquaculture) through the Malta Council for Science and Technology (MCST) are part of the R&I FUSION Programme until 2020.

Also, some itemised budgets are provided for further training and lifelong learning through the STAP-scheme. EUR 200 million will be allocated to create training opportunities in AI and digital skills for individuals – and with a multi-annual programme for the improvement of Lifelong Development focusing on digital skills.

Norway: The Research Council of Norway has no programmes dealing specifically with AI, but AI has been one of several priorities in the IKTPLUSS initiative. Calculations from 2019 show that over 40% of the Research Council of Norway's allocations to ICT was awarded to projects in AI, robotics and information management (big data). This represents almost NOK 400 million (approx. EUR 39.5 million).

Among others, an itemised budget (NOK 125 million, approx. EUR 12.3 million) was provided for Digital Innovation Hubs in the 2019 national budget.

Portugal: The "Digital Transition" dimension of the national RRP (EUR 2.46 million) includes five components, also comprising AI and other technologies: Companies 4.0 (EUR 650 million); Quality and Sustainability Public Finance (EUR 406 million); Economic Justice and Business Environment (EUR 267 million); more efficient Public Administration (EUR 578 million); and a Digital School (EUR 559 million). Measures to support digital goals represent an amount that account for 22% of the plan's total allocation, exceeding the 20% threshold defined by European regulations: 12 of the 20 components of the RRP have a direct contribution to the digital goal.

Slovenia: To implement the AI strategic objectives, Slovenia earmarks an investment of EUR 110 million of public funding in its National programme for AI until 2025.

Spain: The national AI strategy has set aside EUR 600 million for the period 2021–2023 and expects to mobilise EUR 3.3 billion in private investment. The Recovery and Resilience Plan devotes EUR 500 million to AI (what is the 0.7% out of the total of RRP budget).

Sweden: Sweden's innovation agency, Vinnova, funded AI projects for SEK 735 million (approx. EUR 73.5 million) in 2021. The total budget for Vinnova funded AI projects in 2021 was SEK 1.413 billion (approx. EUR 141 million), and the remaining budget is from the project participants. In the national budget for innovation and research until 2024 at least SEK 550 million (approx. EUR 55 million) has been assigned to research and innovation in digital technologies and AI and its use and impact on society.

Source: This 'Investments' section has been elaborated by the author based on national AI strategies, the 2nd edition of the AI Watch report (2021), and direct feedback from Member States during the last stage of revision of the present report.

5 Concluding remarks

This report shows that the **EU and Member States are on the right track** in seizing the benefits and promoting the development of human-centric, sustainable, secure, inclusive and trustworthy artificial intelligence in Europe. It provides a comprehensive analysis of the substantial efforts of Member States in creating **fruitful policy conditions for AI development** and **maximising the impact of joint AI actions at European level** as outlined in the 2021 review of the Coordinated Plan. One of the recommendations of the Coordinated Plan is the encouragement for all Member States to develop their national AI strategies.

On 1 February 2022, **23 Member States and Norway published national AI strategies**, while four are still in progress. Moreover, four countries have already published updated editions of their initial AI strategies. This demonstrates Member States' commitment to develop strategic visions for AI with concrete policy actions and investments. It is worth noting that national AI strategies either released or updated after the 2021 Review of the Coordinated Plan appear more aligned in their structure, goals, vision and mechanisms.

National initiatives play a **key role in putting forward and achieving common EU goals**: on setting enabling conditions for AI development and uptake; on making the EU the place where excellence thrives from the lab to the market; on ensuring that AI works for people and is a force for good in society; and on building strategic leadership in high-impact sectors. Besides developing national policy actions, Member States are actively participating in initiatives taken at the EU level, such as European Digital Innovation Hubs, Testing and Experimentation Facilities and EU-led public-private partnerships.

While shaping AI policies is important, it is equally crucial to **monitor and follow-up on the progress** with regular updates of initial strategies, sharing best practices and coordinating closely to create synergies and strengthen EU's global competitiveness in AI development and uptake. Enhancing countries' clarity in their commitments over time would be beneficial along three dimensions. First, it would lead to a more effective identification of policy advancements. Second, it would increase the likelihood to attract international investors that would see a clear roadmap of steps, stakeholders, itemised budget and expected impact. Third, it might open opportunities for EU countries willing to collaborate on specific projects.

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