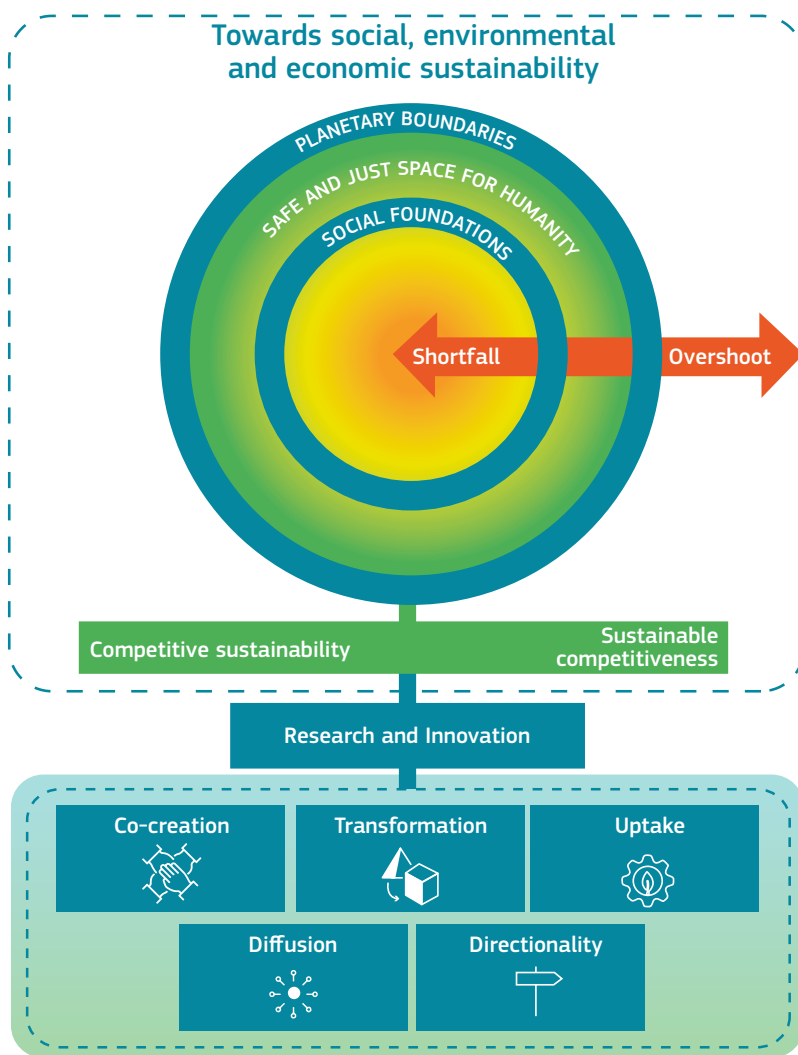


# CHAPTER 0

*Executive Summary*

**TOWARDS A FAIR,  
CLIMATE-NEUTRAL,  
DIGITAL EUROPE:  
IMPLICATIONS FOR  
R&I POLICY AND  
BEYOND**

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Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation

Note: Doughnut visualisation based on Kate Raworth's work on the Doughnut Economics.

**Research and innovation (R&I) are key for the future we want.** They enable and drive the transition to a green and sustainable Europe tomorrow. They help us to better understand our world and provide solutions for the challenges ahead. While the COVID-19 pandemic (Box 0-1) has recently been disrupting our society, Europe has been facing global forces in the longer term

and our planet has reached a tipping point. Climate change poses an existential threat: one of the 8 million species on earth is at risk of being lost<sup>1</sup>, and forests and oceans are being polluted and destroyed. At the same time, no one should fall short on life's essentials, such as food, housing, health and education. In this context, R&I helps us to build a safe and just

1 Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2019).

space for humanity, which avoids the overshoot of our planetary boundaries and preserves our social foundations. At the same time, the digital transformation of our economy and society, empowered by artificial intelligence (AI), blockchain and quantum computing, is revolutionising the way we live, work and innovate at an unprecedented speed.

**Hence, Europe must address the twin challenge of the green and digital transitions to become a modern, resource-efficient and competitive economy.** This means that our R&I policy will need to adapt to ensure that R&I contributes to an ample concept of sustainability – social, environmental and economic – while driving EU competitiveness. Europe's competitiveness should build on a framework of institutions, policies and factors that ensure sustainability in the long term (sustainable competitiveness), and sustainability should become a key driver of Europe's competitiveness and growth (competitive

sustainability). To achieve this, EU R&I policy should be guided by the following principles (see also Chapter 1):

- ▶ **co-creation**, working and acting together for a better society;
- ▶ **diffusion**, sharing knowledge across society, territories and people;
- ▶ **uptake**, turning research into sustainable solutions with social and economic value;
- ▶ **transformation**, changing the way we consume and produce; and
- ▶ **directionality**, with R&I leading the way.

The evidence presented in this report leads to **11 policy headlines** to support our people, planet and prosperity. These include, but are not limited to, messages for EU R&I policy:

## R&I FOR A SAFE AND JUST SPACE FOR HUMANITY

- #1. As an overarching policy message: **the European Green Deal requires a shift towards a transformative innovation policy.**
- #2. Making sure that growth **does not leave anyone behind** ... people, regions, countries and firms.
- #3. Equipping Europeans with the **skills to navigate the changing world.**
- #4. Fast-forwarding to **gender equality** in and through R&I.

## R&I FOR GLOBAL LEADERSHIP

- #5. Shaping Europe's **competitive edge in the global race for technology.**
- #6. Modernising R&I policy to make it **fit for purpose in the digital age.**
- #7. Ensuring **scientific leadership** and stimulating **knowledge flows** within the EU.
- #8. Building a **vibrant and resilient R&I ecosystem** in the post-Siemens-Alstom era.

## R&I FOR ECONOMIC AND SOCIETAL IMPACT

- #9. **Maximising the value of R&I results** for society, the economy and policy.
- #10. Making the EU's **regulation** innovation-friendly and forward-looking.
- #11. Anticipating the future world through better **evidence for policy.**

## BOX 0-1 COVID-19

The COVID-19 crisis is unprecedented and the world has been struggling to contain the pandemic. It has disrupted our lives, economy and society and stopped almost all economies worldwide from fully functioning. This crisis has demonstrated how our intimately connected world has contributed to a global pandemic causing widespread sickness and casualties and disrupting people's personal and professional lives and economies on a global scale. The crisis shows how our citizens' health and well-being, our economy and our society in general are closely interlinked.

The situation demonstrates more than ever how an anticipative, rapid and effective R&I response is crucial. R&I is an essential part of the coordinated EU response to the threat to public health from COVID-19. EU actions for R&I are focusing on:

- ▶ funding and financing R&I in virology, vaccine development, treatments and diagnostics, and wider social and economic impacts;
- ▶ speeding up research by optimising framework conditions such as research infrastructures, platforms to share information, and taking ethical issues into account;
- ▶ translating research findings into public health policy to mitigate the impacts and improve crisis preparedness;
- ▶ internal and external coordination; and
- ▶ citizen outreach and communication.

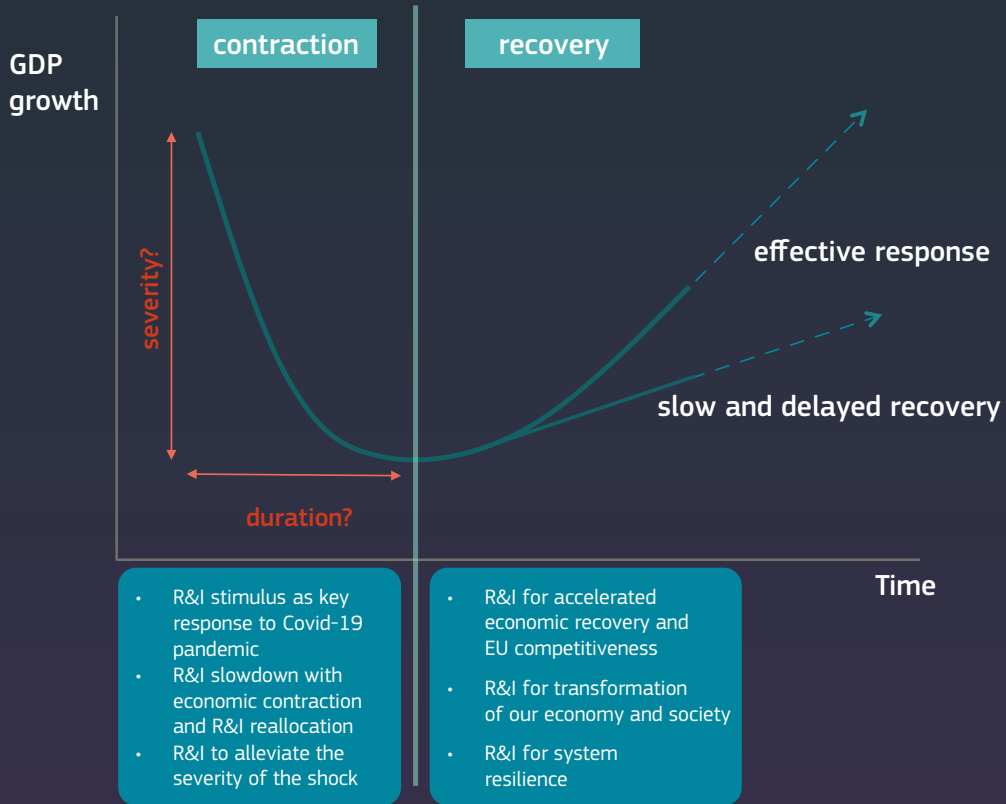
In global emergencies, such as this pandemic, it is essential to remove all obstacles to the free flow of data, researchers and ideas. AI and other digital technologies can also help to track the spread of the virus and speed up the process of diagnosis, detection and monitoring.

Moreover, while R&I is at the core of the response to the pandemic itself, it will also be crucial in the economic recovery from the crisis, not only to spur economic activity, but also to accelerate the transitions our planet and society need – a new economy for health and well-being in a broad sense (physical, mental, skills, social, environmental and economic aspects).

Hence, R&I can directly contribute to a recovery that delivers on the European Green Deal. Europe should strive to make its economic recovery truly transformative by investing massively in science-driven and innovative solutions that accelerate the transitions both our planet and society need. R&I will thus be fundamental to underpinning the shift towards a circular and low-carbon economy and securing a path to net-zero emissions by 2050.

R&I can also help to build system-wide resilience. Technologies are already helping to alleviate, at least partially, the severity of the current economic shock, with digital technologies at the core of business continuity in several sectors. It is of paramount importance to invest in making our society and economy stronger, more resilient and capable of a rapid and integrated response by drawing on the latest scientific discoveries and ensuring equal access to healthcare across the EU.

Figure 0-1 R&I and economic recovery from the COVID-19 crisis



Source: DG Research and Innovation

Science, research and innovation performance of the EU 2020

## R&I FOR A SAFE AND JUST SPACE FOR HUMANITY

### #1 **As an overarching policy message: the European Green Deal requires a shift to a transformative innovation policy**

- ▶ 100% increase in greenhouse gas emissions since 1980
- ▶ Twice as many Europeans aged 80+ by 2100
- ▶ 45% of global wealth owned by the richest 1%

**Our climate and environment, economy and society are experiencing profound changes that will fundamentally alter our current way of life.** R&I activities, and R&I policy, are taking place in a context where global and long-term forces are influencing our needs, including climate change, loss of biodiversity, an ageing population, and growing inequalities. Against this backdrop, the way we both produce and consume is not sustainable: currently, no country in the world seems able to meet its citizens' basic needs at a globally sustainable level of resource use.

**R&I contributes to address these challenges and is key to delivering on the Sustainable Development Goals (SDGs).** R&I can provide solutions<sup>2</sup> to overcome the challenges we face, enable us to better understand our world and make our society more resilient in the long term. In the context of accelerating digitalisation, R&I solutions are also needed to mitigate the environmental footprint of ICT and AI, improving, for example, the energy efficiency of data centres and high-performance computers, and telecommunications infrastructure. The EU is already performing strongly in several areas, leading technological progress in the fields of energy, climate, environment, food and the bioeconomy.

It is crucial that the EU maintains and reinforces leadership in key areas to successfully deliver on the SDGs.

**The interconnection between social, economic and environmental issues calls for a profound transformation of our systems,** in particular agro-food, energy and transport. This sustainability transformation is an unprecedented governance challenge at all levels, from local to global. It results from the combined effects of the urgency, the scale of the necessary transformations, the complexity, and the interdependence of issues in a context of fragility and unpredictability. The **European Green Deal** provides a strategy to make the EU economy sustainable by turning climate and environmental challenges into opportunities across all policy areas. However, the Deal will only be possible by means of a highly ambitious agenda linking research, innovation and investments with reforms and regulation that can mobilise a collective response across Commission services, Member States, regions, companies of all sizes, academia and the public.

**To deliver on the Green Deal, EU R&I policy should shift to a transformative policy which sets the direction in investments, reforms and regulation**

<sup>2</sup> These can include science-driven and deep-tech innovations as well as social innovations and non-research-based innovations

(see Box 0-2) to stimulate the emergence and diffusion of knowledge and (radical) solutions for the transformation towards sustainability. A transformative innovation policy can become a compass to help the EU to navigate the complexities of our world and co-create a common direction, as a key enabler of the European process for SDG policy coordination. However, this is not an easy task: a transformative innovation policy involves several policy challenges, such as **synergies** between policies, **co-creation**,

involving a wider set of actors, and ensuring the dissemination of radical innovation across the market and society. **Horizon Europe**, the EU's R&I Framework Programme for 2021-2027, is a key part of EU transformative policy. It will continue to create new knowledge and solutions to achieve the SDGs and will provide increased directionality through its **mission-oriented approach** (on, for example, climate change, healthy oceans, climate-neutral and smart cities, and soil health and food) and European partnerships.

## BOX 0-2 Instruments for an EU R&I policy

Actions to deliver on EU R&I policy can be regrouped under three main categories – investment, regulation and reforms – in combination with a co-creation approach across the entire Commission agenda and joining up capacity with and across the Member States through the European Research Area (see Box 0-3).

### Investment

Several EU initiatives aim to step up investment in R&I capacity. Among them, the EU's R&I Framework Programmes are its main instruments for investing in R&I and directing investment towards EU political priorities.

**Horizon Europe**, covering the period 2021-2027, will be the EU's largest ever R&I Framework Programme, and will presents different novelties compared to its predecessor, Horizon 2020, which has covered the period 2014-2020.

- ▶ EU-wide **missions** are an important new feature of Horizon Europe. They will focus on a handful of ambitious but time-bound and achievable high-visibility goals. They are an R&I tool but offer the scope to support

much broader aims to deliver European public goods on issues that really matter, such as fighting cancer, preserving our citizens' health from all kinds of pollution, ensuring food security and restoring land, and protecting our seas and oceans.

- ▶ The **European Innovation Council** (EIC) is another major novelty in Horizon Europe. It aims to put Europe on top of the next wave of breakthrough, market-creating innovation at the intersection of digital/AI and deep tech. It will be the one-stop shop for innovation, delivering on EU objectives to enable more innovators to bring breakthrough technologies to market and making it easier for small businesses to become large innovators.
- ▶ The next generation of R&I European **partnerships** also aims to respond to the needs of all EU Member States and stakeholders (citizens, industry including small and medium-sized enterprises (SMEs) and civil society) in line with agreed EU strategic priorities.



Smart specialisation strategies under the **EU Structural Funds** are another key initiative to support R&I. During 2014-2020, the European Regional Development Fund has contributed more than EUR 40 billion to the development of R&I strategies by Member States and regions across Europe.

In the coming years, the Commission will aim to ensure access to affordable finance and mobilise private funds for R&I through different instruments, such as a dedicated window under the **InvestEU Fund** that relies on financial instruments and budgetary guarantees, and **VentureEU**, which has the potential to double the total venture capital investment in Europe. The **European Investment Fund** also provides risk financing for SMEs and small mid-caps.

### Regulation

The impact of these investment instruments will be greater if policy and regulation actively stimulate innovation. By applying this **innovation principle**, the Commission can help ensure that innovative activities by European entrepreneurs, researchers, business and civil society are aligned with the broader social, environmental and economic objectives and that innovation realises these objectives better and more quickly. The acceleration of technological development also calls for less traditional approaches to regulation and policy, such as **regulatory sandboxes and policy experimentation** (see also message #10).

### Reforms

Most of the public budget and policies for R&I are in the hands of the Member States. This is why there is a need to encourage national policy reforms. A **European Semester** integrating the SDGs supports Member States in making effective reforms of their national and regional policies and systems. Notably, this involves linking up the necessary reforms with an appropriate synergy of investments from the relevant programmes in the Multiannual Financial Framework (e.g. European Structural and Investment Funds (ESIF), European Social Fund (ESF), Horizon Europe). This will support the alignment of efforts at the national and EU levels to address the ecological, economic and social transitions. The European Semester is reflected and reinforced by the **European Research Area** (see Box 0-3) and complemented by specific R&I assessment and governance. The **Policy Support Facility** (PSF) is an instrument to encourage Member States to improve their R&I policies. The **Structural Reform Support Service** (SRSS) also helps EU countries to design and carry out structural reforms as part of their efforts to support job creation and sustainable growth.

**Given the size of the challenges ahead, having an ambitious target for investing in R&I will be crucial.** Although the EU has yet to fulfil its R&D investment ambition in 2020, the **3% target** has proven to have clear mobilising effects. National R&I investments that are aligned with a common direction can significantly accelerate the transition towards

an environmentally, socially and economically sustainable Europe. The **European Research Area** (see Box 0-3) can drive such an ambition and make a significant contribution to addressing our challenges by building critical mass across countries, leveraging the renewed European Semester along the SDGs.

## BOX 0-3 The European Research Area

The European Research Area (ERA) provides a framework to join up our national and European R&I agendas, strengthen national, regional and local capabilities, bridge gaps in R&I performance, and achieve the critical mass needed to maintain our international competitiveness and tackle the major challenges we face together.

The ERA is key for all dimensions that relate to **researchers** in Europe, including their working conditions and mobility (see message #7). It has the potential to mainstream core value and principles and boost ownership of R&I in all Member States and Associated Countries.

Similar to the overarching nature of the challenges that we face, the need for an innovation policy to enable the transformations required can be seen as an **overarching policy**

**message that can be reinforced when considered together with the following 10 policy messages.**

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### READ MORE IN:

- ▶ **Chapter 1** Megatrends and sustainability
- ▶ **Chapter 4** Equality and cohesion
- ▶ **Chapter 9** Transformative innovation and socio-technical transitions to address grand challenges

## #2 Making sure that growth does not leave anyone behind ... people, regions, countries and firms

- ▶ 72 %, the share of total R&D expenditure by the top world 250 R&D investors
- ▶ 27 of 266 regions account for half of EU R&D spending
- ▶ 19 of the 29 EU unicorns are currently located in capital regions

**There are laggards in EU R&I.** There is a concentration of R&I activities in a few regions, countries and companies in Europe, and different EU R&I divides can be observed according to several indicators.

- ▶ At the level of **people**, digitalisation, automation, and robotisation risk creating job displacement and further shrinking the labour share of income, which could have consequences for inequality, particularly income inequality and inequality of opportunity.
- ▶ At the level of **regions**, Europe shows high concentration and agglomeration effects, with no upward convergence of regions and, for some regions, a strong need to shift to an innovation-driven growth model.
- ▶ At the **country** level, the EU R&I landscape presents very strong disparities. North-western Member States continue to show stronger R&I performance than other Member States. The EU has shown convergence in economic output with many countries catching up since 2000, but the economic growth in many central, eastern and southern European countries slowed down in the post-crisis decade.
- ▶ At the **company** level, the widening gap in terms of productivity between frontier firms and the rest points to a lack of technology

diffusion. At the bottom of the distribution, the misallocation of resources, including credit, barriers to entry and inefficient product and labour markets eases the survival of less-productive firms which would otherwise have exited the market (zombie firms). However, among laggard firms, some are entering the economy, operating below their productivity potential during the first stage of their development. For these firms, R&I can play a key role by improving their absorptive capacity and allowing them to catch up with firms with higher productivity.

**To tackle these different R&I divides, the EU needs to support the cohesive and inclusive growth of companies, regions and countries.**

R&I should be promoted through place-based policies to boost underutilised regional potential and strengthen regional innovation systems, especially in less-developed regions, to increase EU competitiveness as a whole and close the R&I divide. Cities are also key actors which need to be acknowledged and can play a significant role. There is a need to encourage public support to R&I for the catching-up laggard firms, increasing their capacity to absorb and adopt technology. It is also essential to ensure that Europeans have the skills to accompany the new technological revolutions (see also policy message #3).

**This implies greater coordination at all levels of R&I policies and Cohesion Policy<sup>3</sup>,**

3 The implementation of smart specialisation strategies since the reform of the European cohesion policies in 2014 represents an important step in the right direction.

**together with education and training.** R&I policy plays an important role for laggard companies and regions to catch up by improving the conditions to speed up knowledge creation

and diffusion, through investment, regulation, science-business links, framework conditions, and the capacity and quality of R&I systems. In this context, the **ERA** is key.

### READ MORE IN:

- ▶ **Chapter 3** Productivity, structural change and business dynamism
- ▶ **Chapter 4** Equality and cohesion
- ▶ **Chapter 5** Investment in intangible assets
- ▶ **Chapter 10** The bottom also matters: policies for productivity catch-up in the digital economy
- ▶ **Chapter 12** The research and innovation divide in the EU and its economic consequences

### #3 Equipping Europeans with the skills to navigate the changing world

- ▶ 8.2% decline of middle-skills employment within the workforce over 1995-2018
- ▶ 133 million new work roles may emerge worldwide until 2022
- ▶ 8 out of 10 firms consider lack of staff with the right skills a barrier to their investment activities

**With technological change, new jobs will require new knowledge and skills for workers to adapt and progress in the fast-moving labour market.** The rise of digital technologies and their convergence with the physical world is already affecting millions of workers and companies around the world, changing the nature of many jobs. Today, and even more so in the future, more and more jobs will require specific skills that combine technological knowledge and problem solving together with soft skills such as collaboration or empathy. Europe's population is slowly

making progress in mastering the increasingly important digital skills, but more is needed to broaden and upgrade the skills set demanded in the digital age.

**In this context, there is a need to step up efforts and look for new orientations regarding skills.** The **Skills Agenda**<sup>4</sup> is going in this direction, and also supports the green and digital transition. As the pace of innovation continues to accelerate, governments need to act and reinforce the competitiveness of their economies for the future. They will have to find

4 For example, by modernising vocational education and training policies, developing skills intelligence, engaging with industrial sectors/value chains, incentivising learners to take their upskilling in their own hands, helping people to have their skills validated and recognised, and developing an EU framework for micro-credentials to facilitate the recognition of shorter training.

an investment framework and strategies that enable people to harness the benefits of the technological revolution and avoid negative scenarios. Europe's prosperity and social model depends on its ability to ride the new wave of innovation ahead of us, whilst ensuring broad participation in the benefits accruing from these innovations.

**Overall, EU policies need to tackle the mismatches of available skills on the labour market and improve skills intelligence and recognition.** With very limited growth in the share of adults participating in education and training, it is important to increase adult participation in learning, in particular for those most in need of access to learning. This means incentivising investments in training, mentoring, coaching and other activities that promote lifelong learning and soft skills, such as the

capacity to adapt and adopt new technologies in a fast-changing world. The EU must also attract talents to research in order to sustain its scientific excellence as a time when international competitors (in particular China) are expanding their talent pools. Against this backdrop, education and training will be key to refining and amplifying research skills in Europe. As skills are essential to most of the Commission priorities, including the Green Deal, social Europe, the gender strategy, and the industry strategy, there is a need for increased **synergies among programmes such as Horizon Europe, the ESF and Erasmus+**. Further strengthening links between the **ERA and the European Education Area** will be required to ensure skills and education are key drivers of Europe's competitiveness and innovation.

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## READ MORE IN:

- ▶ **Chapter 4** Equality and cohesion
- ▶ **Chapter 5** Investment in intangible assets
- ▶ **Chapter 11** The consequences of AI-based technologies for jobs

### #4 Fast-forwarding to gender equality in and through R&I

- ▶ Women represent about a third of all EU researchers and one fifth of researchers in the business sector
- ▶ 73% of platform workers are men
- ▶ 16% of start-up founders worldwide are women
- ▶ Only 6% of unicorn founders worldwide are women; in the EU it is 2%
- ▶ Women represent just over a quarter (27%) of board members in the largest publicly listed companies

**Despite progress, gender inequalities are persistent in Europe, as well as in R&I activities.** Everyone benefits from greater female participation in the knowledge economy

but we are not there yet: despite some progress, women are still under-represented in R&I and the digital economy. In education, gender imbalances among graduates are

larger compared to enrolled students. Although women represent roughly half of EU graduates at doctoral level, they represent only about a third of all EU researchers and only one fifth of researchers in the business sector.

**There is also a pronounced gender gap in the creation of innovative startups.** The emergence of digital technologies does not help to close the gap, as observed by the lower participation of women in ICT-related fields and platform work. A gender diversity gap in AI research also persists, although it is less pronounced in Europe than in other regions worldwide.

**This calls for efforts to be pursued at all levels to promote gender equality.** Gender equality and gender ‘mainstreaming’ (the integration of a gender perspective in the preparation and evaluation of policies) in research, the promotion of these policies in R&I, and support for women’s participation in the labour market should be maintained, getting them in the right position or type of job and, where possible, reinforced in order to make further progress. The EU must also tackle the start-up gender gap, beyond the classical market failures.

### READ MORE IN:

- ▶ **Chapter 3** Productivity, structural change and business dynamism
- ▶ **Chapter 4** Equality and cohesion
- ▶ **Chapter 5** Investment in intangible assets
- ▶ **Chapter 7** R&I enabling artificial intelligence

## R&I for global leadership

### #5 Shaping Europe’s competitive edge in the global race for technology

- ▶ The EU accounts for about one fifth of the world’s R&D, publications and patents
- ▶ China’s share in R&D worldwide has increased almost fivefold from 5% in 2000 to 24% in 2017; this rapid increase can be observed for most R&I indicators
- ▶ Productivity growth in the EU over 2008-2018 has been reduced by half compared to 1995-2007

**The rapid pace of technological development among global competitors is creating concerns over technological sovereignty.** While the EU is a global R&I powerhouse, accounting for almost 20% of R&D worldwide

but with less than 7% of the world’s population, it lags behind global competitors for various indicators, including in terms of investment in R&I and other intangibles, especially from the private sector. Furthermore, these competitors

are evolving rapidly. The rise of China in particular is quite impressive and can be illustrated in technologies such as AI, where the Chinese evolution over time is significant, even though Europe shows a strong performance. EU's scaling-up performance also lags behind the United States and China: for each EU private unicorn there are eight in the United States and four in China.

**Against this backdrop, R&I can reinforce companies' ability to be competitive at the global level through improved productivity,** resulting in jobs and creation of value, in a sustainable way. Competitiveness, productivity and innovation are separate although very closely interrelated concepts. In the global context, it would be a mistake to ignore the fact that innovation can drive EU competitiveness through productivity growth: spurring innovation acts directly on what is produced, making goods better and cheaper, as well as ensuring that what is used to produce is done efficiently. Productivity can also help overcome the trade-off between environmental policy and long-term growth. Increasing efficiency in the production process can be compatible with producing in a sustainable way and supporting the sustainable transition. However, despite the rise in digital technologies in the past decade promising large productivity gains, productivity growth has been sluggish, holding back more robust economic growth in Europe and other advanced economies.

**EU technological sovereignty at risk has several implications which link R&I policy to industrial policy.** An **EU industrial strategy**, supported by a vibrant ecosystem that allows for the scaling up of its innovators and SMEs (see policy message #7), is key to countering the deindustrialisation trends in the EU and increasing long-term EU competitiveness while meeting the needs of a transition towards a climate-neutral and sustainable economy. It is crucial that the industry plays its part in achieving EU technological sovereignty by safeguarding essential elements

of strategic value chains, including raw materials, assembly lines, machine tools and services. The EU's strategy for cooperation in R&I with third countries should take into full consideration the need to protect EU strategic interests. R&I cooperation also provides a common basis for engagement, developing trust and common agendas that can be blueprints for common governance of broader issues. In this context, science diplomacy can be an effective instrument of soft power in support of EU external action. Furthermore, these international considerations should be made in the light of European values and the European identity, including the choice of a different social protection system compared, for example, to the USA.

**At the same time, the EU approach to R&I has long been one of openness to the world** to facilitate brain and knowledge circulation, combined with strategically targeted actions with key partner countries. This multilateral approach is at the heart of EU efforts for international coordination towards achieving the SDGs, and has served EU interests by establishing mutually beneficial cooperation with international partner countries. This approach is becoming increasingly necessary as more and more new centres of excellence and markets develop outside Europe. Attracting talents to EU R&I is key to sustaining EU excellence in R&I as other countries, in particular China, are expanding their talent pools while the EU is facing negative demographic developments. Moreover, in the current R&D and geopolitical landscape, setting up a level playing field for fair competition and cooperation with third countries is lagging behind in some cases, calling for the EU to redouble negotiating efforts while anticipating any risks to its interests. Against this backdrop, **ensuring multilateralism and purposeful openness, while assertively negotiating a global level playing field, should be at the heart of the EU's approach to international cooperation.**

## READ MORE IN:

- ▶ **Chapter 3** Productivity, structural change and business dynamism
- ▶ **Chapter 5** Investment in intangible assets
- ▶ **Chapter 6** Scientific performance, knowledge flows and innovation output
- ▶ **Chapter 7** R&I enabling artificial intelligence

### #6 Modernising R&I policy to make it fit for purpose in the digital age

- ▶ 7/10 of the top companies by market capitalisation are US and Chinese tech giants
- ▶ 72% share of total R&D expenditure of the top world 250 R&D investors (out of the top 2000 R&D investors)
- ▶ EU28 accounts for 8% of global AI private investments
- ▶ 60% of all AI science is in fields other than computer science

**Digitalisation is transforming R&I.** All areas of research are becoming data-intensive, increasingly relying upon and generating big data. Technology, notably in the business-to-consumer (B2C) segment, is spreading faster than ever due to the transition from physical to digital goods combined with network effects in the age of digital transition. The convergence of the digital and physical worlds is increasing innovation complexity and leading to deep-tech science-driven innovations. There are increasing industry concentration and mark-ups over time (both in Europe and to a greater extent in North America), not confined to digital-intensive sectors. The market dominance of ‘tech giants’ is not only visible in terms of R&D concentration and market capitalisation, but also when it comes to some of the key technologies underpinning digitalisation, such as search engines, operating systems and cloud infrastructure. While the R&I investments needed to produce deep-tech innovations can prove costly, companies that sell digital products can manage to operate almost under ‘zero marginal costs’.

**R&I in AI has experienced significant development over the recent years.** Data explosion, stronger computational power, more sophisticated algorithms and open source software have enabled breakthroughs in AI R&I. AI is increasingly blending with digital technologies such as blockchain and with the physical world in fields such as advanced manufacturing and materials science. In terms of performance, the EU ranks among global leaders in AI science but trails in AI innovation, although it is in line with its share in global R&D. Private investments are on the rise, notably in the United States and China, but EU investments remain insufficient.

**Digital transition means policy-making needs to evolve.** With innovation moving at an unprecedented speed, policy should react faster to the changing contexts. Fostering deep-tech, science-driven innovations requires the right policy mix, such as supporting frontier research, R&D labs, innovation and digital hubs, appropriate research and digital infrastructures, and access to capital for digital R&I. To exploit



the full potential of science digitalisation, policies must be adapted to reinforce digital skills of researchers and across society, promote open science as well as ensuring the necessary investments in high-quality data infrastructures. There is also a need to improve digital competences (see message #3) and foster the adoption of digital technologies.

**The EU should capitalise on its scientific and industrial strengths to lead in AI development**, and foster technologies that both benefit and augment its potential. The EU and Member States should join forces to raise the level of public and private investments in AI, deepen the **Digital Single Market**, achieve AI technology sovereignty and diffuse AI practices across the Union. AI also requires enhancing talent production and retention in the EU, investments and capacity-building in related digital technologies, such as high-

performance computing, European cloud and micro-electronics, and digital infrastructure, notably 5G.

**Europe should improve the ‘trust in tech’**. The promotion of guiding principles of trustworthy, human-centric, and ethical AI is a strength and not an obstacle to the EU AI innovation ecosystem. This also calls for improving access to data for innovation in Europe while providing clarity about principles and regulations regarding privacy and the ethical use of data.

**The rise in concentration has implications for business dynamism, competition policy, and wealth distribution**. There is a need to support European digital companies to compete globally in providing cloud infrastructure, operating systems and other digital technologies that are underpinning digitalisation.

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## READ MORE IN:

- ▶ **Chapter 2** Changing innovation dynamics in the age of digital transformation
- ▶ **Chapter 5** Investment in intangible assets
- ▶ **Chapter 7** R&I enabling artificial intelligence
- ▶ **Chapter 11** The consequences of AI-based technologies for jobs
- ▶ **Chapter 14** Digital adoption in Europe and the United States

## #7 Ensuring scientific leadership and stimulating knowledge flows within the EU

- ▶ The EU accounts for one fifth of publications and highly cited publications in the world. The EU's share of highly cited scientific publications in food and bioeconomy is 27%
- ▶ 13% of EU researchers are currently employed in another country with large differences between Member States

**The EU is a powerhouse in science.** It is a champion in scientific production and ranks among the top players in excellence, although not at the top, with the USA maintaining its global leadership in terms of scientific quality. New global developments, such as the UK's exit from the EU, the sharp rise of China, digitalisation, and a new focus on sustainability are impacting the EU's scientific performance.

**EU science is and should remain open.** Europe's diversity, freedom of movement of people and cooperation between R&I actors is potentially an unrivalled source of R&I performance. The EU leads in terms of **open science policy**, with a significant impact and structuring effects on research performance. However, it can do more and foster further knowledge flows between disciplines and actors. Yet stark disparities remain between countries in international and inter-sectoral mobility patterns in the EU. In general, countries with higher R&I performance tend to have a higher inflow and outflow of researchers. Furthermore, the gap in productivity performance between highly productive economies and firms at the frontier and the rest points to a clear lack of technology diffusion in Europe.

**In this context, it is essential to support the dissemination of research results, researchers' mobility, public-private cooperation and (open) international cooperation,** as they are key ingredients for knowledge diffusion, creating solutions to grand challenges and boosting competitiveness in Europe. While the EU's open access policy is well advanced, with a strong open access and open data mandate in the EU Framework Programme, there is a need to step up efforts in implementing its ambitious European open and FAIR data policy.

**To remain a leading global scientific player and ensure that knowledge flows between EU actors, Europe needs a strong ERA.** The EU and its Member States must strengthen efforts to increase the effectiveness and performance of the public research systems through stronger R&I investments and policy reforms. This means improving further national R&I systems, continuing to facilitate and strengthen the interaction between industry and academia, stepping up efforts to implement an ambitious European open data policy, and strengthening the capacity of small firms to engage in R&I collaborations. Completing the **Single Market** is also key to fostering knowledge diffusion across the continent.

### READ MORE IN:

- ▶ **Chapter 6** Scientific performance, knowledge flows and innovation output

## #8 Building a vibrant and resilient R&I ecosystem in the post-Siemens-Alstom era

- ▶ 7 out of 30 top global start-up ecosystems are in the EU
- ▶ 7% of 'today's unicorns' are based in the EU
- ▶ 8 times more venture capital funds are raised in the USA than in the EU
- ▶ In 2018, the share of public sources in total venture capital funds was 22%

### Although Europe is rich in ideas and talent, it can improve the framework conditions and ecosystem in which business takes place.

While top-performing EU Member States have very efficient products and labour markets, on average, the EU lags behind the United States and Japan in these aspects. Institutional quality is high in the core of the EU and in capitals, with a high degree of regional variation and heterogeneity within and across countries. Lower access to risk capital remains a constraint to scaling up: in the United States, eight times more venture capital funds are raised for innovation than in the EU. Slightly more than 1 in 10 enterprises in the EU are high-growth, but only a relatively small share are in high-tech, medium-high-tech manufacturing and high-tech knowledge-intensive services. Overall, the EU presents 7 ecosystems in the world 'top 30' start-up ecosystems, compared to 12 in the United States and only 3 in China. It also presents a decline in business dynamism over time, which is observed in other regions in the world and may hamper productivity growth.

### Europe needs to better support the scaling up of its innovators and SMEs.

When it comes to tech scaleups and unicorn companies, a pronounced scaling-up gap remains in relation to the United States and (sometimes to) China. Europe should capitalise on its strong science and richness of ideas for innovation to have key players in the global scene that reflect

EU's values and ambitions. This is compatible with a 'tech-with-a-purpose' approach which integrates social and environmental concerns in business missions to ensure that new products and services bring not only economic but also societal value. Overall, there is a strong need for policy initiatives that aim to tackle the scaling-up needs in terms of capital in EU startups, such as the **European Innovation Council**, the **VentureEU** programme, and the different financial instruments available via the **European Investment Bank**.

### These results also call for policies that tackle the heterogeneity among Member States by ensuring efficient framework conditions and institutional quality

across regions and countries, in particular in the peripheral economies in the south and east. There is a need to improve overall framework conditions for innovation, including access to finance – risk capital and other alternative sources of financing – and the deepening of the **Single Market** to ensure the scaling-up of 'made in EU' disruptive ideas, and their permanence in the EU, while maintaining a global outreach. It also means building more resilient start-up ecosystems underpinned by a strategic vision that builds upon the EU's industrial strengths and tackles societal challenges by providing solutions addressing, for example, climate change (interlinked with the European Green Deal).

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**READ MORE IN:**

- ▶ **Chapter 3** Productivity, structural change and business dynamism
- ▶ **Chapter 8** Framework conditions
- ▶ **Chapter 13** Regulations and technology diffusion in Europe: the role of industry dynamics

## R&I for economic and societal impact

### #9 Maximising the value of R&I results for society, the economy and policy

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- ▶ The EU accounts for 1 in 5 PCT patent applications worldwide
- ▶ The EU is third after the USA and South Korea in terms of public-private co-publications

**Producing excellent solutions is not enough.** It is necessary to go beyond the approach of innovation output only and have a more holistic approach to ensure robust exploitation of R&I results and, overall, knowledge valorisation. This refers to the process of creating value from knowledge and turning the results into sustainable solutions with economic value and societal benefits. R&I can only play a decisive role in shaping social, environmental and economic transitions if excellent results are quickly made available and put to practical use on a large scale.

**Europe needs to make more of its R&I.** Even though the EU outperforms the United States in terms of scientific output and number of researchers, it is surpassed in scientific quality, technological progress, share of high-tech

sectors in the economy, and business-academia linkages. Hence, Europe needs to address its deficiencies by promoting a culture of knowledge valorisation in European R&I policy, ensuring that knowledge-based institutions know how to manage their intellectual capital and improving the links between academia, industry, citizens and policymakers.

**This calls for a reinforced knowledge-valorisation policy in Europe** that relies on a set of instruments acknowledging different knowledge-valorisation channels. This means supporting European intellectual property policy and culture as well as fostering science-industry interaction and engaging citizens and local communities in knowledge uptake by the markets and by society.

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**READ MORE IN:**

- ▶ **Chapter 6** Scientific performance, knowledge flows and innovation output

## #10 Making the EU's regulation innovation-friendly and forward-looking

**Europe needs a fit-for-purpose, forward-looking and overall innovation-friendly regulatory framework** to ensure well-functioning markets that incentivise competition and innovation, maximising the impact of EU R&I investments. Regulation, when featuring adequate levels of stringency and appropriate timing, can steer innovation towards addressing societal needs. At the same time, regulation needs the flexibility to adapt to an industry and society that are evolving rapidly. It should strike a balance between predictability and flexibility, and should also guarantee fair competition without sanctioning failure or risk-taking.

**There is room to make regulation smarter in Europe, in particular for R&I.** There are strong differences between the EU Member States in terms of perceived regulatory quality. However, compared to China, Europe appears to enjoy substantially more trust and confidence regarding its regulations and standards. This means that Europe should capitalise on its *acquis* while facing potentially unfair practices; this calls for proper agility and flexibility in its regulatory framework.

**A fast-moving and increasingly complex environment poses new challenges for regulation design.** The growing role of digitalisation in various sectors of the economy may not always be properly reflected in regulation, and the same applies to the increasingly data-driven nature of innovation. In this context, experimental approaches to regulation, including the so-called '**regulatory sandboxes**' and **policy experimentation** can also be relevant.

**Regulation design can be a crucial lever for stimulating R&I to deliver on policy objectives.** It goes beyond improving the environment for doing business and can contribute to achieving sustainable growth and desirable social and environmental benefits. Using horizon scanning and innovative regulatory approaches to harness future technological advances and steer them towards delivering on European Commission priorities, the innovation principle can provide valuable insights into other policies in the areas of climate, environment, health, food, competitiveness and industry. It can help harness future technological advances and steer them in the direction of delivering on European Commission priorities.

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### READ MORE IN:

- ▶ **Chapter 8** Framework conditions
- ▶ **Chapter 13** Regulations and technology diffusion in Europe: the role of industry dynamics

## #11 Anticipating the future world through better evidence for policy

**R&I policy has to deal with a lot of uncertainties, and related risks**, maybe even more so than in other policy fields because of the intrinsic forward-looking nature of R&I. Priorities and choices must be informed, and evidence from various sources, such as indicators, analyses, and policy evaluations, are essential to guide policymaking. However, when it comes to predicting or forecasting future developments, the task is not a trivial one. Although the notion that the future is uncertain is hardly novel, it poses challenges for policies that take a long time to set up and execute as they must rely on longer-term forecasts that can have a poor track record. Debates on the future of work illustrate the need for solid evidence in order to better anticipate upcoming developments in the labour market. While technological transformation is not expected to be friction free, there is still little evidence, beyond the perception of stakeholders, on the extent of massive disruption across sectors. In this context, faster and more accurate forecasts that provide better quality can be more desirable, for example, to identify the required future skills, but they imply policy design that allows for a faster response.

**Horizon scanning is key for a strategic R&I policy that anticipates the future world.** A good understanding of capacities and aspirations for future innovation is an invaluable basis for reflection and debate on the potential impacts of different investment decisions and on the normative and strategic considerations that should guide such investment decisions. A scan of the horizon at a specific point in time raises our awareness of potentially important areas of R&I and enables a better-informed R&I strategy. It allows us to ask ourselves whether or not we need to invest in all these areas and why, and by so doing, to better understand the opportunity cost of our choices. Foresight analyses and horizon scans should be systematic, continuous and comprehensive, feeding into decision-making processes that are engaging and participative, involving broad sets of stakeholders and the concerned publics, in a new EU R&I policy that will successfully pave the way to a fair, green and digital Europe.

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### READ MORE IN:

- ▶ **Chapter 11** The consequences of AI-based technologies for jobs
- ▶ **Chapter 15** Scanning the innovation horizon and throughout the whole report