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Research and Innovation

Science, research and innovation performance of the EU 2026



Securing Europe's growth

Science, research and innovation performance of the EU 2026 – Securing Europe's growth

European Commission
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EUROPEAN COMMISSION

Science, research and innovation performance of the EU 2026

Securing Europe's growth

2026 Directorate-General for Research and Innovation

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Foreword



The world has radically changed since the last edition of the Science, Research and Innovation Performance of the EU report in 2024, above all in the geopolitical dynamics shaping science and technology. The 2026 edition of this biennial flagship report offers a comprehensive analysis of Europe's research and innovation (R&I) performance and trends and draws out the policy lessons that matter most at this moment. Its vast number of findings and insights make it an invaluable source of expert analysis, embedded in a coherent policy narrative. I invite you all to explore this latest edition, which I see as framing Europe's competitiveness challenge along three dimensions integral to R&I policy:

First: People. This edition stresses Europe's considerable strengths in upstream science and research in the context of an open science culture and calls for investing in the brilliant minds that underpin it. The EU proudly ranks second in global scientific output and produces 57 % of its publications through international collaboration; but our overall research excellence and notable strengths in e.g. health and biotechnology are less pronounced for digital strategic technologies. Moreover, the report highlights that persistent talent shortages, a fragmented European R&I geography, and precarious research contracts threaten our long-term scientific capacity. By strengthening the European Research Area and the Commission's 'Choose Europe for Science' strategy, we are actively attracting and retaining global talent and reinforce the EU as a highly competitive scientific powerhouse in a period of geopolitical uncertainty.

Second: Technology. We are at a technological crossroads. Breakthroughs in AI, quantum computing, advanced materials, biotechnology and clean technologies are redefining competitiveness and economic performance. This latest report shows that Europe's R&D intensity saw little change at 2¼ % of GDP in 2024, but an estimated EUR 560 billion is required in additional cumulative investments to reach our 3% R&D intensity target by 2030. But even reaching that 3% of GDP target would not necessarily suffice to keep pace with global competitors, some of whom spend around 3.5% or more of annual GDP on R&D each year. Europe retains formidable industrial strengths in the green transition and excels in wind energy, carbon capture, and hydrogen, but our dependencies in the digital domain are stark. With 90% of global data centres located outside EU jurisdiction and a declining share of global patent applications, securing our technological sovereignty also means deploying capital to scale up high-tech sectors.

Third: The Role of the Public Sector. Innovation requires a bold and cohesive approach to R&I funding at all levels of governance. This report also investigates Europe's R&I collaborations in terms of its high degree of fragmentation, particularly in co-patenting. EU and national actors must therefore move in partnership to create synergies and foster spillovers. Furthermore, this edition reveals how heavily our scale-ups rely on foreign capital, with non-European investors providing half of late-stage deep-tech funding. By leveraging tools like the European Innovation Council, which successfully attracts over EUR 3.50 in private funds for every euro invested, and improving regulatory frameworks, the public sector can cultivate the risk appetite required to valorise European research and ensure innovation leads to market uptake.

I invite you to explore this report's wealth of ideas and findings as we work together to build a more resilient, competitive and innovative Europe.

Ekaterina Zaharieva
European Commissioner for Startups, Research & Innovation

Ekaterina Zaharieva

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EXECUTIVE SUMMARY

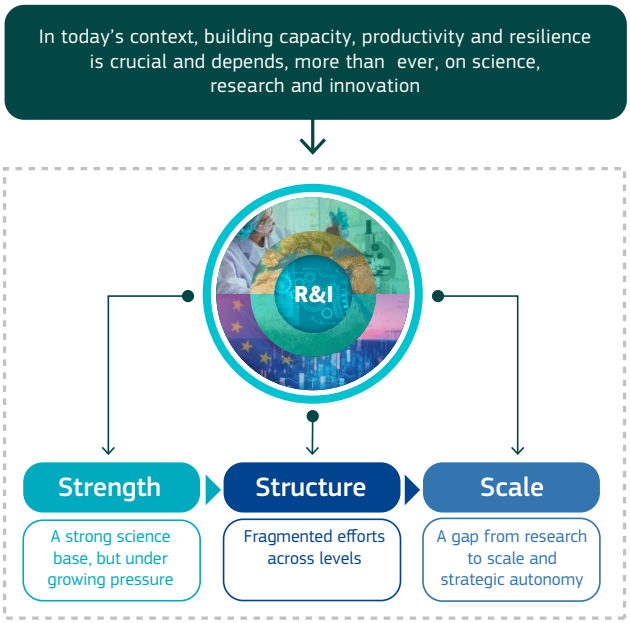
The EU faces a fundamental economic challenge. In a world of intensifying geopolitical competition, rapid technological change and slowing productivity growth, sustaining prosperity, competitiveness and strategic autonomy increasingly depend on the ability to generate, deploy and diffuse new knowledge. Science, research and innovation are among the most important drivers of productivity growth and, consequently, of the EU's long-term economic performance.

The 2026 edition of the Science, Research and Innovation Performance of the EU report builds on a wide range of new analyses and data sources to offer a comprehensive and detailed overview of how the EU is performing today in terms of science, research and innovation. Each chapter can be read independently, catering to readers with various backgrounds and interests.

The introductory chapter 'Securing Europe's growth' sets out an overarching perspective: for the European economy to grow and keep pace with the economies of the other major global powers, productivity should be the focus. The need for faster productivity growth, in turn, puts science, research and innovation at the very core of European policymaking. Economic growth, competitiveness, resilience and strategic autonomy are all objectives that can be achieved only if the EU is able to translate its strengths in terms of scientific capacity and talent into innovation and productivity.

Three critical messages emerge from the report (Figure 1): (i) **strength** – the EU retains significant strengths in science, although these are increasingly contested in a rapidly evolving global environment; (ii) **structure** – the EU's research and innovation (R&I) system remains fragmented across countries, regions and institutions, limiting its ability to fully exploit its collective capabilities; (iii) **scale** – the EU continues to face difficulties in scaling innovation and transforming research excellence into market leadership, industrial deployment and productivity growth. Together, these challenges define the strategic agenda for European science and R&I policy.

Figure 1 From strength to scale



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit.

PART I

Part I starts with a selection of key figures on recent trends in chapter 1. It then presents key analytical insights across six dimensions: R&I investment (chapter 2), the European science system (chapter 3), technologies and global challenges (chapter 4), financing and scaling innovation (chapter 5), the geography of EU R&I (chapter 6), and artificial intelligence (AI) (chapter 7).

Investing in R&I

While the EU has increased its investment in research and development (R&D) over the past two decades, R&D intensity remains below that of several major competitors, and the gap in absolute spending continues to widen. The EU's R&D intensity rose from 1.81% to 2.24% of gross domestic product (GDP) between 2000 and 2024, yet it remains well below the EU's 3% target and far below the levels of Japan (3.44%), South Korea (4.96%) and the US (3.45%) reported in 2023, with the gap in absolute spending continuing to widen (chapter 2.1). This gap can be explained by the structure of European R&D, where public R&D is mainly channelled to universities and basic research, while private funding remains concentrated in mid-tech manufacturing, with a comparatively small share in the fast-growing high-tech and knowledge-intensive services sectors.

The EU's challenge is not only to invest more but also to ensure that different sources of investment are better aligned across different layers of government. The report highlights the importance of viewing R&I as an integrated system rather than as a collection of individual activities. The evidence presented in the report suggests that EU R&I funds do not crowd out national funds; instead, they reinforce each other: an increase in national investment in R&D is associated with an increase in Horizon Europe funding two years later, and the R&I component of Cohesion Policy funding has a significant crowding-in effect on the capacity of a country to attract funding under Horizon Europe (chapter 2.2).

The European science system

The EU remains one of the world's leading scientific powers, producing a large share of global scientific publications and maintaining a highly collaborative research system.

It ranks second globally in scientific output, with output increasing again in 2024 after several years of decline. Furthermore, scientific collaborations account for 57% of all EU publications, reflecting the growing role of the European Research Area (ERA) in building a single, borderless market for knowledge (chapter 3.1). However, the EU's position is less strong in fields related to strategic technologies, where China is advancing rapidly and the US continues to lead. Strengthening excellence in these fields and retaining senior researchers, particularly women in science, technology, engineering and mathematics (STEM), will be essential to remain competitive.

The EU is actively working to become the destination of choice for global research talent through the *Choose Europe for Science* initiative, though researchers continue to face challenges linked to precarious contracts and a 'publish or perish' culture. These challenges call for responsible research assessment frameworks that better reflect the true value of scientific work (chapter 3.2). The EU benefits from a dense network of universities and research organisations and leads globally on Open Science and academic and scientific freedom. However, emerging geopolitical tensions and the rise of AI necessitate careful reflection on how research outputs are shared and how data quality and security are ensured (chapter 3.3).

Technologies and global challenges

The global technological landscape is becoming more competitive. While the EU continues to hold strong positions in several fields, other major economies have expanded rapidly. Between 2000 and 2022, the EU's share of patent applications under the Patent Cooperation Treaty (PCT) fell from approximately 30% to around 16%, while China's rose from 3% to nearly 33%, signalling a profound redistribution of global innovation capacity. The EU performs well in advanced materials, manufacturing and several green transition technologies but lags in digital technologies including AI, advanced semiconductors and cloud computing, where weaker technological positions frequently coincide with supply chain dependencies (chapter 4.1).

Part of the explanation lies in how the EU converts its research into economic value. The report identifies knowledge valorisation and technology deployment as central areas where it can improve. Innovation is not only about generating new knowledge but also about ensuring that knowledge is translated into products, services and productivity gains. Yet, while the EU's innovation output has increased by almost 10% over the past decade, knowledge valorisation remains uneven across countries, institutions and sectors. Cross-border industry-science collaborations are limited, and bottlenecks at the transition from research to scale-up continue to delay the broader economic impact of R&I investment (chapter 4.2).

Looking at specific sectors reveals where this gap is most tangible. Across life sciences, clean technologies and digital, the EU retains upstream R&I strengths. However, these strengths often weaken further downstream, where commercialisation, deployment and industrial scale become increasingly important (chapter 4.3). These deployment challenges take on added urgency in the context of defence and space, where rising NATO targets could require at least EUR 383 billion in additional annual expenditure by 2035. Yet EU defence investment remains skewed towards equipment procurement rather than R&D, and the EU's share of global space investment is limited and declining. This raises important questions about how public resources can be used most effectively to strengthen long-term technological sovereignty (chapter 4.4). The proposed European Competitiveness Fund signals a growing recognition that closing the EU's innovation gap will entail accompanying strategic technologies along the entire pathway from research to market.

Financing and scaling innovation

The EU's difficulties in scaling innovation are closely linked to broader structural conditions. EU productivity growth over the past 25 years has been roughly half that of the US, and while a post-COVID-19 rebound was encouraging, this momentum has since slowed (chapter 5.1). Weakened business dynamism, market fragmentation, regulatory complexity and barriers to growth continue to limit the expansion of innovative firms. These factors contribute to a widening gap between frontier firms and the rest of the economy, slowing the diffusion of new technologies and reducing aggregate productivity growth.

Finance plays a crucial role in this process. The EU has made considerable progress in developing its startup ecosystem and venture capital (VC) markets. However, it continues to trail the US in scaleup performance, with a persistent late-stage funding gap (chapter 5.2). Furthermore, EU institutional investors hold approximately USD 12 trillion in assets but allocate relatively little to VC. As a result, many of the EU's most promising companies continue to depend on external sources of finance at critical stages of development: around 50% of deep-tech growth-stage funding still

originates from outside Europe. Nonetheless, EU support has been proven to be highly catalytic, with Horizon Europe-backed startups having raised EUR 70 billion in VC since 2010 and the European Innovation Council (EIC) having mobilised over EUR 4 billion in additional private investment.

Capital alone is not enough. Technological change is rapidly shifting labour demand towards high-skill, non-routine tasks. Yet the EU faces persistent talent shortages in precisely these occupations. The report highlights the importance of skills, lifelong learning and workforce adaptability in supporting technology adoption and productivity growth. Regulatory frameworks also matter. While the EU leads globally on better regulation practices, innovation considerations remain underrepresented in impact assessments, and regulatory fragmentation across Member States continues to raise compliance costs for innovative companies. A growing number of Member States are responding by actively using regulatory sandboxes to test innovative solutions and reduce uncertainty, though these should be seen as one tool among many rather than a default solution (chapter 5.3).

The geography of EU science, research and innovation

These financing and scaling dynamics do not play out evenly across the EU. The report further shows that Europe's R&I challenges have a strong geographical dimension. The R&I divide is evident both at the regional level and between urban and rural areas. This divide is widened by self-reinforcing dynamics of agglomeration that favour the most urbanised and historically innovative areas, and it could lead to sub-optimal use of the EU's R&I potential (chapter 6.1). Such concentration can support excellence and efficiency, but it may leave valuable capabilities elsewhere underutilised. This remains an important question for cohesion, as well as for competitiveness and resilience. The EU can strengthen its overall innovation performance by making better use of capabilities distributed across its territories and by improving connections between regions, institutions and innovation ecosystems.

The same logic applies to collaboration. Collaborative R&I activities cluster in the most innovative Member States, and the EU's collaboration system is more fragmented than that of the US, particularly in co-patenting, with this gap growing in the most advanced technology fields where integrated effort matters most (chapter 6.2). The ERA and Horizon Europe, the participation base of which is broader than that of its predecessor, are central instruments for bridging these gaps and building a more integrated internal market for knowledge.

This drive towards greater openness and connectivity extends beyond the EU's borders. International cooperation continues to be a major strength of the European R&I system. EU Member States are increasingly active in global research partnerships: third countries bring complementary expertise, while reciprocity provisions expand opportunities for EU participation in global programmes (chapter 6.3). At the same time, international patenting activity remains heavily concentrated among a small number of partners, and diversification of such linkages will be important to reduce vulnerability to potential disruptions in cooperation.

The role of AI

AI illustrates many of the broader themes identified throughout the report.

AI is rapidly transforming how research is conducted, how firms innovate and how economies grow. AI adoption can deliver firm-level productivity gains and is accelerating scientific discovery across fields. However, the global AI landscape is largely dominated by other major competitors, leaving the EU dependent on foreign infrastructure. This has serious implications

for economic security (chapter 7). The EU's share of global AI patent applications has declined from around 20% in 2000 to 12% in 2022, though major EU cities retain solid positions in AI-related scientific output, on a par with their Asian and US peers. The EU is moving in the right direction now that its AI policy framework has entered a more operational phase. However, turning frameworks into competitive advantage will require sustained investment in compute capacity, data infrastructure and skills at a speed commensurate with the challenge.

PART II

Part II brings together contributions from academics, the Joint Research Centre (JRC), the Organisation for Economic Co-operation and Development (OECD) and the European Investment Bank (EIB) on the following topics.

Chapter 8 argues that the impact of innovation policy naturally hinges on the scale of R&D investment but that investment composition also plays an important role. Evidence from the US suggests that government-funded but privately owned innovation has a disproportionate impact on basic research, productivity and GDP growth. The EU appears to have a narrower pipeline of science-intensive innovation from public institutions. The challenge is, therefore, to strategically increase R&D spending by strengthening institutional channels, connecting public research to private innovation and improving the measurement and tracking of publicly funded innovation.

Chapter 9 makes the case that place-based strategies are indispensable to tackling societal challenges effectively. In contrast to place-blind policies applied uniformly across heterogeneous territories, place-based policies are tailored to exploit region-specific opportunities and address region-specific bottlenecks. The chapter discusses the critical importance of regions for competitiveness, technological sovereignty, the green transition, cohesion and addressing societal discontent.

Chapter 10 examines the EU's technological position in advanced materials through the lens of economic complexity, distinguishing between absolute and relative capabilities and showing that the EU's position differs markedly across sub-fields such as composites, nanomaterials and biomaterials. The chapter argues that combining these two types of indicator can support the design of more targeted R&I policies, allowing the EU to build on existing strengths and better prioritise technological development across Member States and regions.

Chapter 11 explores how the digital and net-zero technological transitions, and the interactions between them, are likely to shape productivity outcomes. Drawing on firm- and sector-level evidence, it highlights the implications of uneven technology diffusion and heterogeneous adjustment pressures, outlining policy directions to support diffusion and capability building for broad-based productivity gains consistent with the EU's twin transition objectives.

Chapter 12 examines how access to finance shapes the EU's ability to turn innovation into competitiveness. It highlights the need to mobilise more institutional capital for VC and growth equity and reduce fragmentation and home bias in European capital markets, providing evidence that well-designed public instruments can crowd in private investment and strengthen exit opportunities. Closing the EU's innovation finance gap requires a lifecycle approach combining targeted public support, deeper capital markets and stronger cross-border investment.

INTRODUCTION

SECURING EUROPE'S GROWTH

Paolo Pasimeni, Erik Canton, Julien Ravet

1. A new and challenging macroeconomic context

Since the start of the 2020s, the economic context in which we operate has changed drastically. Between the global financial crisis (GFC) and the COVID-19 pandemic, the economy was plagued by a chronic insufficiency of aggregate demand: a phenomenon often characterised as 'secular stagnation'. Following the pandemic, the context rapidly changed into one of structural aggregate supply constraints caused by a series of deep and unprecedented negative shocks, impairing the capacity of our economy to grow.

Following the GFC, the EU, in particular, found itself in a suboptimal macroeconomic equilibrium in which monetary policy was constrained by the effective lower bound while fiscal policy remained overly cautious. The resulting policy mix proved insufficient to close the output gap, contributing to a prolonged period of economic slack, elevated unemployment and persistent undershooting of the inflation target.

The post-pandemic macroeconomic context, on the other hand, was very different. If the post-GFC period was dominated by insufficient aggregate demand, persistent economic slack and below-target inflation, the post-pandemic period has been characterised by repeated adverse supply shocks that have constrained productive capacity and pushed inflation upward.

The central challenge is no longer a chronic deficiency of aggregate demand but rather a succession of negative supply-side shocks. The COVID-19 pandemic disrupted production across the world; then, before these disruptions had fully dissipated, Russia's invasion of Ukraine triggered a severe energy shock, particularly for Europe, while geopolitical fragmentation, trade tensions and bottlenecks in global value chains further impaired productive capacity. Rather than a temporary shock, these events constitute a succession of overlapping supply disruptions, a persistent constraint on aggregate supply that continues to reduce potential output and create inflationary pressures, even as economic activity remains below expectations.

In this context, the most pressing need is to engineer a positive supply-side shock capable of raising potential output and strengthening economic resilience. For this reason, research, technological development and innovation have become critical policy levers, as they enhance productivity, support structural transformation and relax supply-side constraints over the medium and long term.

By 2025, the EU's economy was 7% bigger than in 2019, the year preceding the pandemic. Over the same period, the US economy expanded by 15%, effectively growing at twice the rate of the EU. Meanwhile, China's economy had grown by one third since 2019, roughly double the pace of the US. Population growth during this period was stagnant in both the EU and China and only modest in the US, meaning that average per capita income in the EU increased significantly less than in the US or China.

A simple growth decomposition exercise tells us that the bulk of the growth in these economies has come from strong productivity growth, substantially stronger than in the EU. This is arguably the most important cause for concern. It also explains the renewed focus on competitiveness, which, in reality, means relative productivity growth.

Historical trends in productivity growth show that the gap between European countries and the US has typically grown in periods of relative underinvestment. In other words, when investment levels in Europe lagged behind those in the US, subsequent productivity growth also tended to be lower.

This empirical observation is consistent with what various strands of economic theory have often suggested: in neoclassical, endogenous or Schumpeterian growth theories, investment is either the proximate cause of productivity growth or the fundamental mechanism through which innovation and knowledge accumulate. In a context of stagnant or declining demographic trends, the main source of economic growth is productivity growth. Achieving sustained productivity growth depends on our capacity to boost investment in research, technological development and innovation.

Beyond investment, other measures have the potential to boost productivity. Most countries today, and in particular China and the US, are actively supporting their economies. Economic literature suggests carefully calibrating public intervention to avoid misallocation, rent-seeking, capture and inefficiency. Yet actions to encourage entry of new firms into key markets, simplification to enable small and medium-sized enterprises (SMEs) and startups to scale up, provision of technical support for technology transfer and for the early detection of emerging technologies, human capital development, education, targeted and temporary protection for key industries and place-based innovation policies are all types of intervention that support the economy without protecting the interests of incumbents or raising barriers to innovation. Together, these form what we would define as 'good industrial policy'.

2. Research and innovation (R&I) in a new competitiveness context: from strength to scale

The EU is entering this new phase of global competition with significant assets. It has a strong scientific base, world-class researchers and infrastructures, internationally connected research systems, leading capabilities in several green and industrial technologies, a large single market and a distinctive model based on openness, responsibility and scientific freedom. But these strengths do not automatically translate into productivity, technological leadership or strategic autonomy.

R&I has always been central to Europe's prosperity. It expands the frontier of knowledge, supports productivity growth and provides solutions to economic, environmental and social challenges. In the current context, its role is more directly connected to competitiveness, resilience and strategic autonomy. Global competition is increasingly shaped by technological capabilities in areas such as artificial intelligence (AI), advanced materials, biotechnology, clean technologies, space and defence-related technologies. These fields are sources of future growth, and they also shape industrial capacity, resilience and geopolitical influence. Yet SRIP 2026 shows that, over the past 25 years, labour productivity in the EU has improved by around half as much as in the US (see chapter 5.1). At the same time, the EU underinvests in R&I, remaining below its own 3% research and development (R&D) investment target and the R&D intensity of Japan, South Korea and the US (see chapter 2.1).

The EU's investment in R&I must be considered in terms of both its scale and how effectively it is converted into impact. Investment levels, public-private interactions, the allocation of resources across sectors and places and the ability to translate research strengths into innovation, deployment and productivity all matter. SRIP 2026 shows that these issues can be framed as a set of interconnected gaps: the R&D gap is about the scale of investment and its composition and leverage; the innovation gap is about deployment, finance and demand; the territorial gap is about disparities and underused capabilities; and the productivity gap is about frontier technologies and their diffusion, adoption and efficiency. These gaps reinforce one another. For example, slow adoption and diffusion of new technologies depress returns to R&D, weakening the incentive to invest in the first place.

The assessment of the EU's performance in science, research and innovation leaves three overarching messages about strength, structure and scale. The first message concerns the EU's scientific strengths and the pressures on them. The second concerns how the EU's R&I efforts are organised across governance levels and places and the fragmentation that limits their collective impact. The third concerns the pathway from research to markets, deployment and productivity and the strategic stakes attached to it. Together these messages describe how the EU can turn a strong but uneven base into greater collective impact for competitiveness, resilience and strategic autonomy. The challenge is to move from strength to scale.

Strength: a strong science base, but under growing pressure

The EU remains one of the world's major scientific powers. It ranks second globally in scientific output (see chapter 3.1), maintains strong performance across a broad range of disciplines and is particularly well positioned in several fields linked to societal challenges, including climate and health. Scientific collaboration is also a distinctive strength of EU science (see chapter 6.3).

These results reflect the depth of the EU's research system. The EU benefits from a dense network of universities, research-performing organisations, research and technology infrastructures, funding instruments and cross-border collaboration mechanisms. The European Research Area (ERA) gives this system a broader logic: the circulation of knowledge, researchers and ideas across national borders. In a fragmented geopolitical environment, this remains one of the EU's most important R&I assets.

The report highlights the distinctive nature of the European research model. It is built around a strong public role (see chapters 2.1 and 8), a commitment to open science, public engagement, responsible research assessment and academic and scientific freedom. Most European countries rank very highly in the Academic Freedom Index at a time when academic freedom is under pressure globally (see chapter 3.3). This gives Europe a values-based advantage that supports its attractiveness and international positioning.

This is the context in which the Choose Europe for Science initiative is being developed (see chapter 3.2). As well as attracting talent, it aims to consolidate the EU's position as a place where researchers have access to high-quality institutions, infrastructures, networks and freedoms. This issue has become more salient as the effects of geopolitical turbulence and changes in the attractiveness of other research systems on global researcher mobility have increased. After decades in which talent mainly flowed elsewhere, early signals now suggest

a change, with the EU becoming increasingly attractive for more experienced researchers.

Evidence, however, also points to pressures on this asset base. The EU's global share of scientific output has declined over time, while China continues to expand rapidly, and the US maintains a strong position in scientific impact and excellence (see chapter 3.1). The EU's relative position is also weaker in some strategic technology-related fields, where global competition is intensifying. The *Choose Europe for Science* initiative therefore sits alongside a competitiveness question: how to maintain scientific excellence in the fields that will shape future technological capabilities?

Research careers are another critical point because of tensions related to precarious contracts, career uncertainty, the 'publish or perish' culture and the need to reform research assessment systems (see chapter 3.3). These issues affect attractiveness, excellence and inclusion. The retention of senior female researchers, especially in science, technology, engineering and mathematics (STEM) fields where women remain underrepresented, is not only an equality issue but also a factor shaping mentoring, participation and scientific output. Demography is raising the stakes: with the EU labour force projected to shrink by some 12 % (around 25 million people) over the coming decades (see chapter 3.2), competition for scarce scientific talent will only intensify, making the renewal of the research workforce a strategic concern in its own right.

AI leadership requires talent and infrastructure. The EU remains strong in AI-related scientific output, with several of its regions performing at levels comparable to those of their Asian and US peers (see chapter 7). At the same time, the use of AI in science is expanding rapidly, with China emerging as a clear leader and the EU broadly on a par with the US. This makes data, computing capacity, talent and responsible governance central to the future of European science. The *European AI in Science Strategy* and the Resource for AI Science in Europe (RAISE) initiative fit within this broader agenda of making the EU attractive and capable in AI-enabled research.

The overall message is nuanced. The EU has a strong scientific base and a distinctive research model. These are strategic assets. But their value depends on continued attractiveness, openness with safeguards, strong research careers, access to infrastructures and capabilities in emerging scientific and technological fields.

Structure: fragmented efforts across governance levels

The way in which the EU's R&I assets are organised is of the essence. The EU is a multi-level governance system in which investment efforts are driven by national policies, regional capabilities, sectoral priorities and public and private synergies (see chapter 2.2). This diversity is one of the EU's strengths, but it also creates fragmentation if priorities, resources and capabilities do not sufficiently reinforce each other.

The investment challenge is about scale and composition. The EU's R&D intensity rose from 1.81 % to 2.24 % of gross domestic product (GDP) between 2000 and 2024, but it remains below the 3 % target and the levels of Japan, South Korea and the US (see chapter 2.1). This report highlights a situation of 'stable shares but shrinking weight': maintaining R&D intensity as a share of GDP does not prevent a decline in global influence when the underlying economy grows more slowly than those of competitors. Closing the 3 % gap would require around EUR 127 billion in additional annual investment. At the same time, the widening gap to the US in private

R&D intensity is driven not so much by firms within the same sectors spending systematically less but mainly by differences in sectoral composition: private R&D in the EU remains more concentrated in mid-tech manufacturing, while high-tech and knowledge-intensive sectors account for a larger share of business R&D in the US.

Access to finance is therefore a key part of scaling EU innovation, but not the only one: talent, regulation and demand conditions also shape the pathway from research to markets (see chapter 5.3). Technological change is increasing demand for high-skilled, non-routine tasks, while the EU faces persistent shortages in occupations expected to grow most strongly. Regulatory fragmentation across Member States can increase compliance costs and slow scaling, even though regulatory sandboxes and public procurement can help test and create demand for innovative solutions.

A key challenge is coherence across levels of governance. Public R&D funding in the EU is predominantly national, while EU-level instruments provide a common framework for collaboration, competition and scale. This makes coherence between EU priorities and Member State strategies central to the overall impact of public R&I investment. SRIP 2026 points to the importance of 'vertical coherence', where national thematic priorities and EU programmes reinforce each other, amplifying resources and supporting cross-border ecosystems. The analysis shows new evidence of complementarity across different layers of government, indicating consistent crowding-in effects between EU and national instruments and also among EU instruments (see chapter 2.2). A significant R&I divide persists at regional level and between urban and rural areas (see chapter 6.1) as innovation activity remains spatially concentrated with self-reinforcing dynamics.

However, a connected European R&I system does not require all regions to follow the same technological path. Regional capabilities differ widely, and knowledge, skills, institutions and industrial structures shape what each territory can realistically contribute (see chapters 9 and 10). This points to a capability-based approach where interregional collaboration helps mobilise differentiated strengths, reduce duplication and connect regional assets to European priorities. Collaborative R&I activities remain strongly concentrated in regions located in the most innovative Member States (see chapter 6.1). The European R&I collaboration system is more fragmented than that of the US, especially for co-patenting, where the gap is more pronounced than for co-publications. The fragmentation gap is increasing in several advanced technology and scientific fields, precisely where innovation requires closer and more integrated collaboration (see chapter 6.2). Although rising, defence spending remains fragmented and weighted towards equipment procurement rather than R&D (see chapter 4.4).

Taken together, these findings suggest that a key challenge is to organise efforts more coherently, addressing fragmentation. Vertical coherence means ensuring that investments deployed at EU and national level reinforce each other, building synergies. Regional capabilities, cross-border collaboration and specific funding instruments shape the EU R&I system. Vertical coherence is the condition for turning the EU's diversity into collective capacity.

Scale: a gap from research to scale and strategic autonomy

Scale is a strategic priority for the EU. The European innovation gap is most visible in the EU's limited capacity to transform knowledge into technology, innovation and productivity. The technologies that the EU masters and de-

ploys determine its capacity to pursue its own objectives and to withstand external pressure. Yet the EU currently depends on others for much of its scaling capacity. Its weakest technological positions and greatest supply chain dependencies lie in digital fields such as advanced semiconductors, cloud computing and AI. At the same time, European firms rely mostly on foreign capital to scale up, and while the EU's scientific cooperation is broadly diversified, its international co-patenting is heavily concentrated in links with the US.

Evidence shows that EU innovation output has increased by close to 10% over the past decade (see chapter 4.2), but this is not enough to close the gap to the leading innovation systems. Academic patenting remains concentrated in a limited number of universities and regions, while industry-science collaboration is still predominantly national. Cross-border linkages remain comparatively limited, suggesting that the single market for knowledge, innovation and technology is still incomplete.

The report also shows a major redistribution of global innovation capacity. Between 2000 and 2022, the EU's share of patent applications under the Patent Cooperation Treaty (PCT) fell from about 30% to around 16%, while China's rose from 3% to nearly 33% (see chapter 4.1). The EU performs relatively well in advanced materials, advanced manufacturing and several green technologies but, as mentioned above, lags in complex digital areas such as AI, advanced semiconductors and cloud computing. In several cases, weaker technological positions coincide with reliance on foreign suppliers, linking innovation performance to economic security and supply chain dependencies. Across life sciences, clean technologies and digital technologies, the EU has a substantial R&I base but faces various bottlenecks (see chapter 4.3). In life sciences, these relate to clinical development, late-stage finance, regulatory pathways and market access. In clean technologies, they concern manufacturing scale, infrastructure, energy costs, circularity, bankable projects and demand for clean products. In digital, they are linked to diffusion, compute capacity, connectivity, skills and dependence on critical infrastructures and services.

Startups and scaleups illustrate both progress and remaining constraints. The EU continues to trail the US in startup and scaleup performance, with fewer scaleups and a large late-stage funding gap (see chapter 5.2). Venture capital (VC) remains fragmented and geographically concentrated, and EU institutional investors allocate relatively little to it despite holding large assets (see chapter 12). At the same time, startup creation has grown considerably, and the performance of the European VC market has improved. The European Innovation Council (EIC) has also become a major deep-tech investor, mobilising additional private investment, which has had positive firm-level effects on sales and employment. The EU has strengths in AI-related scientific output but accounts for only a small share of global AI compute capacity and investment. More broadly, productivity growth requires adoption and diffusion of technologies, sectoral specialisation and movement of less productive firms towards the frontier (see chapter 11).

3. Turning assets into impact

The R&I performance of the EU cannot be captured by a single indicator. Input remains essential: investment, talent and infrastructure form the basis of the system. Output matters too: publications, patents, startups, scaleups, technological capabilities and productivity reveal where the EU is gaining or losing ground. But what is crucial are the links between them: how knowledge circulates, how public funding leverages private investment, how regional capabilities are mobilised, how research results reach firms and users and how new technologies are diffused across the economy. The EU is not starting from scratch. It has scientific excellence, strong public research institutions, research and technology infrastructures, a distinctive model of open and responsible science, industrial capabilities, entrepreneurial talent, high savings, regional specialisations and instruments for collaboration and investment. These assets provide a strong basis. Their impact, however, depends on whether they operate as a connected system rather than as separate strengths.

The report points to the importance of a more systemic understanding of R&I policy. More investment remains important, but its impact depends on composition, sequencing and leverage. Scientific excellence remains essential, but its contribution to competitiveness depends on valorisation, deployment and diffusion. Openness remains a defining feature of the EU's research model, but its future role is increasingly linked to reciprocity, research security and strategic capacity. Regional diversity remains a strength, but its contribution depends on how differentiated capabilities are connected to wider European priorities, ecosystems and value chains.

This perspective is particularly relevant for the next phase of EU R&I policy. The competitiveness agenda, the future framework programme, the ERA, the proposed European Competitiveness Fund, the *EU Startup and Scaleup Strategy* and sectoral strategies in areas such as AI, life sciences, clean technologies, defence and space all raise the same underlying question: how to turn Europe's R&I assets into greater collective impact?

SRIP 2026 provides the evidence base for that discussion.

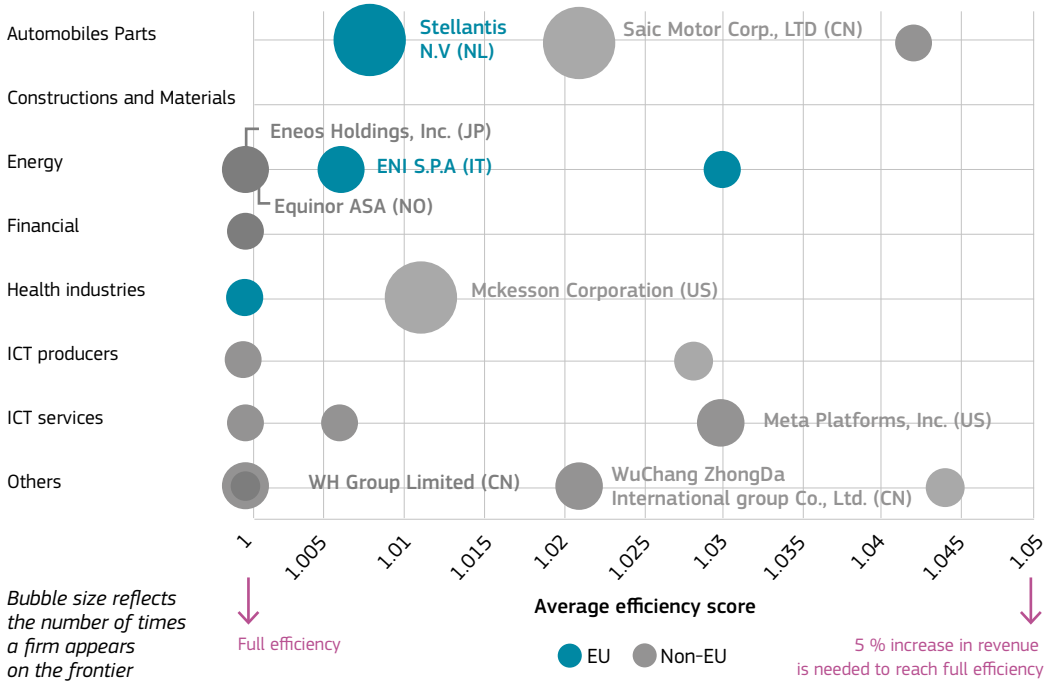
PART 1

CHAPTER 1

KEY FIGURES

1. The main EU firms investing in R&D sit below the global efficiency frontier, which US firms dominate. Technical efficiency improvements can help boost Total Factor Productivity.

Figure 1-1 Firms observed on the efficiency frontier in the EU Industrial R&D Investment Scoreboard



Science, Research and Innovation Performance of the EU 2026

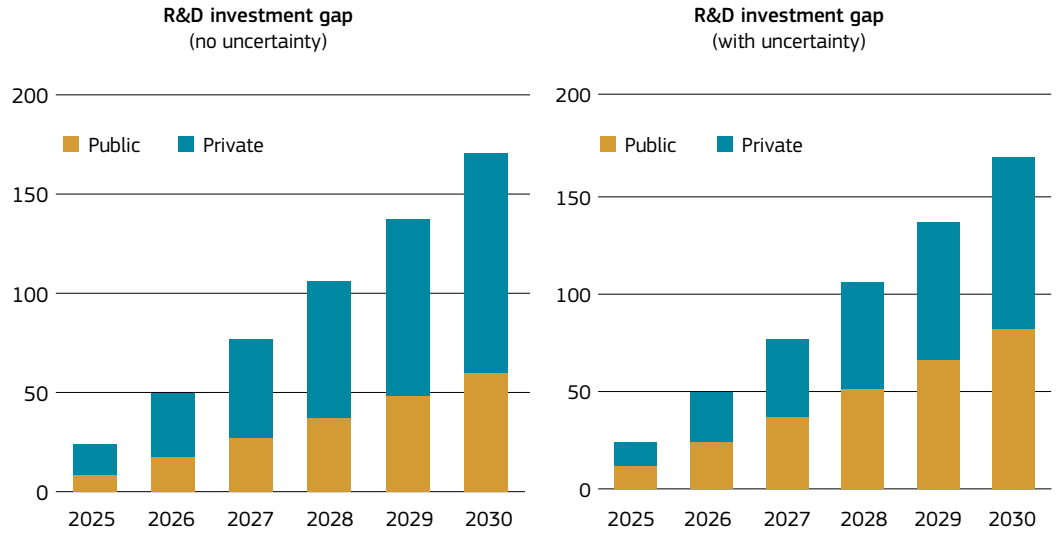
Source: Al-Ajlani and Ravanos (2027, forthcoming) based on EU Industrial R&D Investment Scoreboard and Orbis.

Note: The efficiency measure reported in this analysis corresponds to the output-oriented DEA expansion factor φ, where a score of 1 indicates a fully efficient frontier firm and values above 1 represent the proportional increase in outputs required to reach the frontier. The efficiency scores are calculated using pooled data across years, firms and sectors. Only firms that appear on the efficiency frontier more than once are labelled.

For more details, see chapter 5.1.

2. About EUR 565 billion of additional investment in R&D will be needed to meet the 3 % target by 2030. Private R&D investment tends to contract in times of uncertainty, demanding stronger public investments to reach the target.

Figure 1-2 The R&D investment gap to reach the 3 % target, billion EUR

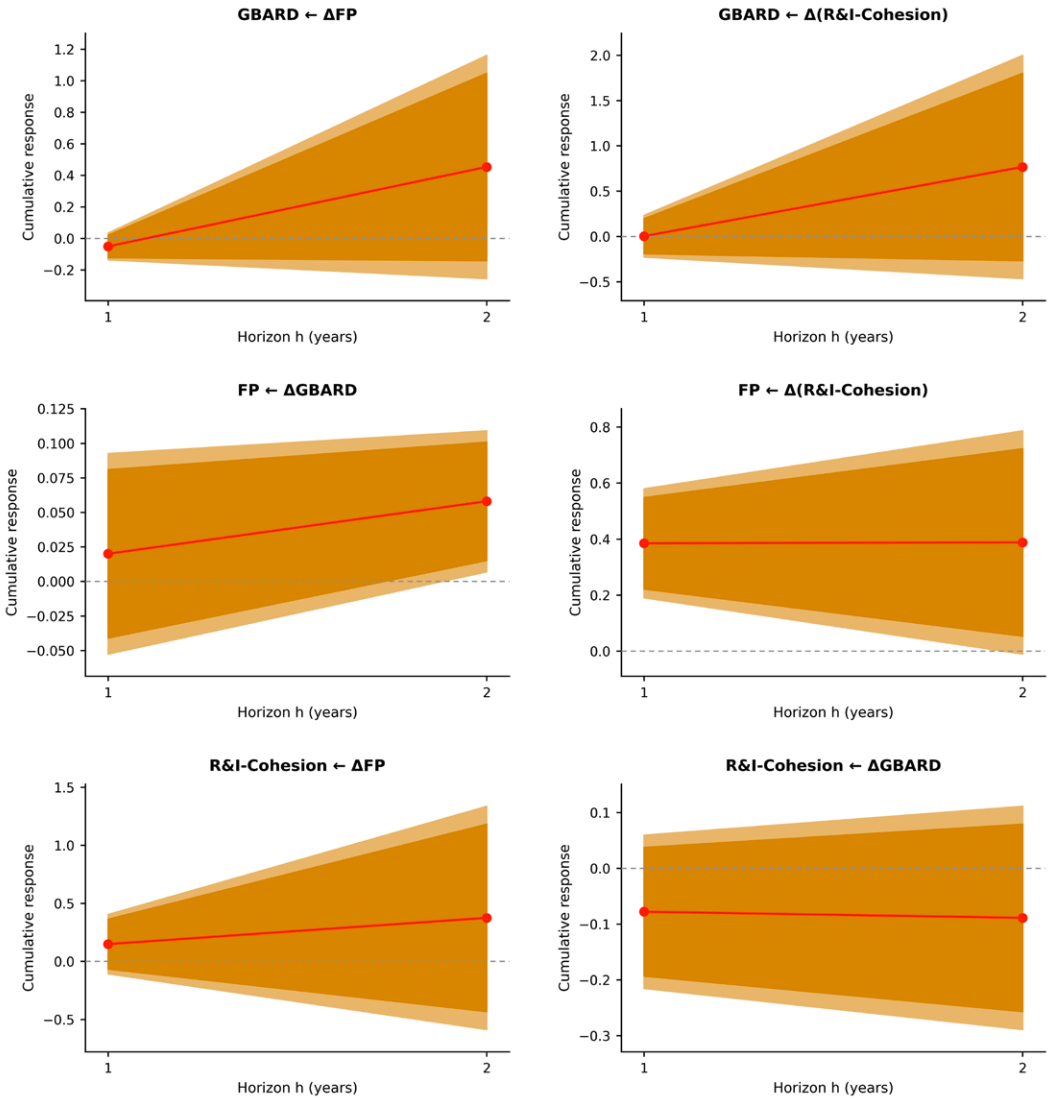


Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on European Commission AMECO and International Monetary Fund (IMF) data.
For more details, see chapter 2.1.

3. EU R&I funding does not crowd out national funds for R&I. On the contrary, evidence suggests that a crowd-in effect is at play.

Figure 1-3 Vertical coherence of R&I investment in the EU, impulse responses, 2016–2023

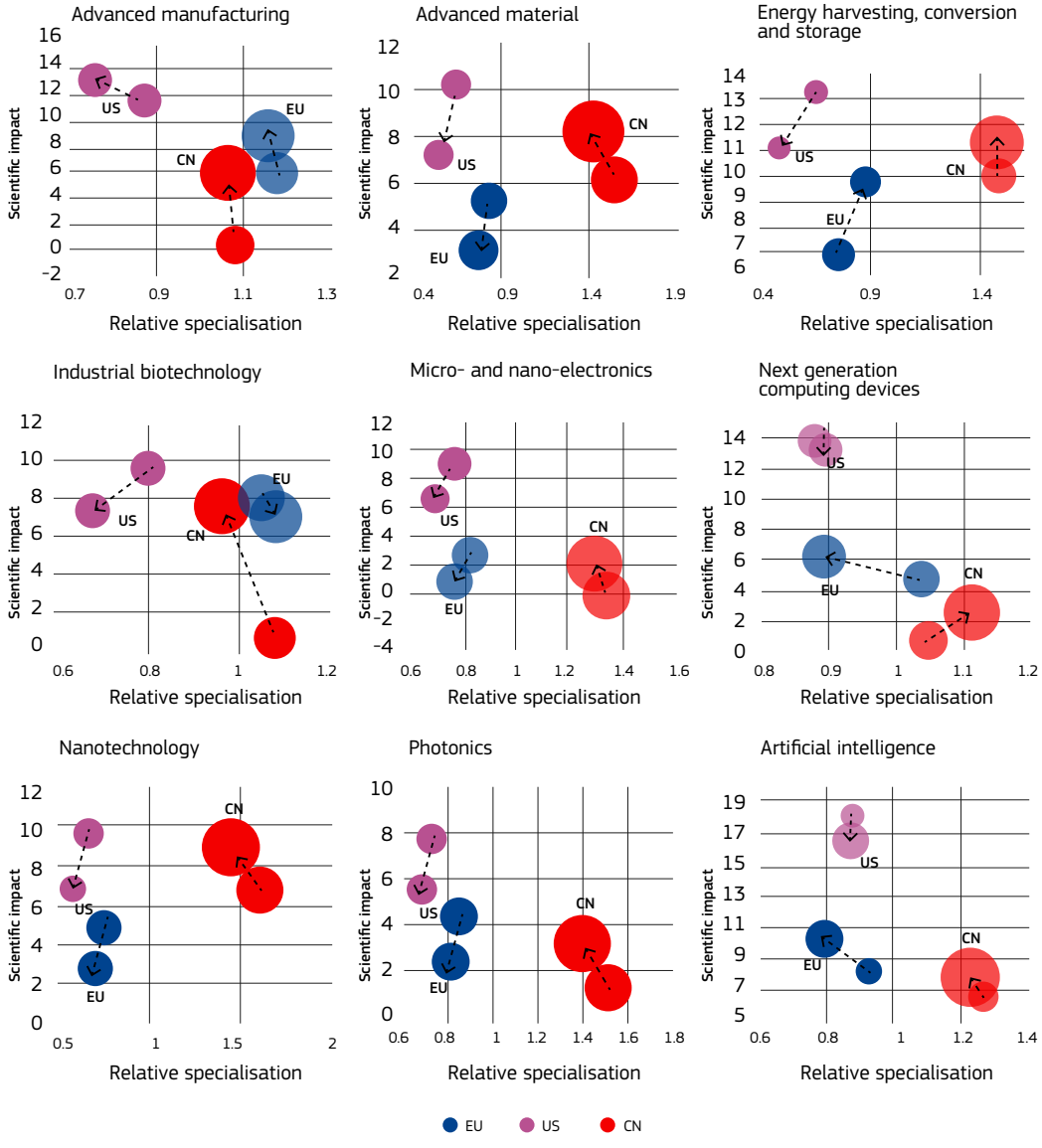


Science, Research and Innovation Performance of the EU 2026

Source: Authors' calculations based on TEDAM LP-IV estimates.
For more details, see chapter 2.2.

4. The EU remains a global scientific player in several key technologies, though with lower relative specialisation and scientific impact than the US and China.

Figure 1-4 Dynamic positions in scientific impact and specialisation in key technologies, 2015–2019 and 2020–2024



Science, Research and Innovation Performance of the EU 2026

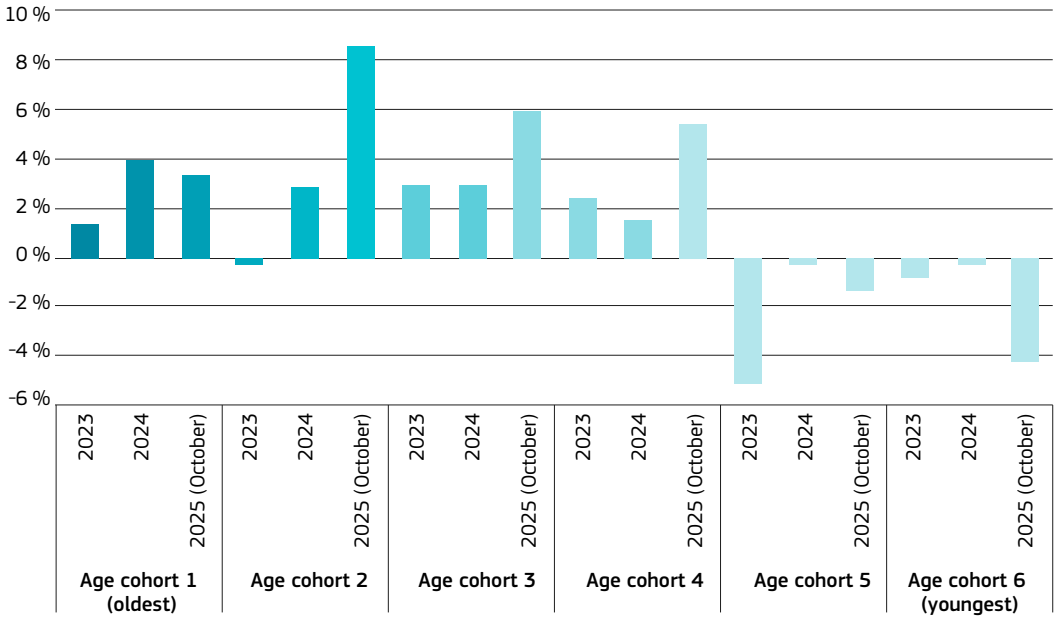
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

Note: Scientific impact is measured using the Citation Distribution Index (CDI), where a higher score indicates greater scientific impact. Relative specialisation is expressed relative to the world average (=1): values above 1 indicate above-average specialisation, while values below 1 indicate below-average specialisation. Bubble size reflects the number of publications, and the arrows indicate changes between 2015 and 2019, and 2020 and 2024.

For more details, see chapter 3.1.

5. Amidst geopolitical tensions and a context of declining research mobility, the EU remains attractive for researchers, especially for experienced ones, though precarious careers remain a barrier to retaining talent.

Figure 1-5 Net flows of publishing academics for the EU with other major scientific powerhouses by cohort



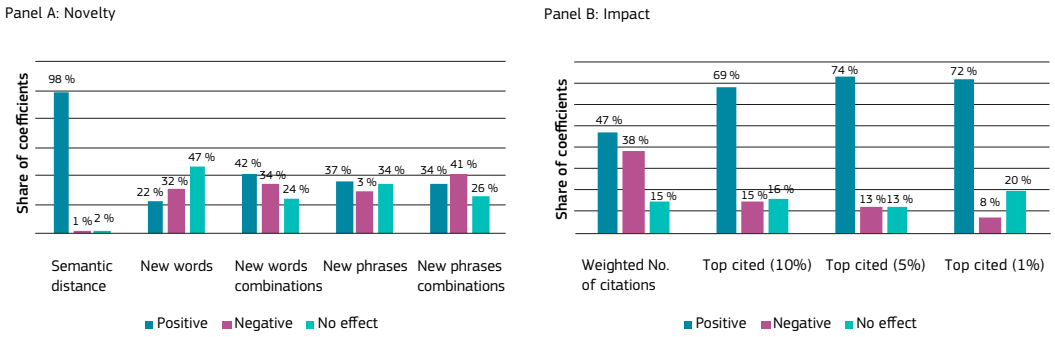
Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on ORCID institutional affiliation data.

Note: Only researchers with at least one scientific publication in OpenAlex are considered. Data for 2025 are available only up to October. Cohorts are defined by the year of first publication: age cohort 1 - before 2001; age cohort 2 - 2001–2005; age cohort 3 - 2006–2010; age cohort 4 - 2011–2015; age cohort 5 - 2016–2020; age cohort 6 - 2021–2025 (October). For more details, see chapter 3.2.

6. The integration of AI into science has important implications for both the novelty and impact of scientific research.

Figure 1-6 The relationship between AI and scientific novelty and impact

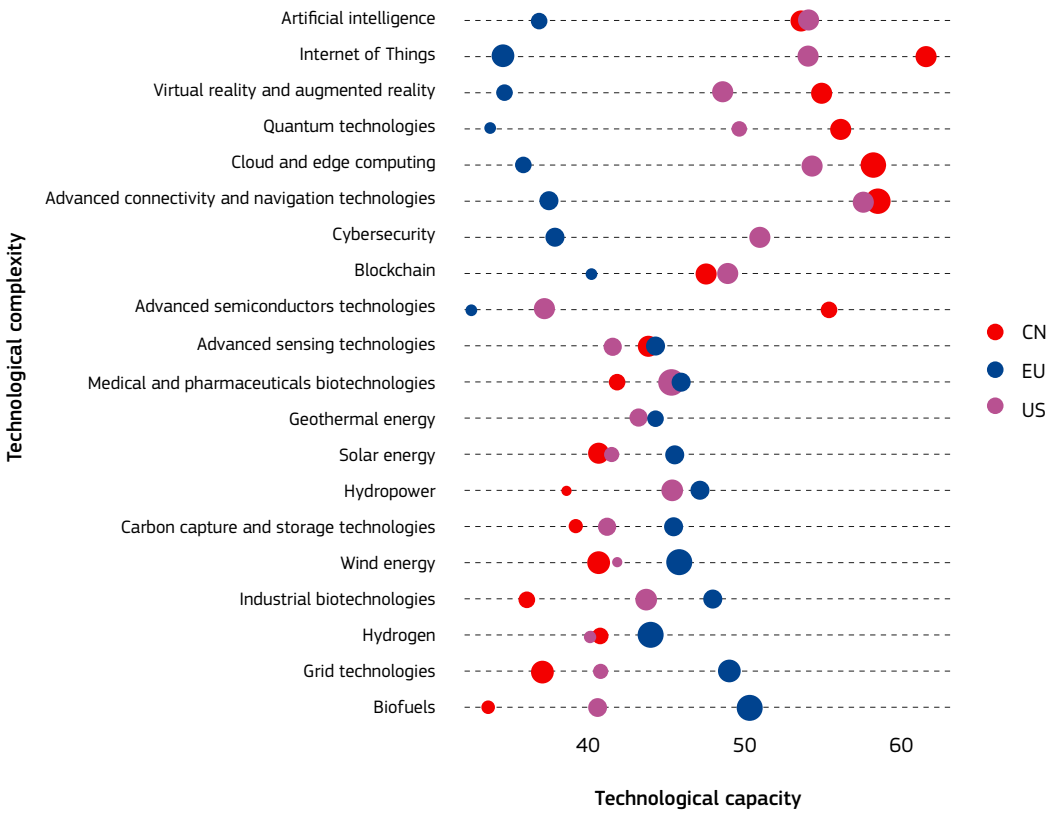


Science, Research and Innovation Performance of the EU 2026

Source: Bianchini *et al.* (2026).
Note: Panel A shows the share of positive, negative and non-significant coefficients for novelty indicators. Panel B shows the corresponding shares for impact indicators.
For more details, see chapter 7.

7. The innovation gap with the US and China remains substantial in digital technologies, whereas the EU retains some strengths in green technology fields.

Figure 1-7 The EU positioning in selected critical technologies vs the US and China, 2019–2023



Science, Research and Innovation Performance of the EU 2026

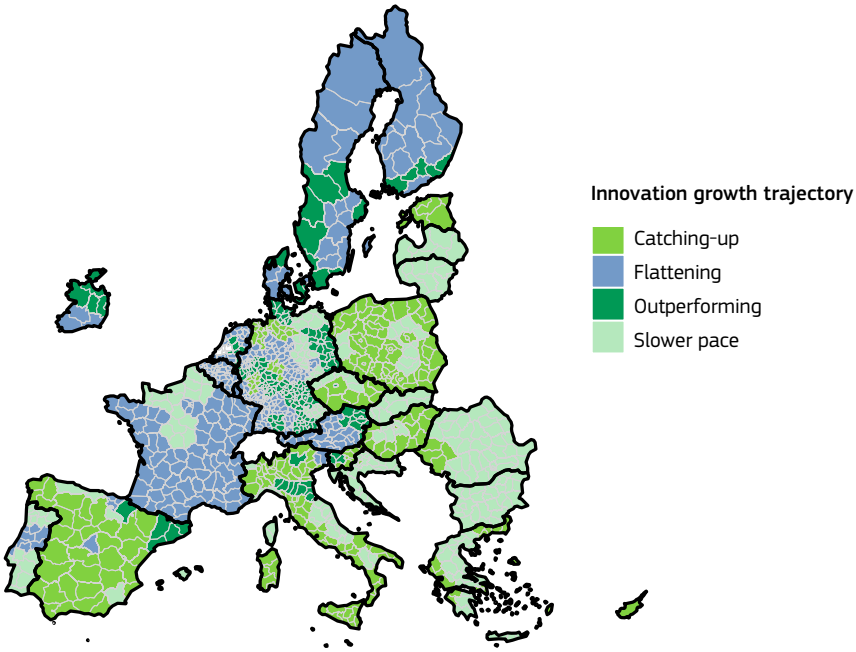
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on PATSTAT (2025; as of December).

Note: The x-axis indicates the relatedness density in any of the technology fields considered. On the y-axis, technologies are ranked by complexity levels as captured by the Technology Complexity Index (TCI), normalised between 0 and 100. The size of the bubble captures the degree of specialisation that each country reports in a given technology field, as measured by the revealed comparative advantage (RCA). Relatedness density for the EU is calculated as the population-weighted average of the EU Member States.

For more details, see chapter 4.1.

8. R&I capacity is unevenly distributed across European regions, and the pace of regional innovation growth varies considerably across the EU.

Figure 1-8 Innovation growth trajectories of European regions, 2018–2025



Science, Research and Innovation Performance of the EU 2026

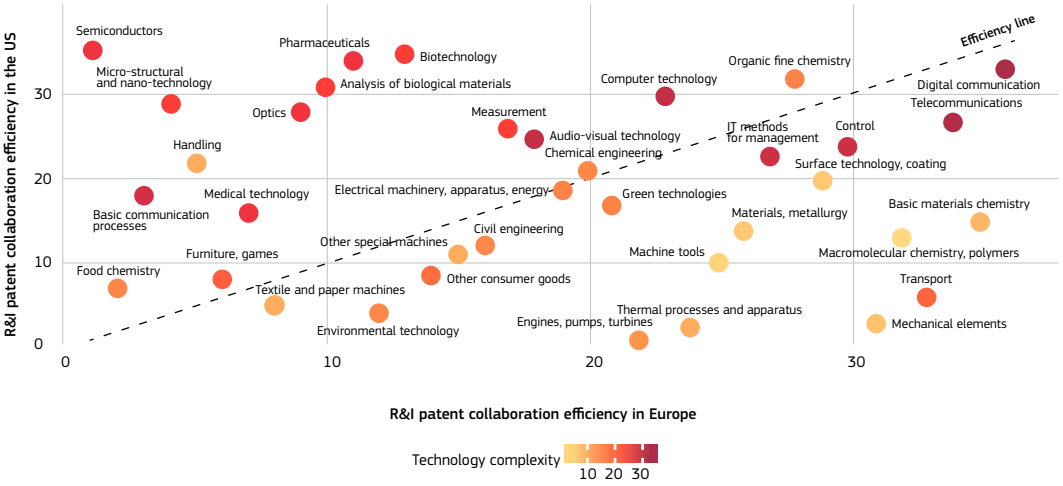
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on the Regional Innovation Scoreboard (European Commission, 2025b).

Note: NUTS 1 or NUTS 2 regions may be presented depending on the country and data availability. The labels describe regions' innovation trajectories relative to the EU average since 2000 as follows: 'catching-up' refers to innovation growth rates that are below average but with faster progress; 'flattening' refers to above-average rates but with slower progress; 'outperforming' refers to above-average rates with faster progress; and 'slower pace' refers to below-average rates with slower progress.

For more details, see chapter 6.1.

9. The degree of fragmentation within the European R&I collaborative system worsens the EU-US innovation gap in most advanced technology fields.

Figure 1-9 Technological complexity and R&I collaboration efficiency in Europe and the US, patent data 2019–2023



Science, Research and Innovation Performance of the EU 2026

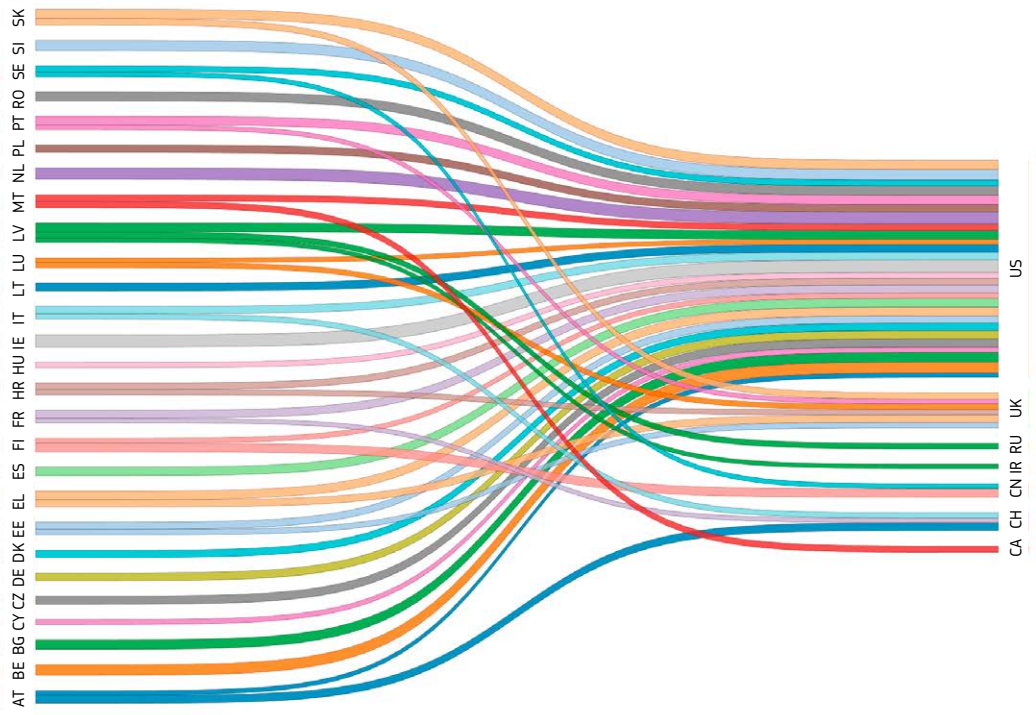
Source: Balland *et al.* (2025).

Note: The axes rank the efficiency estimates per technology area based on their magnitude. The visualisation uses a colour gradient where red represents more complex technologies and yellow indicates less complex technologies, mapped into the 36 WIPO technology classes. The diagonal line can be interpreted as a sort of competitiveness boundary, serving as a reference point for understanding the efficiency gap: technologies above the diagonal show higher collaboration efficiency in the US, while technologies below the diagonal perform relatively better in Europe.

For more details, see chapter 6.2.

10. EU Member States are increasingly engaging in global research collaborations, with the US and the UK being their main scientific partners.

Figure 1-10 Shares of co-patents between EU Member States and third countries, by top partner countries (shares above 20 %), 2020–2023



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on PATSTAT.

Note: For each Member State, the figure illustrates the share of collaborations with the non-EU countries shown on the right-hand side. This share is calculated as the number of patents a Member State holds with a given third country divided by the total number of that Member State's international co-patents. Patent counts reflect fractional counts and locations refer to inventor location. The figure only shows third countries with shares exceeding 20 %.

For more details, see chapter 6.3.

CHAPTER 2

INVESTING IN RESEARCH AND INNOVATION

CHAPTER 2.1

R&D INVESTMENT

Florence Benoit, Jan-Tjibbe Steeman

KEY QUESTIONS

- Why does research and innovation (R&I) policy matter and how has it evolved?
- How does the level and growth of research and development (R&D) investment in the EU compare with major global competitors?
- How do industrial composition and sectoral priorities influence EU private R&D performance, and how do these factors contribute to the gap with global peers?

HIGHLIGHTS

- The rationale for R&I policy has progressively broadened from correcting market failures toward supporting whole innovation systems and, increasingly, delivering on strategic objectives including competitiveness, technological sovereignty, and the green and digital transitions.
- Yet despite this growing policy ambition, the EU significantly underinvests in R&D relative to its main competitors. On current trends the 3% target would not be met until around 2057 and reaching it by 2030 would require roughly EUR 565 billion in additional investment.
- The investment gap is rooted in a structural imbalance. Private R&D in the EU remains concentrated in mid-tech manufacturing rather than the high-tech manufacturing and knowledge-intensive services that drive R&D intensity in the US and increasingly in China.
- Public R&D has partly compensated for weak private investment, but its relative weight is quietly shrinking. Although public R&D intensity has remained broadly stable as a share of GDP, the EU economy grows at roughly half the rate of the US and one-sixth the rate of China, meaning that stable shares translate into declining global weight in absolute terms.

POLICY INSIGHTS

- As R&I policy faces an expanding set of objectives, coherent priority-setting and well-designed policy mixes become more important than the overall level of spending alone.
- The private R&D gap with the US is driven more by industrial composition than by firm behaviour, suggesting that incentivising R&D spending alone is insufficient. Supporting the conditions that allow high-tech sectors to grow and scale in Europe has become equally important.
- Stable public R&D intensity as a share of GDP conceals a declining global footprint.
- The EU's public R&D model, heavily channelled through universities and towards undirected basic research, differs structurally from the more mission-directed, applied-research-focused models of the US, China, South Korea and Japan. Rebalancing this mix may deserve attention alongside increasing overall funding levels.

Innovation is a central driver of long-term productivity, economic growth and societal transformation. Governments play an important role in creating the conditions that support it, not only with direct research funding but through a much broader set of instruments including regulatory frameworks, standards, public procurement, skills development, technology transfer mechanisms and intellectual property regimes.

Investment in research and development (R&D) is arguably one of the most direct and measurable expressions of this broader commitment to innovation. R&D matters because it is one of the main drivers of long-run economic performance, enabling technological progress, innovation, productivity and growth (Romer, 1990; Aghion and Howitt, 1992). While recognising that R&D is not the only driver of innovation and productivity (for instance, Comin and Hobijn (2010) show how diffusion of innovation is at least as important as a driver of productivity), R&D generates substantial spillovers that operate at the local, regional and international level. Such spillovers are central to productivity at both the macroeconomic level (Coe *et al.*, 2009) and firm level, with impacts going beyond the boundaries of the investing firms (Jones and Williams, 1998).

Given the non-rival and partially non-excludable nature of knowledge, private firms cannot fully appropriate the returns to R&D, leading to underinvestment relative to the social optimum (Arrow, 1962; Nelson, 1959). Public investment can then crowd in private investment, particularly for financially constrained firms, by stimulating their absorptive capacity (Cohen and Levinthal, 1990). These features make R&D a fundamental determinant of long-run growth and a primary justification for public investment.

While the importance of R&D is clear, the EU still underinvests compared to major global competitors. Total R&D spending in the EU has risen over the past two decades, but remains modest relative to countries such as the US, China, Japan and South Korea. At the same time, the EU's public R&D system is structured and governed differently from those of its main competitors and is characterised by widely varying national R&D intensity across Member States. Understanding the EU's R&D investment gap therefore requires not only looking at spending levels but also at the policy choices and governance structures that shape how investment is directed and how effectively it translates into innovation outcomes.

1. The evolution of R&I policy

Public intervention in R&I has traditionally been justified by market failures associated with knowledge production. Knowledge exhibits characteristics of a 'public good'. Once created, it can generate spillovers that enable others to benefit freely from the innovation. As this prevents firms from fully appropriating the returns on their investments, private investment often falls below socially optimal levels (Arrow, 1962; Nelson, 1959; Jaffe, 1986). Additional barriers, including financing constraints, uncertainty and information asymmetries, further limit private investment, reinforcing the case for public support through instruments such as R&D subsidies, public research funding and fiscal incentives (Hall and Lerner, 2010).

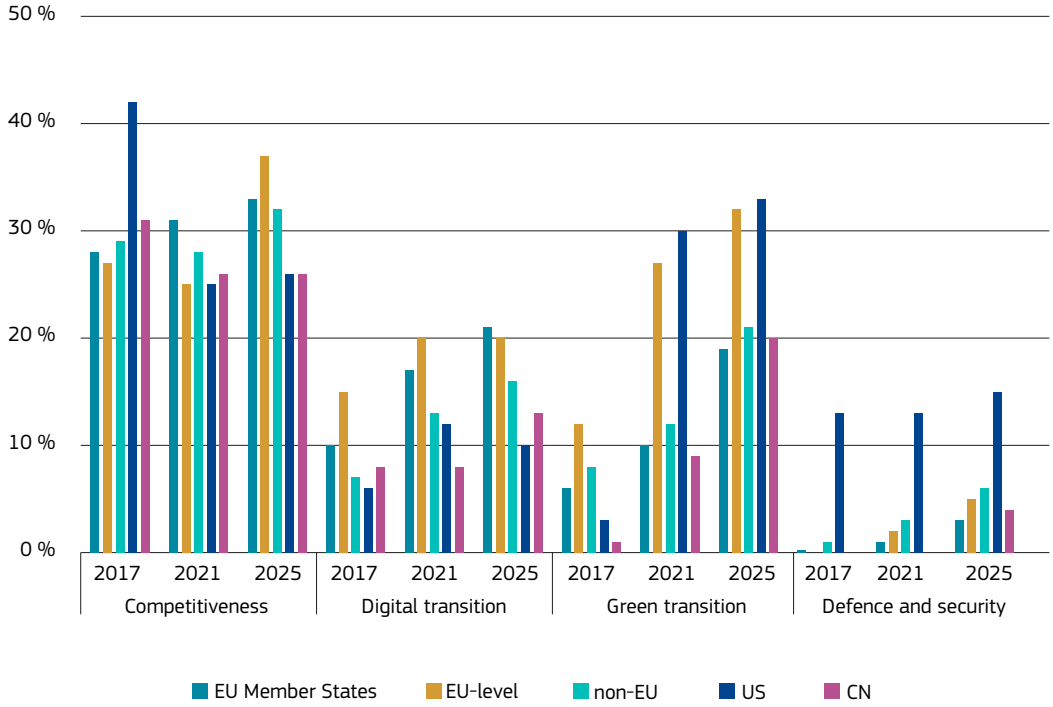
Beyond these traditional market failures, innovation is increasingly understood as systemic and dependent on complex interactions between firms, research organisations, governments and institutions.

Failures in coordination, knowledge diffusion or institutional frameworks provide an additional rationale for policy intervention (Freeman, 1987). Rather than protecting specific firms or declining industries, public support for R&I aims to strengthen the broader innovation ecosystem by encouraging knowledge creation, diffusion and technological development. In this sense, R&I policy can be viewed as one of the least distortive forms of industrial policy, enabling creative destruction, firm entry and exit, and sustained productivity growth (Aghion and Boulanger, 2011) across the economy without picking winners.

This shift from correcting isolated market failures to supporting whole systems is increasingly important as R&I is asked to address wider economic, social and security goals. Geopolitical tensions and strategic competition have led countries to use economic instruments, including trade policies, investment controls and technological regulations to achieve broader political and security objectives – a dynamic often described through the concept of geoeconomics (Blackwill and Harris, 2016). In this context, critical technologies, resources and supply chains increasingly function as strategic assets, shaping a country's ability to compete economically while also influencing their geopolitical positioning and strategic autonomy (see chapters 4.1 and 4.4). The EU, the US and China have all introduced major policy packages to boost R&I investment in targeted science and technology areas, reflecting this broader shift (Steeman *et al.*, 2025).

These shifting priorities are visible in how Member States are orienting their policy instruments, though the degree of directionality varies across topics and time. Over the last decade, competitiveness has become well established in EU Member State Science, Technology, and Innovation (STI) policy initiatives, with around 33 % of policies addressing competitiveness, a modest increase from 28 % in 2017 (Figure 2.1-1). Similar figures are observed for the EU-level STI policies, with 37 % in 2025, as well as for the US (26 %) and China (26 %), although the latter two countries show a decline over time. For the EU Member States, the share of policies addressing digital topics rose from 10 % to 21 %, while those focused on the green transition increased from 6 % to 19 % over the same period. Defence and security remain a smaller but growing topic area for EU Member States, rising from near zero in 2017 to around 3 % in 2025, with notable increases in France, Sweden, Czechia and Germany. A similar rise can be observed at the EU level, in China and the rest of the world, in contrast to the US, where this topic is already well established in STI policies. An increase between 2017 and 2025 in EU-level policies and in the US regarding the green transition is also apparent. Finally, some EU Member States, particularly in central and eastern Europe, show higher levels of directionality across all areas, while others, such as Luxembourg and the Netherlands, report lower overall levels. This variation shapes not only what gets funded, but also affects how national and EU-level investments align with one another – a theme taken up in chapter 2.2.

Figure 2.1-1 Strategic prioritisation of STI policies for the years 2017, 2021 and 2025



Science, Research and Innovation Performance of the EU 2026

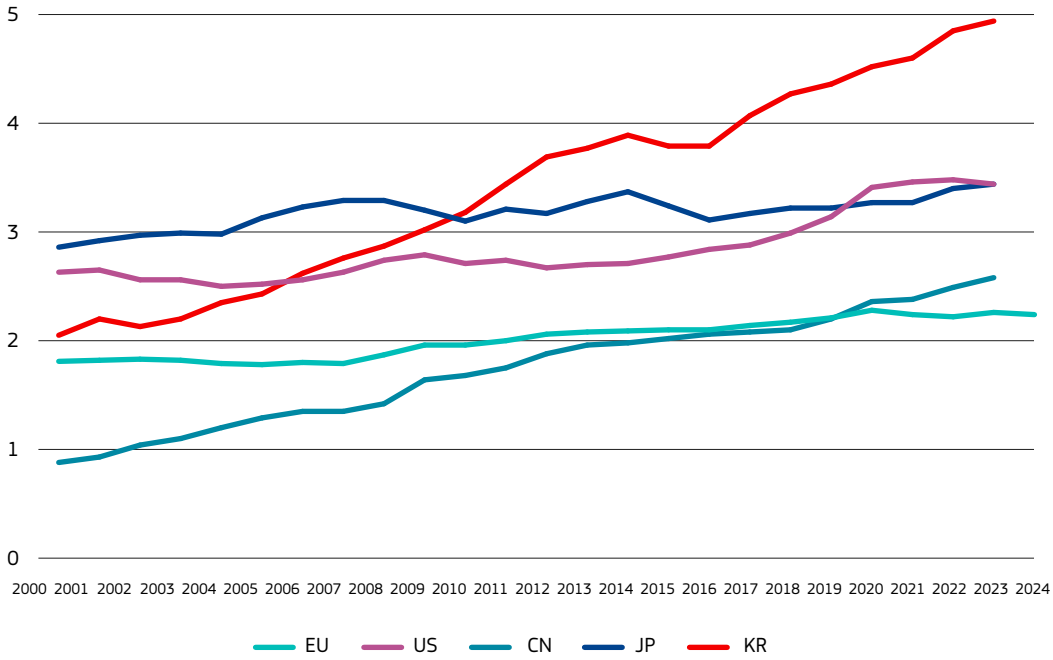
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on OECD/European Commission STIP Compass.

Note: Policy initiatives were identified through keyword matching applied to the titles, descriptions and stated objectives of initiatives. EU Member States refers to national policies at Member State level; EU-level refers to supranational policies; non-EU refers to all other countries in the database that are not EU Member States. The list of keywords was defined by the authors and is available upon request.

2. Where does the EU stand in terms of R&D investment?

Against the backdrop of an increasingly strategic and competitive global R&I environment, investment in R&D has become a central concern for policymakers. The EU has steadily expanded its R&D efforts over the past two decades, but this growth remains modest compared with other major economies. Total R&D spending rose from EUR 142 billion in 2000 to EUR 403 billion in 2024, while R&D intensity increased from 1.81% to 2.24% of GDP, indicating gradual but consistent progress (Figure 2.1-2). However, other major economies have expanded their R&D investment much faster. In 2023, the US remained the world's largest R&D investor, spending EUR 884 billion, with an R&D intensity of 3.45%, roughly double the EU's expenditure and well above its intensity level. China, which overtook the EU in R&D spending in 2020, reached EUR 435 billion in 2023 and reported an R&D intensity of 2.58%, thereby continuing to widen the gap. Other international peers, notably South Korea and Japan, also outperform the EU in terms of R&D intensity, at 4.96% and 3.44% respectively.

Figure 2.1-2 Gross expenditure on R&D as % of GDP (R&D intensity), 2000–2024



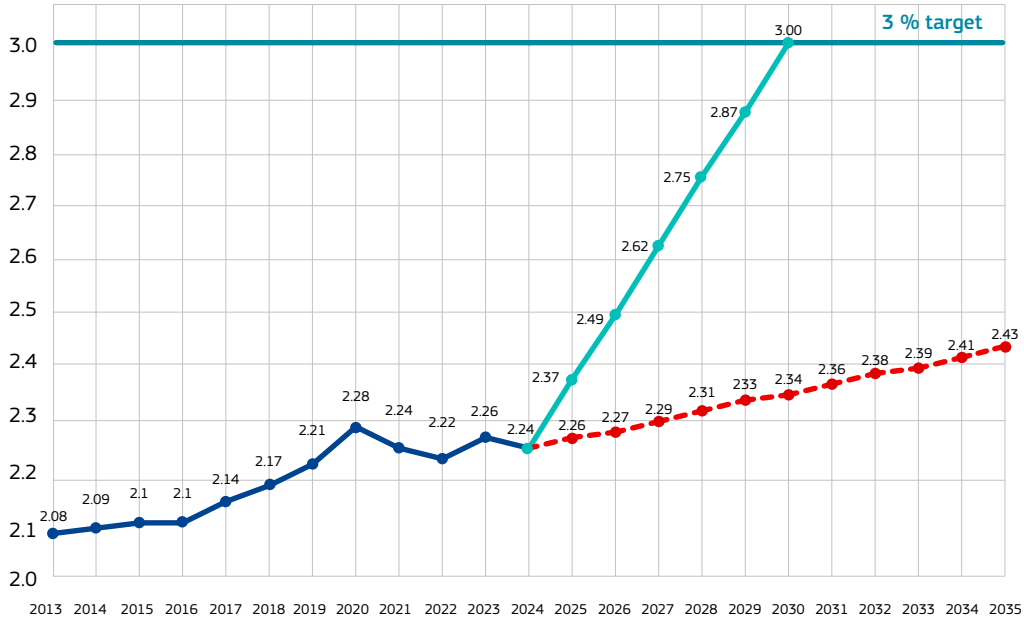
Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Eurostat (DOI link: https://doi.org/10.2908/RD_E_GERDTOT).

Note: International comparison is limited to the largest R&D investors.

Despite this upward trend, the EU remains far from its long-standing goal of reaching 3% R&D intensity and closing the gap would require a significant acceleration of investment. The 3% R&D intensity target was formally set in 2000 under the *Lisbon Strategy*, inspired by Japan's leading R&D intensity at the time and intended to position the EU at the global frontier of innovation (Rakic *et al.*, 2021). Since then, R&D intensity has only increased gradually. If recent trends persist, the EU is projected to reach just 2.34% by 2030, with the 3% target not achieved until around 2057 (Figure 2.1-3). Reaching the target of 3% of EU GDP for total investment in R&D by 2030 would imply an additional total investment of EUR 565 billion. Splitting this amount between the public and private sectors (assuming the relative shares remain the current ones), would mean about EUR 370 billion in additional investment from the private sector, with the remainder from the public sector. Hence, meeting the 3% would not require simply maintaining current efforts, but rather changing the trajectory of both public and private R&D investment.

Figure 2.1-3 The evolution of EU R&D intensity under various scenarios



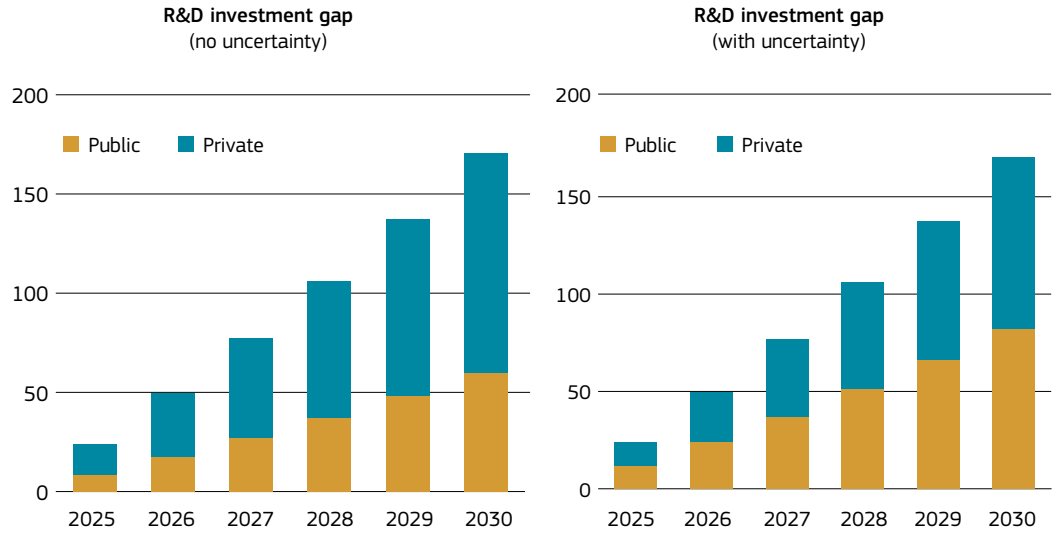
Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Eurostat (DOI link: https://doi.org/10.2908/RD_E_GERDTOT).

Note: The current trend projection assumes that the trend over the last observed decade (between 2013 and 2022) would continue.

Meeting the 3% target becomes an even greater challenge in an environment of heightened uncertainty, as private R&D investment tends to contract precisely when uncertainty rises. In times of increasing uncertainty, private sector investment typically contracts as firms delay investment (Bloom, 2009), and this negative impact is even stronger in the case of R&D investment (Bansal *et al.*, 2019). This mechanism may even be reinforced if uncertainty affects demand expectations (Basu and Bundick, 2017) and in the case of financial frictions (Gilchrist *et al.*, 2014). Most estimates point to a 10% drop in private R&D investment following a macroeconomic shock, with that effect doubling in the case of large or prolonged ones (Barrero *et al.*, 2017; Handley and Li, 2020). Taking into account the unprecedented series of current geopolitical shocks, we design a scenario in which the share of private investment in R&D is 20% lower than the current level, as shown in Figure 2.1-4. In that case, additional public investment should cover almost half of the total need (about EUR 270 billion) to compensate for the missing private contribution.

Figure 2.1-4 The R&D investment gap to reach the 3 % target, billion EUR



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on European Commission AMECO and International Monetary Fund (IMF) data.

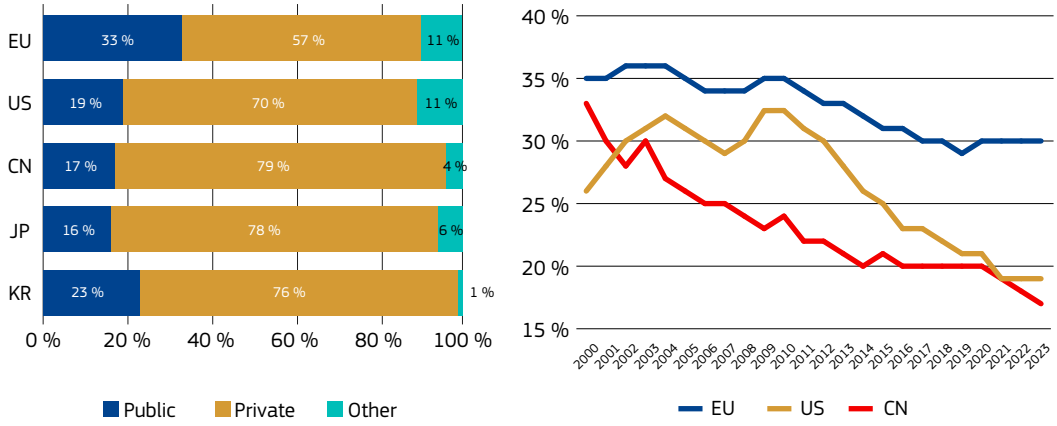
The requirement for such a large increase in private investment points to a deeper structural challenge, namely the EU's lower levels of private R&D investment. Private R&D spending in the EU reached EUR 221 billion in 2023. While outspending Japan (EUR 104 billion) and South Korea (EUR 64 billion), the EU remains well below the levels recorded in China (EUR 345 billion) and the US (EUR 615 billion). However, when adjusting for economic size, the distance from global competitors grows further as shown in Figure 2.1-6. EU R&D intensity reached 1.28 % in 2023, but lags behind that of China (2.04 %), US (2.40 %), Japan (2.68 %) and South Korea (3.77 %). The literature points to a range of structural factors behind this gap, including the EU's lower concentration of high-tech, scale-intensive industries and the conditions that shape firms' ability to grow and commercialise new technologies (see chapters 4.2 and 5.2).

While the EU's public R&D investment remains on par with other countries as a share of GDP, it may mask an important underlying vulnerability. In absolute terms, EU public R&D investments reached EUR 127 billion in 2023, placing the EU among the world's largest public R&D funders. It spends more than China (EUR 74 billion), Japan (EUR 21 billion) and South Korea (EUR 19 billion), although it falls short of the US (EUR 167 billion). When accounting for economic size, EU public R&D intensity remained at 0.74 % in 2023, which is higher than the levels recorded by China, the US, and Japan, all of which fall between 0.44 % and 0.65 %. Only South Korea surpasses the EU at 1.13 % (Figure 2.1-6). However, this apparent strength conceals an underlying vulnerability. The EU economy grows at a much slower pace: roughly half the rate of the US (see chapter 5.1) and around one-sixth of China's GDP growth since

2010. Maintaining comparable R&D intensity therefore does not prevent the gap in absolute investment from widening over time. Even steady investment as a share of GDP can translate into declining global weight if the underlying economy grows more slowly. Over time, this dynamic can constrain the EU's capacity to generate innovation and productivity gains at scale.

The contrast between relatively high public investment and lower private investment points to a structural imbalance in how the EU R&D system is funded. Public sources account for approximately one-third of total R&D financing in the EU, compared to around 17 to 19 % in both the US and China (Figure 2.1-5, left). This relatively high public share is in part a consequence of private investment not having kept pace. Since 2010, both the US and China have been shifting toward increasingly private-driven R&D systems, alongside the expansion of digital and scale-intensive sectors (Figure 2.1-5, right). This shift is reflected in the share of private funding with international counterparts reporting shares between 70% and 79%, while the EU stands at 57% of total R&D investment. Sustaining current levels of public investment alone may therefore not be sufficient to close the gap.

Figure 2.1-5 Gross domestic expenditure on R&D by source of funding, 2023 (left), share of public funding 2000-2023 (right)



Science, Research and Innovation Performance of the EU 2026

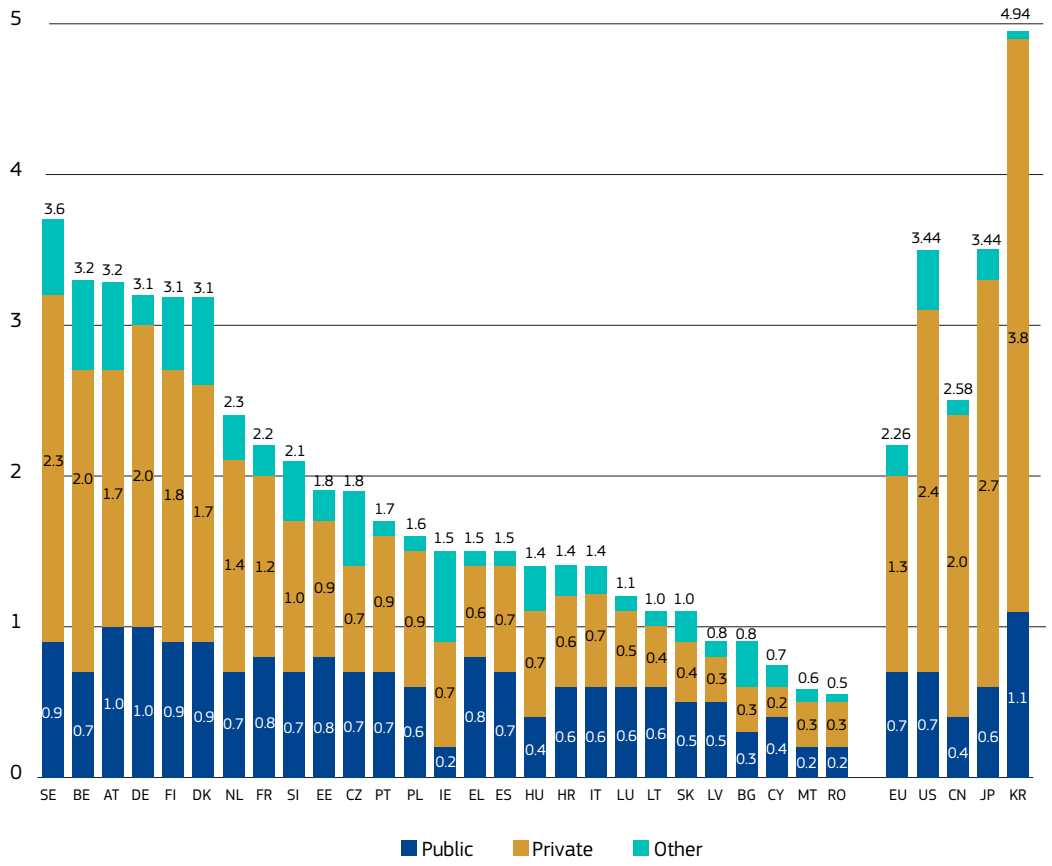
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Eurostat (DOI link: https://doi.org/10.2908/RD_E_GERDFUND).

Note: For the left side; R&D expenditures labelled as 'private' are funded by the business enterprise sector; the label 'public' combines funding by the government sector and European Commission as part of the rest of the world; and the label 'other' combines funding by the higher education, private non-profit and the remaining parts of the rest of the world. For the right side; the data represents only the government sector due to missing values (prior to 2015) for the European Commission as part of the rest of the world.

This structural imbalance plays out differently across Member States, with wide variation in both R&D intensity and the degree of public versus private investment. National R&D intensities range from 0.52% to 3.64% (Figure 2.1-6), reflecting differences in industrial specialisation and innovation system maturity, among other factors. Only six Member States currently exceed the EU's 3% benchmark, namely Sweden (3.64%), Belgium (3.24%), Austria (3.22%), Germany (3.13%), Finland (3.09%) and Denmark (3.07%). Five countries remain below 1%, including Romania (0.52%), Malta (0.58%), Cyprus (0.66%), Bulgaria (0.79%) and Latvia (0.82%). In many countries with lower overall R&D intensity, public funding represents the largest share of total investment, whereas in high-intensity countries, private investment dominates the mix (Figure 2.1-6). This reflects a broader pattern in which

public R&D tends to step in where private investment capacity is more limited (Czarnitzki *et al.*, 2025). However, how public spending translates into broader research activity varies considerably. Measured as the ratio of total to public R&D intensity, some Member States perform at levels comparable to the US, China and Japan, i.e., Ireland (above 7), Belgium (around 5) and Sweden (above 4). Others such as Latvia, Lithuania, Cyprus, Greece and Luxembourg report a ratio below 2. These differences partly reflect industrial structure and economic composition, but may also point to variation in the broader conditions that influence how effectively public investment is associated with private R&D activity (see for example chapter 3.2 on technology infrastructures).

Figure 2.1-6 R&D intensity, by source of funding for Member States, EU and other major economies, 2023



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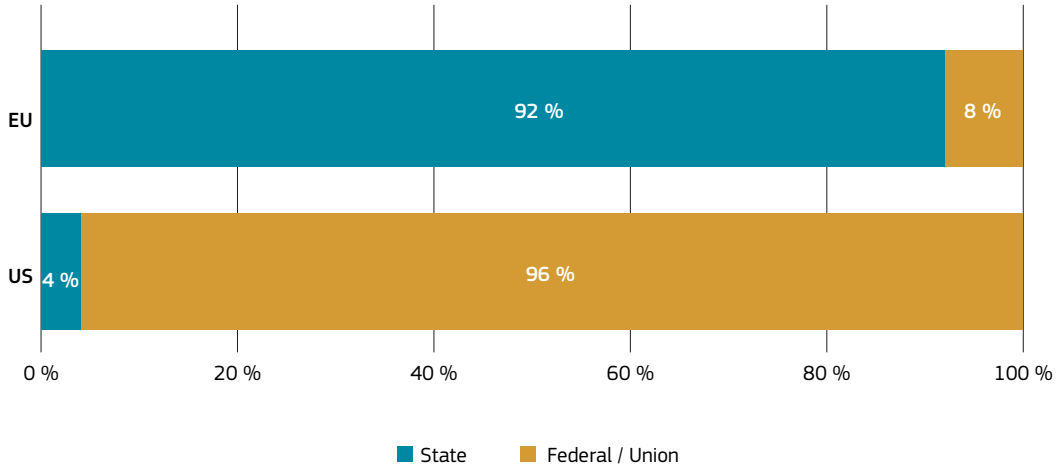
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Eurostat (DOI link: https://doi.org/10.2908/RD_E_GERDFUND).

Note: R&D expenditures labelled as 'private' are funded by the business enterprise sector; the label 'public' combines funding by the government sector and European Commission as part of the rest of the world; the label 'other' combines funding by the higher education, private non-profit and the remaining parts of the rest of the world.

3. Public R&D investments: governance and funding priorities

Public R&D spending in the EU primarily relies on national resources, a fundamentally different system from the US approach of centralising funding at the federal level. In the EU, around 92 % of public R&D funding originates from national governments (Figure 2.1-7). EU-level programmes, predominantly the Framework Programme for Research and Innovation and the R&I part of Cohesion Policy, account for roughly 8 % of total public investments. By contrast, in the US, 96 % of public R&D funding comes from the federal budget, with only 4 % from state and local sources. This difference is not only administrative. Existing research has shown that centralised systems tend to find it easier to coordinate research agendas and scale up investments around shared priorities, while more decentralised systems may better reflect diverse national needs but can make coordination across borders more challenging (Edler and Fagerberg, 2017).

Figure 2.1-7 State versus federal R&D funding in the EU and US as a share of total government R&D funding, 2023



Science, Research and Innovation Performance of the EU 2026

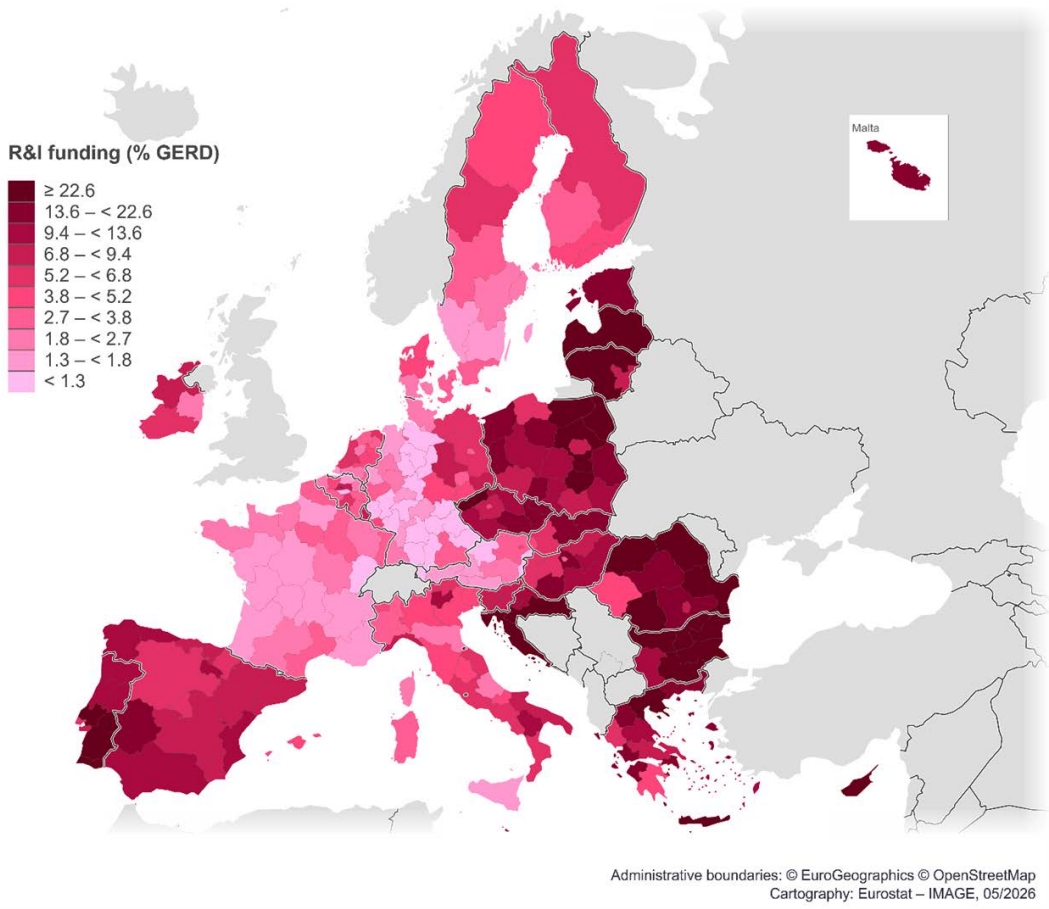
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Eurostat (DOI link: https://doi.org/10.2908/RD_E_GERDFUND) and National Centre for Science and Engineering Statistics (US).

Note: For the EU, Union funding is measured as funding by the European Commission as part of rest of the world. For the US, non-federal government funding is funding by state and local governments. Depending on the data year used, the percentage of EU Union level funding may be higher, potentially close to 10 %.

Despite representing a smaller share of total public R&D spending, EU-level funding plays a strategic role that national programmes alone cannot easily replicate, particularly in enabling cross-border collaboration and tackling grand societal challenges. National funding allows countries to adapt research investments to their own regional needs, societal proprieties and industrial strengths. However, when each country funds research independently, it can lead to fragmentation, duplication of effort and a limited ability to bring together the scale of resources and expertise required to address major scientific and societal challenges (see chapter 6.2). EU programmes help address these limitations by pooling resources, coordinating research agendas and supporting collaborative initiatives that no individual Member State could easily sustain alone. In doing so, EU-level funding strengthens Europe's collective ability to address shared priorities such as climate change, health challenges and digital transformation (Mitra *et al.*, 2024). The extent to which this potential is realised, however, depends in part on the ability of national and regional research systems to engage with EU programmes and translate funding into outcomes (see chapter 6.1).

EU funding plays a very different role depending on the Member State, which means that the interaction with national funds also differs. In many central and eastern European countries such as Poland, Lithuania, Poland, and Romania, as well as parts of Southern Europe, including Croatia, Greece, and Portugal, EU funding represents a substantial share of total public R&D expenditure, often exceeding 22% in the period from 2021 to 2025 (Figure 2.1-8). In most western and northern European countries, EU funding typically accounts for less than 4% of R&D expenditure, with national and private investment remaining the dominant funders. These structural difference in funding composition may produce different incentives for policy alignment. Where EU funding constitutes a large share of the overall research budget, the incentives to align national strategies with EU priorities tend to be stronger. In contrast, where national systems are largely self-sufficient, alignment is more likely to be driven by strategic policy choice (Fagerberg *et al.*, 2009).

Figure 2.1-8 Average contribution of EU-level R&I funding to total public GERD: Horizon Europe and R&I Cohesion Policy, 2021–2025



Science, Research and Innovation Performance of the EU 2026

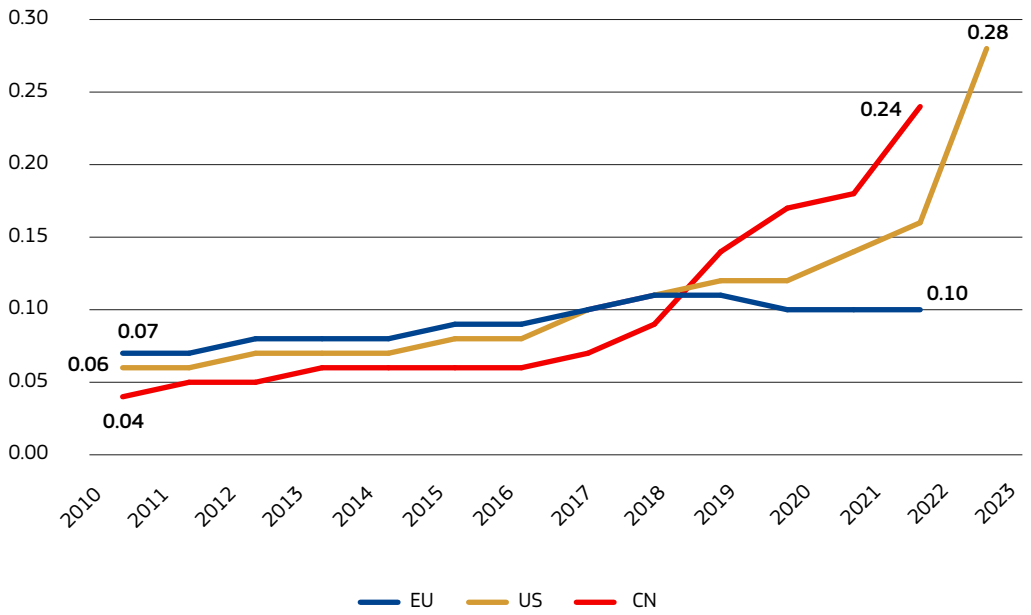
Source: Marques Santos and Conte (2026).
Note: Horizon Europe includes aggregated values of projects started by the end of 2025. R&I Cohesion Policy refers to estimates based on the EU share of operations decided by Operational Programmes by the end of 2025.

The characteristics of Member State R&D investments

Member States channel their public R&D support through two broad types of instruments, namely direct institutional support and tax incentives. Direct instruments, such as grants, subsidies, public procurement and the establishment of public research institutions, allow governments to focus funding on specific priorities and sectors. Indirect instruments, including tax incentives, credits, and favourable regulatory adjustments, encourage private-sector innovation by lowering the cost of R&D without directly funding specific projects. Research indicates that both tax incentives and direct funding are similarly effective, with one extra unit of R&D tax or direct support translating into 1.4 extra units of R&D (OECD, 2023), yet they support different stages and needs in the R&D process.

Since 2010, the use of tax incentives has increased significantly in the US and China, while the EU's use of this instrument has stagnated. As shown in Figure 2.1-9, over the past decade, tax incentives as a public support measure have risen sharply, with China increasing its support by sixfold (from 0.04 % of GDP in 2010 to 0.24 % of GDP in 2023) and the US by more than fourfold (from 0.06 % of GDP to 0.28 % of GDP over the same period). The EU has also increased this type of support, but since 2019, a stagnation and slight decrease is observed, creating a diverging path compared to the US and China. In 2022, this resulted in a difference between the US and China on the one hand and the EU on the other, whereas in 2010, the difference between the major blocks was small, pointing to diverging approaches between the economies.

Figure 2.1-9 Indirect government tax relief for R&D expenditure (GTARD), EU, US and China, 2010–2023

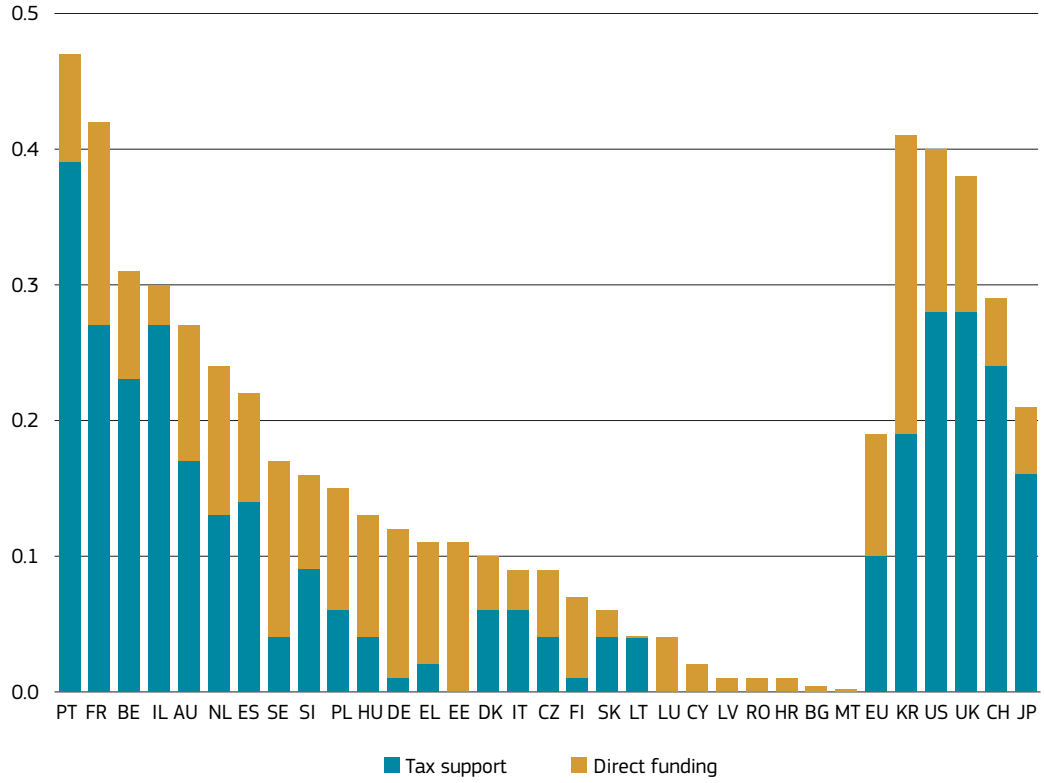


Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on OECD R&D Tax Incentives database.

The use of tax incentives also varies considerably across Member States, with higher-intensity research economies tending to make greater use of indirect support. In 2023, indirect support by Member States in the form of tax incentives accounted for about 53 % of the total support to business R&D, while direct support accounted for 47 %. Member States such as Portugal, France, Belgium and Ireland, and to a lesser extent Austria, the Netherlands and Spain, are among those offering the most generous R&D tax relief as a percentage of GDP (Figure 2.1-10). These figures are somewhat similar to international peers such as the US, UK and China. In contrast, most other EU Member States – and especially several central and eastern EU countries – rely comparatively more on direct funding than tax incentives at much lower overall levels of support.

Figure 2.1-10 Direct government funding and tax support for business R&D as a percentage of GDP, 2023 or latest available year



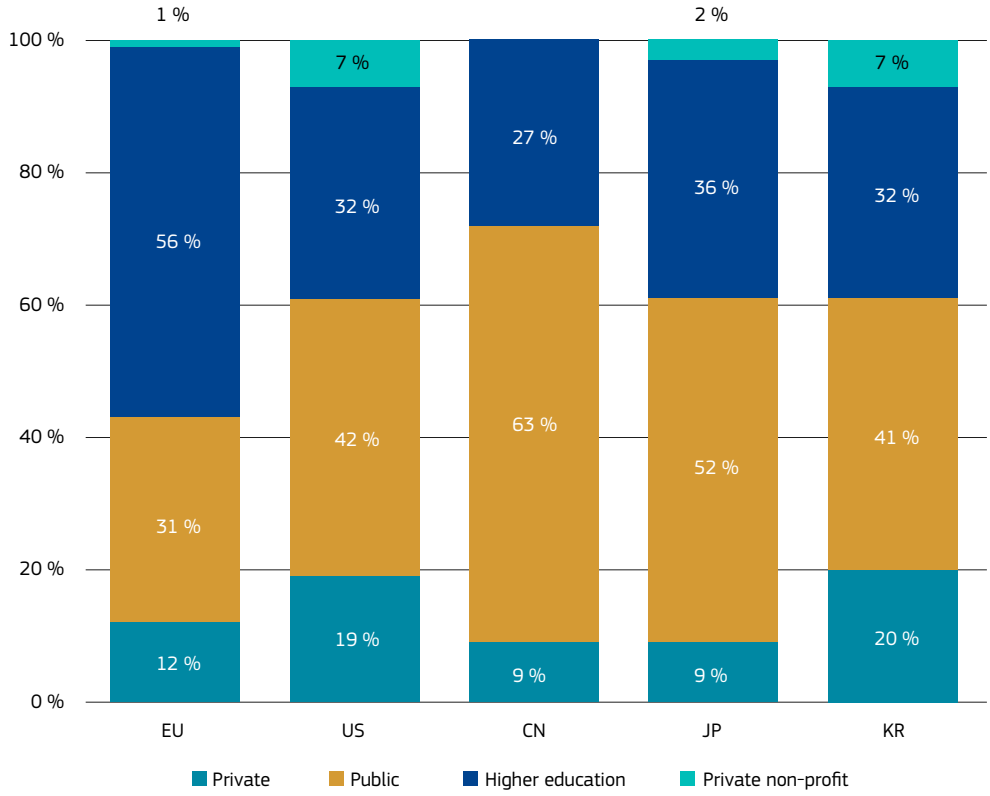
Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on OECD R&D Tax Incentives database.

Note: Tax support is measured as indirect government support through R&D tax incentives (GTARD) and direct funding as government-financed BERD. For additional information on the availability, design and implementation of R&D tax incentives in the EU and OECD area, see the OECD INNOTAX Portal.

Turning to where public R&D funding flows, national public R&D funding within the EU flows predominantly into the higher education sector, contrary to other major economies where governmental R&D organisations are the main recipients. Within the EU, the higher education sector receives 56 % of national government R&D funding, followed by the government sector at 32 % (Figure 2.1-11). This university-centred model reflects a long-standing feature of European research governance, in which universities have historically served as the primary anchors of the public research system (Lepori *et al.*, 2007). This model has been associated with the generation of knowledge that spills over into the broader economy, stimulating private innovation and productivity growth (Cohen *et al.*, 2002; Pavitt, 2001; Jaffe, 1989). However, the extent to which this happens depends on the strength of links between universities and the private sector and on the broader institutional environment in which knowledge transfer takes place (Etzkowitz and Leydesdorff, 2000; Breschi and Lissoni, 2001).

Figure 2.1-11 Sector of performance of public R&D funding, as a share of total, 2023 or latest year available



Science, Research and Innovation Performance of the EU 2026

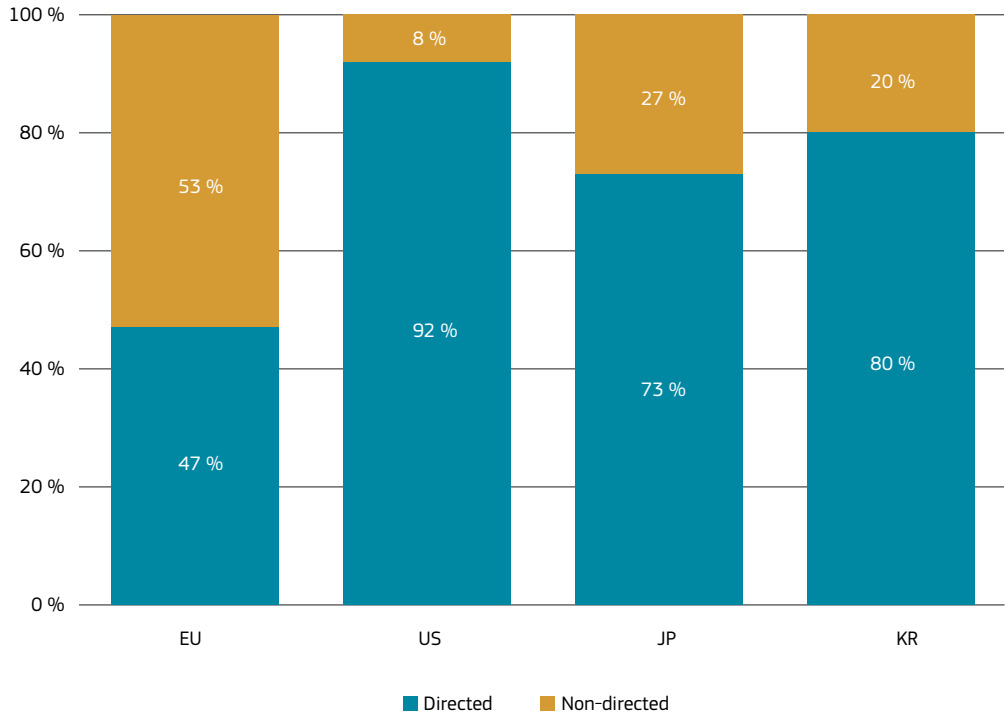
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Eurostat (DOI link: https://doi.org/10.2908/RD_E_GERDFUND).

Note: For the EU, the latest full year available is 2020; for the other countries, 2023 is used. The sector labelled as 'private' is the business enterprise sector, as 'public' is the government sector, as 'higher education' is the higher education sector, and 'private non-profit' is the private non-profit sector.

In other major economies, public R&D funding is organised differently, dedicating a greater share to government research organisations and to the business sector. In China, Japan, the US and South Korea, governmental research organisations receive 63%, 52%, 42% and 41% of public R&D funding respectively (Figure 2.1-11). Government support directed at businesses stands at 20% in South Korea and 19% in the US, compared to 12% in the EU. This reflects a model in which public funding is more directly connected to applied research and commercial development.

Consistent with this university-centred model, the EU also allocates a considerably higher share of its public R&D budget to open-ended, undirected research than other major economies. EU Member States channel around 53% of their R&D budgets into undirected support for the general advancement of scientific knowledge, compared to only 8% in the US, 20% in South Korea and 27% in Japan (Figure 2.1-12). This approach gives researchers freedom to pursue ideas that may not necessarily align with immediate policy needs or predefined priorities and has often been associated with an increase in breakthrough discoveries (e.g., Aghion *et al.*, 2009). The remaining 47% is directed towards specific socio-economic objectives, which is considerably lower than the shares reported for the US (92%), South Korea (80%) and Japan (73%).

Figure 2.1-12 Budget allocations for R&D by socio-economic objective, 2024



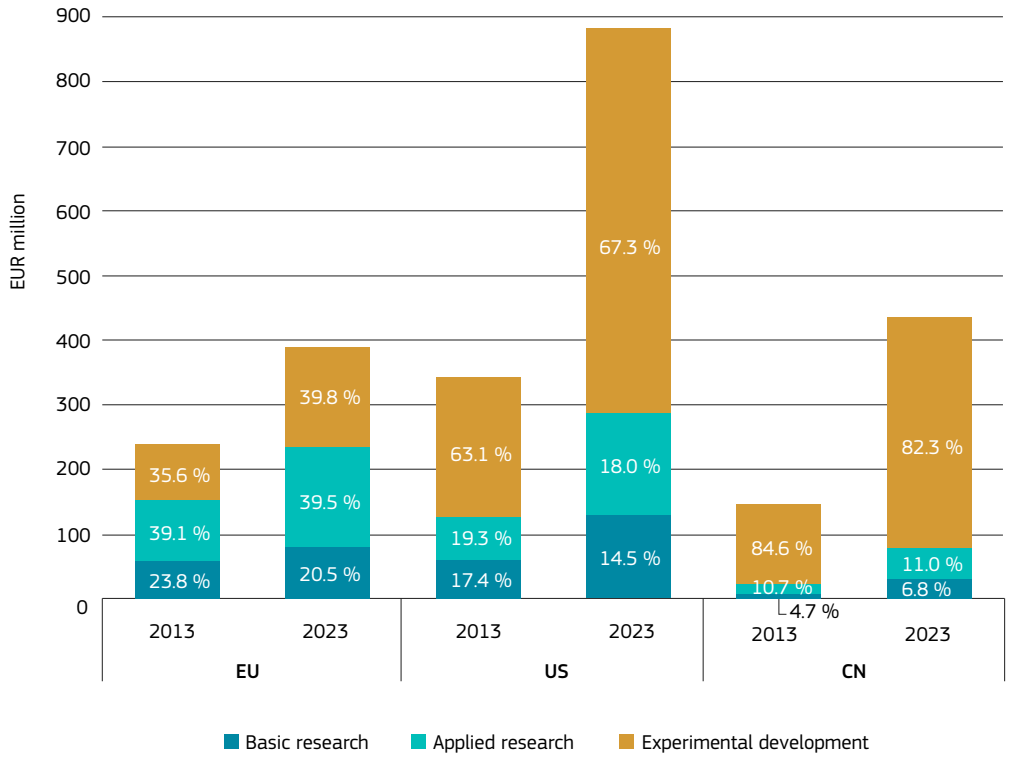
Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Eurostat (DOI link: https://doi.org/10.2908/GBA_NABSFIN07).

Note: NABS12 (general advancement of knowledge: R&D financed from General University Funds (GUF)) covers the estimated R&D content of 'block grants' paid by the government to the higher education sector. NABS13 (general advancement of knowledge: R&D financed from sources other than GUF) covers all budget allocations earmarked for basic research, but which cannot be attributed to a specific objective and are financed by sources other than GUF. Both NABS12 and NABS13 are categories that represent non-directed government appropriations. Data for China is no longer available.

These characteristics of EU's public research system (the concentration of funding in universities and the high share of open-ended research) are reflected in the type of R&D activity performed. R&D can be broken down into three stages, each taking knowledge a step closer to practical use. Basic research is the most exploratory stage as it generates new scientific knowledge without a specific application in mind. Applied research takes that knowledge and uses it to address questions or problems, while experimental development converts this existing knowledge into concrete outputs, processes or products. The EU invests relatively more in the earlier stages of research with 20% of total R&D expenditure allocated to basic research, 39% to applied research and 41% to experimental development (Figure 2.1-13). In contrast, China and the US, allocate 82%, and 67% to experimental development respectively, i.e., the stage where knowledge is most directly converted into commercial outputs. These higher shares are reflected in substantially larger real amounts compared to the EU. Over the last decade, a small shift is observed for the three economies, with the EU (+6 percentage points (pp)) and the US (+4 pp) putting relatively more emphasis on

Figure 2.1-13 GERD by type of R&D funded, EUR billion and % of total, 2013 and 2023



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Eurostat (DOI link: https://doi.org/10.2908/RD_E_GERDACT).

Note: The EU figures are calculated using a sample of EU Member States that have available data for the years 2013 and 2023 and multiplying the shares for the total of the EU. Missing countries for the year 2013: Germany, Luxembourg, the Netherlands, Sweden and Finland; and for the year 2023: Germany, the Netherlands and Finland. The y-axis represents the totals, while the shares are presented within the columns. Percentages do not round to 100 due to non-specified data.

experimental development in 2023 compared to 2013, opposed to basic research, (-4 pp) and (-3 pp) respectively, while China has seen a relative decrease of the share of experimental development (-2 pp), in favour of more basic research (+2 pp) over the same period.

At the business sector level, where the link between research and commercial outcomes is most direct, the EU similarly shows a lower share of experimental development than its main competitors. More granular data for 2023, by sector of performance further indicates that the EU has a relatively low share of experimental development performed by the business sector (37 % of GERD), compared to the US (62 %) and China (75 %). Conversely, the EU shows relatively higher shares of applied research performed by the business sector (25 % of GERD), compared to the US (11 %) and China (2 %). This suggests that European businesses are active in research, but more at an earlier stage of the R&D cycle. Part of this difference reflects the composition of the European industry, which will be explained in section 4 of this chapter.

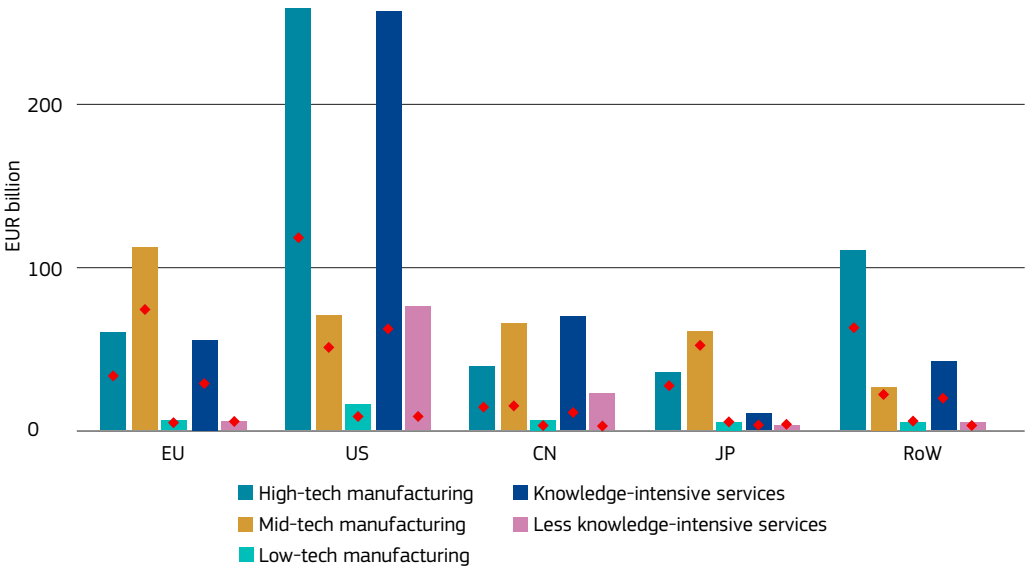
4. Structural and sectorial features of EU private R&D investment

Business expenditure on R&D (BERD) in the EU is relatively stable, but comparatively modest. Reaching approximately 1.50 % of GDP in 2023, the overall EU's BERD remains substantially lower than in other major economies, such as the US and Japan (both about 2.70 %) and South Korea (3.93 %) and slightly below China (2.00 %). Beyond this aggregate gap, the composition of private R&D spending also differs significantly from that of the EU's peers.

EU private R&D investments are largely directed towards mid-tech industries. Based on the top 2 000 R&D investors in the world, EU firms commit large shares of their R&D budgets to mid-tech manufacturing (EUR 112 billion), while high-tech manufacturing (EUR 60 billion) and knowledge-intensive services (EUR 56 billion) receive considerably less (Figure 2.1-14).

The focus of R&D investments underlines a structural gap between the EU and its peers, with potential implications for EU's long-term competitiveness. In 2024, the US deployed EUR 680 billion in total business R&D, with high-tech manufacturing (EUR 259 billion) and knowledge-intensive services (EUR 257 billion) accounting for over three quarters of total investment. China's total business R&D grew nearly fivefold from EUR 43 billion in 2014 to EUR 204 billion in 2024 and its knowledge-intensive services (EUR 71 billion) now slightly exceed mid-tech manufacturing (EUR 65 billion). Japan, similar to the EU, remains concentrated in mid-tech manufacturing, with knowledge-intensive services accounting for just EUR 10 billion.

Figure 2.1-14 Private R&D investment by region and NACE sector type, 2024



Science, Research and Innovation Performance of the EU 2026

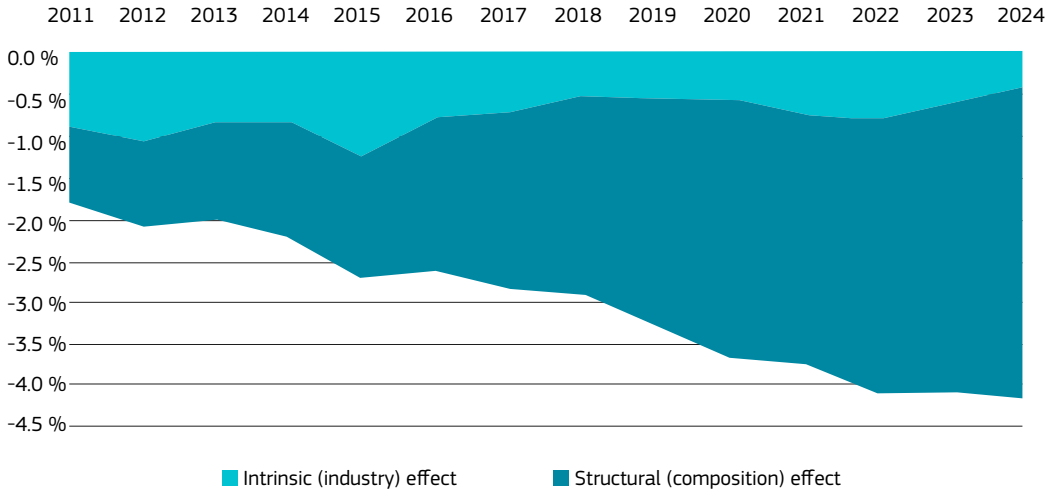
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on the EU Industrial R&D investment Scoreboard 2025.

Note: This figure is based on R&D investment of companies that belong to the top 2 000 companies of the EU Industrial R&D Investment Scoreboard 2025. Further categorisation of NACE (the statistical classification of economic activities in the European Community) sectors by type of sector was made using the Eurostat HTEC classification.

The differences in R&D spending can be explained through both structural composition and intrinsic effects. Structural composition effects relate to the size and weight of each sector within the economy. Regions with a larger share of R&D intensive industries, such as ICT software and health, naturally show higher overall R&D intensity. Intrinsic effects capture what individual firms within a given sector choose to invest. These decisions depend on firm-level factors, including company strategies, capabilities, access to resources and knowledge, and broader innovation cultures. As a result, firms operating in the same sector can still display very different levels of R&D investment across regions (Mathieu and van Pottelsberghe de la Potterie, 2010; Becker and Hall, 2013).

The main driver behind the gap between the EU and the US is sectoral specialisation in high R&D intensity. Historically, EU companies have trailed their US counterparts in terms of R&D intensity, invested at similar levels to Japanese firms, and outperformed most other regions. However, in recent years, the R&D intensity gap has widened causing both US and Chinese firms to outpace EU firms. For the US, this widening between 2011 and 2024 was mainly caused by the structural composition effect as US companies have expanded their presence in highly R&D-intensive sectors. In this case, the intrinsic effect played a smaller and diminishing role (Figure 2.1-15).

Figure 2.1-15 EU-US private R&D intensity gap



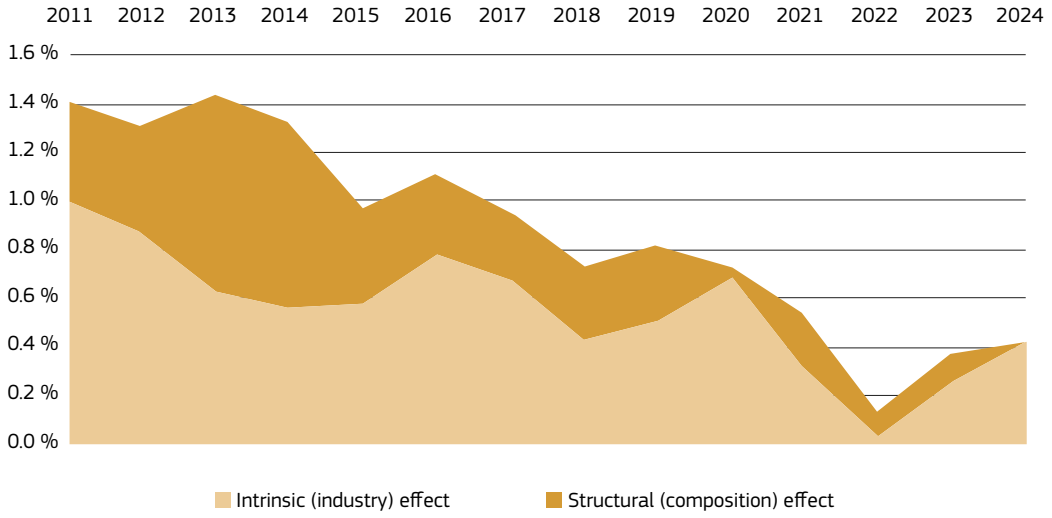
Science, Research and Innovation Performance of the EU 2026

Source: Joint Research Centre, Industrial Strategy, Skills and Technology Transfer Unit based on EU Industrial R&D Investment Scoreboard 2025.

Note: R&D intensity is calculated as R&D expenditure divided by net sales (current euros), based on the top 2 000 global R&D investors each year. The aggregate difference in R&D intensity between two economies is the sum of the differences in output shares of net sales, weighted by their average R&D intensities (structural effect), plus the sum of differences in R&D intensity for all sectors, weighted by their average share of net sales (intrinsic effect).

The EU-China R&D intensity gap is narrowing, driven by both China's changing industrial structure and reductions in within-sector differences. Among the world's top 2 000 R&D investing companies, the EU historically maintained a lead over China, unlike when considering the economy as a whole. This lead was largely due to EU firms' stronger R&D performance in sectors such as health and automotive. However, this gap has narrowed substantially over time. By 2024, the EU's structural advantage had fully disappeared, marking the first year in which the EU registered a slightly negative structural R&D intensity gap (-0.02 %) compared to a positive 0.40 % in 2011 (Figure 2.1-16). This reflects China's growing specialisation in R&D-intensive sectors, particularly ICT services and ICT hardware, fuelled by the rise of major innovators such as Huawei, ZTE, Lenovo, Tencent, Alibaba and Baidu. Although the EU still maintains higher firm-level R&D intensity in key sectors like health and automotive, the overall structural advantage has vanished, with the remaining gap only reflecting differences within sectors.

Figure 2.1-16 EU-China private R&D intensity gap



Science, Research and Innovation Performance of the EU 2026

Source: Joint Research Centre, Industrial Strategy, Skills and Technology Transfer Unit based on EU Industrial R&D Investment Scoreboard 2025.

Note: R&D intensity is calculated as R&D expenditure divided by net sales (current euros) based on the top 2 000 global R&D investors each year. The aggregate difference in R&D intensity between two economies is the sum of the differences in output shares of net sales, weighted by their average R&D intensities (structural effect), plus the sum of differences in R&D intensity for all sectors, weighted by their average share of net sales (intrinsic effect).

The difference in public versus private R&D can lead to variations in broader economic impact. A growing body of empirical research suggests that public and private R&D are not equivalent in this respect (e.g., chapter 8). Public R&D tends to generate larger spillovers across the economy, as the produced knowledge can be acquired by many firms and sectors. By contrast, private R&D is more closely tied to commercial objectives and typically produces more targeted, appropriable returns. Recent estimates indicate that the long-term productivity gains associated with public R&D are significantly higher than those from private investment, largely due to these wider diffusion effects (e.g., Dyèvre, 2024; Gazzani *et al*., 2025).

At the same time, the two forms of R&D are not substitutes, but fulfil distinct and complementary roles. Public investment provides the scientific foundations, while private R&D plays a central role in translating knowledge into marketable products and services (Antolín-Díaz and Surico, 2025). Evidence also suggests that government-funded research, while accounting for a smaller share of total innovation outputs, contributes disproportionately to medium-term productivity dynamics (e.g., Dyèvre, 2024; Fieldhouse and Mertens, 2024). This reinforces the importance of maintaining a balanced R&D system, where strong public research capacity supports and interacts with private sector innovation.

With R&I investments at the core of economies' long-term objectives, such as economic growth and societal returns, attention has increasingly shifted towards an optimal R&I policy design. Beyond the overall scale of funding, recent contributions emphasise the importance of directionality and strategic prioritisation in shaping innovation outcomes (Edler and Fagerberg, 2017; Mazzucato and Semieniuk, 2018). In this context, governments face persistent trade-offs in allocating limited budgetary resources to enhance societal returns. This has led to a growing focus on policy mixes that combine direct funding instruments, such as grants, tax-based incentives, and supply as well as demand-side instruments, in order to influence both the intensity and composition of R&I investment (Edler and Fagerberg, 2017). At the same time, these policy approaches must adapt to evolving economic and technological landscapes, with shifting geopolitical and industrial priorities. As a result, R&I policy is not only concerned with increasing investment levels, but also with directing resources in ways that enhance complementarities between public and private actors and maximise long-term innovation performance.

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CHAPTER 2.2

VERTICAL COHERENCE OF R&I INVESTMENT IN THE EU*

*Andrea Conte, Paolo Pasimeni, Silvia Rocchetta**

KEY QUESTIONS

- How is research and innovation (R&I) investment deployed in a multi-level governance system such as the EU?
- How do we track R&I investment across the full spectrum of EU funding programmes (supranational, national and regional) and governance levels?
- Do EU-level funds crowd-in or -out national investment in R&I? Are there positive spillovers between funding streams?

HIGHLIGHTS

- Public R&I funding is unevenly distributed across Member States and across the main instruments (EU's Framework Programmes, the R&I specific strand of Cohesion Policy, and national research and development [R&D] budgets). This heterogeneity shapes the degree to which additional EU resources can be absorbed and turned into productive outcomes.
- The analysis indicates consistent crowding-in between funding streams. An additional EUR 1 000 of national R&D budget is associated with, on average, EUR 58 of extra Horizon Europe funding two years later (pass through 5.8 %)
- R&I cohesion is a strong lever. The R&I-specific component of Cohesion Policy exhibits the largest pass through rate: every EUR 1 000 of R&I Cohesion Policy outlay is associated with roughly EUR 385 of extra Horizon Europe funding in the following year (+38.5%). This channel therefore represents a powerful source of vertical coherence, reinforcing the capacity of Member States to benefit from EU wide research grants.

POLICY INSIGHTS

- Ensure that funding coordination across governance tiers (supranational, national, regional) is matched by cross policy alignment (thematic priorities) to enhance overall policy effectiveness.
- Use the sector specific results to align work programme calls, co financing rules and monitoring indicators across different instruments. This will enable the EU to target capacity building investments where absorptive capacity is weakest, and to channel complementary funding efficiently.
- Align the R&I component under direct management and maintain the broader complementarity with R&I programmes under shared management. This joint approach strengthens vertical coherence across EU, national and regional levels while optimising the use of public resources.

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Public investment in research and innovation (R&I) in the EU flows through a complex multi-level governance system. Understanding how public investment is deployed through this multi-level governance system and assessing the vertical coherence of such efforts across the EU remain key to ensuring an effective use of public money. This calls for evidence assessing the extent to which EU-level funds crowd-in or -out national investment, shedding light on whether each additional unit of funding allocated to one programme generates positive spillovers that stimulate further investment in the other streams, or whether it displaces (or replaces) investment from them, reflecting a negative substitution effect.

1. Coherence in funding architecture is essential for an efficient R&I system

The allocation of fiscal responsibilities within multi-level governance systems remains a central question in economic and political theory. The question of how fiscal responsibilities should be allocated across different levels of government is particularly relevant for the EU's system of multi-level governance (Wyplosz, 2016; D'Apice and Pasimeni, 2020; Conte and Marques Santos, 2023). A large body of economic literature is devoted to the issue of the optimal assignment of expenditure responsibilities across government layers[1]. Since the pioneering work of Musgrave (1959), which distinguished among the allocation, distribution and stabilisation functions of the public sector, scholars have argued that public spending should be administered by the level of government best able to deploy efficiently, while accounting for differences in citizens' preferences and geographic externalities.

The articulation of such functions is crucial. This is particularly important in the EU, where competences are shared among supranational, national and local authorities. In this context, the design of investment policies is not merely an administrative issue but a fundamental determinant of policy effectiveness, democratic accountability and economic efficiency[2]. The existence of cross-border spillovers, integrated markets and common policy objectives may justify the centralisation of certain competences, whereas the diversity of economic, social and territorial conditions across Member States supports decentralisation in other areas (D'Apice and Pasimeni, 2020).

The EU's budgetary constraints call for an optimisation of coherence across different layers of government. The debate about the EU multiannual financial framework has always focused on the best ways to cope with emerging priorities, while having a comparatively more rigid structure and a much smaller size with respect to national budgets (Tarschys, 2011; Benedetto and Milio, 2012; Monti *et al.*, 2016; Becker *et al.*, 2017; Heinemann *et al.*, 2017; Fuest and Pisani-Ferri, 2019; Busse *et al.*, 2025; Buti *et al.*, 2026). Consequently, determining an appropriate attribution of functions and expenditures across the various layers of government is essential for ensuring that public resources are employed efficiently. Moreover, policy responsibilities must be exer-

1 A comprehensive review of the literature can be found in Oates W.E., (1999, 2005) and, within an EU context, in Oates (2002) and Begg (2009).

2 For an in-depth analysis of the so-called 'decentralisation theorem', see Oates (1972).

cised at the level where they can generate the greatest value, consistent with the EU principle of subsidiarity.

The EU R&D system operates through a layered architecture of public funding, including EU directly managed programmes, such as Horizon Europe, the shared management instruments of Cohesion Policy, and the national R&D budgets (as reported in the Eurostat's Government Budget Allocations for R&D [GBARD] series). Most public investment in R&D in the EU is deployed at the national level (see chapter 2.1); therefore, synergies between EU-level instruments and national budgets are crucial, as the EU budget is only able to finance a small fraction of overall public expenditure in these areas. Although these streams are designed to be mutually reinforcing, empirical evidence of their interaction has been limited.

Coherence in the architecture of R&I funding can be seen as the condition for turning Europe's diversity into collective capacity. In the specific case of the EU R&I system, vertical coherence refers to the alignment of supranational R&I funding (e.g., the EU's Framework Programmes [FP] for R&I), both national (government budget appropriations for R&D) and regional (the R&I strand of Cohesion Policy). When policies at each tier are designed and implemented so that they reinforce one another, they generate synergies: the combined effect of the instruments exceeds the sum of their isolated impacts (Magro and Wilson, 2013; Flanagan *et al.*, 2011).

When this alignment is weak, fragmentation or contradictory policy signals can dilute the overall return on investment. When it is strong, resources are more likely to be used effectively. The more coherent, the more the policies at different tiers of governance strengthen one another by reducing conflicts between objectives and instruments, both in design and implementation (Platjouw *et al.*, 2025). Such coherence can be seen as the condition for turning Europe's diversity into collective capacity. The qualifier 'vertical' distinguishes this from 'horizontal' coherence, which concerns coordination across policy domains at the same level of governance. Examples of horizontal coherence include the alignment of research funding with climate action, digitalisation, health or industrial policy programmes. Horizontal coherence is achieved when these policy streams are organised so that they create synergies. For instance, a climate-focused research call that simultaneously advances digital innovation could be seen to deliver dual benefits without duplicating effort or resources.

Both forms of coherence are essential for an efficient EU R&I system. Vertical coherence ensures that funding flows from the EU, national and regional tiers complement each other, strengthening overall investment capacity. Horizontal coherence guarantees that the same funds contribute to multiple policy objectives, maximising the return on public spending through inter-policy synergies. Together, they help the EU achieve a more integrated, resilient and innovative knowledge economy.

Public R&I financing in EU operates through three distinct institutional logics. Analysing their interaction is a prerequisite for a credible assessment of vertical coherence. These three different sources of public investment for R&I are managed in different ways.

- **Direct EU management**: the European Commission designs competitive calls and awards grants directly to beneficiaries; national authorities have no gate-keeping role. This channel rewards research excellence, generates knowledge spillovers and follows a short-term, grant-by-grant timetable.

- **Shared EU management**: Cohesion Policy R&I funding is co-financed by the Commission and the Member State. Allocation envelopes are fixed ex-ante and disbursement depends on national co-financing and absorption rates. The instrument pursues territorial convergence by upgrading regional R&I systems and operates on a longer implementation horizon.
- **National management**: Member States allocate R&D spending through their own budgetary procedures (GBARD). These allocations reflect national strategic priorities, are subject to domestic fiscal cycles, and embody strategic public-investment decisions.
- **Horizon Europe** creates knowledge spillovers and innovation externalities; its competitive nature encourages efficiency and productivity gains.
- **Cohesion Policy R&I** enhances regional absorptive capacity, a pre-condition for realising the spillovers from supranational programmes; it also contributes to convergence externalities.
- **National R&D budgets (GBARD)** represent strategic public-investment decisions that can generate multiplier effects and shape the domestic innovation system; they are, in general, more flexible in their allocation.

The distinction between direct and shared management is central to any assessment of vertical coherence. Because Horizon Europe, Cohesion Policy and national R&I funds are governed by different institutional logics, eligibility criteria and disbursement schedules, treating them as a homogeneous EU funding block would mask genuine complementarities (crowding-in) or substitution (crowding-out) effects. From an economic perspective, the three channels generate distinct externalities:

The relative importance of each channel varies markedly across Member States. In economies with limited national R&D capacity, EU-level instruments constitute a substantial share of total R&I spending, whereas in larger, richer economies they account for a modest proportion. This territorial heterogeneity influences the scope for vertical synergy. Similar dynamics are observed at the sectoral level, where differences in sectoral composition, technological intensity and global-value-chain position modulate the magnitude of spillovers.

2. Investment is highly decentralised

There is a pronounced territorial heterogeneity in the funding allocation across Member States[3]. Although national R&D budgets dominate in absolute terms, the relative weight of the EU instruments varies greatly across the EU (Table 2.2-1). In some countries R&I Cohesion Policy outlays occasionally exceed national GBARD, whereas in the more research-intensive economies, the combined Horizon Europe and Cohesion Policy contribution represents less than 10% of total R&I effort. These differences largely mirror variations in absorptive capacity, i.e. the ability of a region to transform external resources into productive outcomes (Becker *et al.*, 2013). Regions with limited human-capital endowments or weaker institutional settings

3 The analysis covers the period of 2016 to 2023. This time window matches the implementation phase of the 2014 to 2020 European Structural and Investment Funds (ESIF) programming cycle, for which observed spending under Thematic Objective 01 ('Strengthening research, technological development and innovation') is available. 2016 is the first year for which ESIF spending is recorded, while 2023 is the most recent year available. Both the descriptive figures in Table 2.2-1 and the causal estimates discussed in the next section rely on this same reference period.

tend to rely more heavily on EU-level funding, which in turn creates stronger scope for vertical synergies. Conversely, well-funded national systems exhibit lower marginal effects from additional EU resources, because the incremental knowledge spillovers are partially offset by existing domestic capacity.

EU instruments are designed for different purposes and therefore interact

Table 2.2-1 Average annual public R&I funding by instrument, 2016–2023 (constant 2015 EUR million)

Member State	GBARD (million EUR)	Horizon (million EUR)	R&I-Cohesion (million EUR)	Horizon / GBARD	R&I-Coh. / GBARD	R&I-Coh. / Horizon
Austria	2 948.9	192.1	23.4	6.5%	0.8%	12.2%
Belgium	3 016.6	318.6	35.6	10.6%	1.2%	11.2%
Bulgaria	112.8	15.3	29.2	13.6%	25.9%	190.8%
Croatia	370.7	13.4	70.1	3.6%	18.9%	523.1%
Cyprus	88.5	34.4	13.9	38.9%	15.7%	40.4%
Czechia	1 115.6	46.7	235.4	4.2%	21.1%	504.1%
Denmark	2 684.9	175.7	11.9	6.5%	0.4%	6.8%
Estonia	166.5	24.3	62.6	14.6%	37.6%	257.6%
Finland	1 971.4	155.0	35.3	7.9%	1.8%	22.8%
France	15 196.2	723.5	195.5	4.8%	1.3%	27.0%
Germany	32 632.7	943.3	466.0	2.9%	1.4%	49.4%
Greece	1 228.4	183.9	48.7	15.0%	4.0%	26.5%
Hungary	470.8	34.8	208.2	7.4%	44.2%	598.3%
Ireland	804.9	119.7	24.4	14.9%	3.0%	20.4%
Italy	9 970.8	557.3	385.8	5.6%	3.9%	69.2%
Latvia	65.8	11.0	53.0	16.7%	80.5%	481.8%
Lithuania	141.7	9.4	72.8	6.6%	51.4%	774.5%
Luxembourg	394.9	20.3	1.1	5.1%	0.3%	5.4%
Malta	27.5	3.8	5.4	13.8%	19.6%	142.1%
Netherlands	5 592.1	521.5	52.7	9.3%	0.9%	10.1%
Poland	2 102.9	76.5	890.0	3.6%	42.3%	1163.4%
Portugal	687.0	110.2	404.0	16.0%	58.8%	366.6%
Romania	348.4	27.9	74.5	8.0%	21.4%	267.0%
Slovakia	336.2	14.3	87.3	4.3%	26.0%	610.5%
Slovenia	229.9	35.9	85.0	15.6%	37.0%	236.8%
Spain	6 538.7	640.3	578.0	9.8%	8.8%	90.3%
Sweden	3 728.0	238.2	27.9	6.4%	0.7%	11.7%

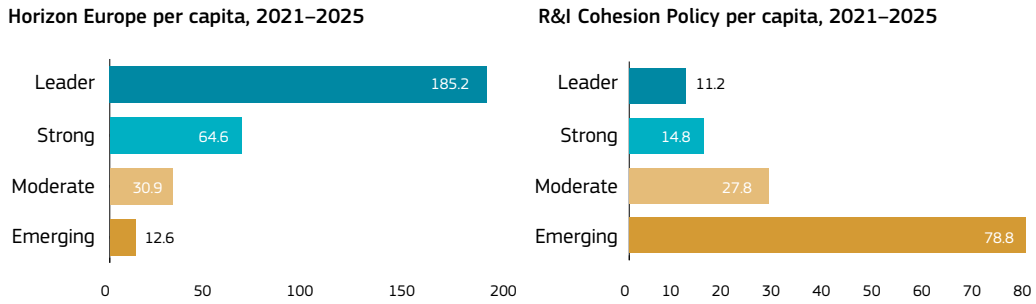
Science, Research and Innovation Performance of the EU 2026

Source: Joint Research Centre based on Eurostat (DOI link: https://doi.org/10.2908/GBA_NABSFIN07), DG Research and Innovation (framework programme allocations) and DG Regional and Urban Policy (ESIF Thematic Objective 01).

Note: Country-level annual averages over the period of 2016 to 2023, in million EUR at 2015 constant prices, deflated with the country-year GDP deflator; ratios computed on unrounded values. The Horizon column is restricted to Horizon 2020. EU, net of the territorial cooperation envelope and of the UK.

with national systems in fundamentally different ways. Funding from Horizon Europe is strongly concentrated in Europe's most advanced innovation ecosystems. Innovation leaders receive roughly 15 times more Horizon funding per capita compared to emerging innovators (Figure 2.2-1, left). R&I funding under Cohesion Policy flows is primarily directed towards regions with lower levels of innovation performance, as emerging innovators receive roughly seven times more R&I Cohesion Policy support than innovation leaders (Figure 2.2-1, right). This pattern suggests that the Horizon Europe instrument primarily supports the best performing innovation ecosystems, while the R&I funding from Cohesion Policy helps ensure that less innovative regions are not left behind.

Figure 2.2-1 R&I funding intensity per instrument (EUR per capita) by Regional Innovation Scoreboard (RIS) 2025 classification, 2021-2025



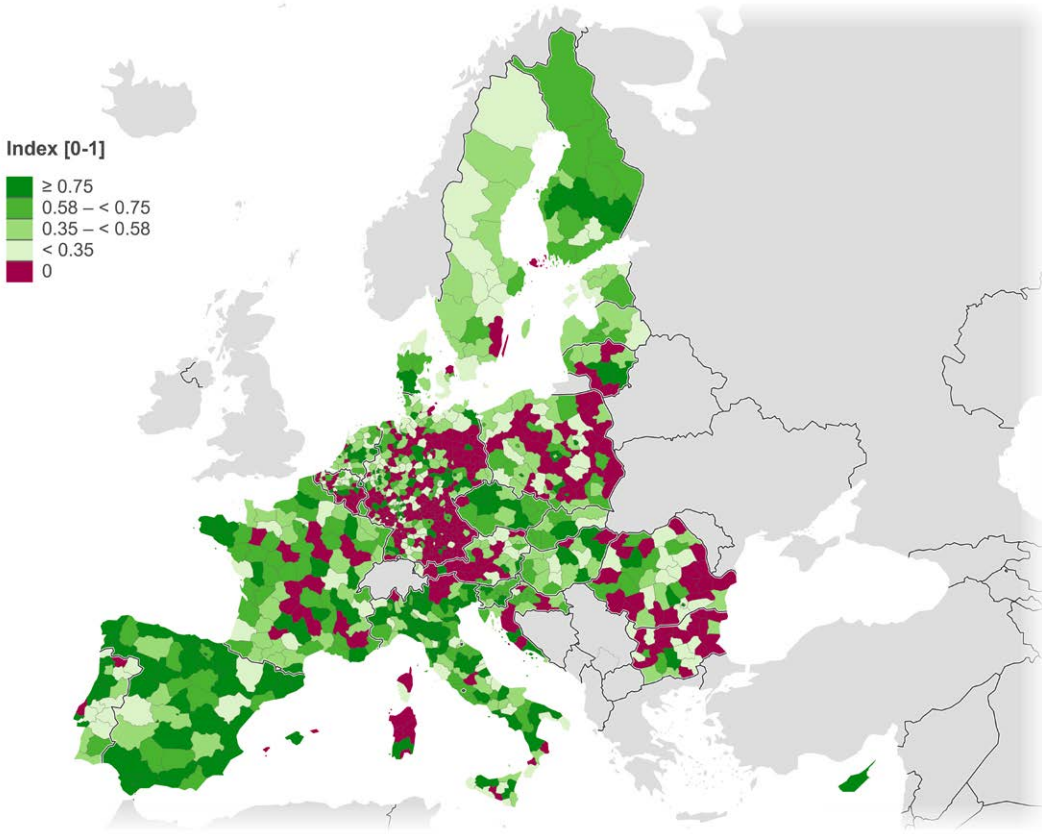
Science, Research and Innovation Performance of the EU 2026

Source: Santos and Conte (2026).

Note: Horizon Europe includes aggregated values of projects started by the end of 2025. R&I Cohesion Policy refers to estimates based on the amount of the EU share of operations decided by operational programmes by the end of 2025.

EU programmes such as Horizon Europe and R&I Cohesion Policy increasingly focus on common societal challenges, including health, climate change, sustainable energy security and transport. However, the degree of alignment varies considerably (Figure 2.2-2). Stronger alignment between the thematic focus of Horizon funding and R&I Cohesion Policy investments is observed in some regions (indicated in darker green), suggesting that both instruments often reinforce similar research priorities. By contrast, other regions in central and eastern Europe (indicated in lighter shades and purple) display weaker alignment, where the two funding streams tend to support a more diverse set of thematic areas.

Figure 2.2-2 Thematic alignment of EU R&I funding across regions: R&I funding synergy index



Science, Research and Innovation Performance of the EU 2026

Source: Bachtrögler-Unger *et al.* (2025).

Note: Figure 2.2-2 reports the cosine similarity index, which measures how closely R&I Cohesion Policy and Horizon 2020 funding are distributed across thematic areas (Societal Challenges) within each NUTS3 region (under the programming period of 2014 to 2020). Values range from 0 (no thematic overlap) to 1 (identical distribution across themes). Greek, Irish and Maltese regions are excluded due to missing NUTS3 project data.

This thematic coherence at the EU level is increasingly mirrored by national research strategies. Evidence suggests that Member States have progressively oriented their national R&D investments towards similar priorities as those promoted in EU programmes, particularly around strategic objectives such as the green and digital transitions, health innovation and industrial competitiveness (European Commission, 2023a; Palmero *et al.*, 2025), although differences may persist in scale and specialisation.

3. Distinct investment programmes reinforce each other

Public R&I investment is organised through a multi-level architecture that is intended to be complementary, yet the joint operation of its channels has rarely been examined in causal terms. The persistent EU territorial R&I divide raises the core empirical question of how other funding streams respond when one stream expands in a given Member State, with three possible scenarios: crowding-in, neutrality and crowding-out (Table 2.2-2). The issue is especially salient given the forthcoming Multiannual Financial Framework 2028-2034 is expected to reshape the EU R&I support around the European Competitiveness Fund (across four policy windows), operating alongside a separate Horizon Europe envelope.

Table 2.2-2 **Funding interaction scenarios and policy implications**

Scenario	Expected dynamics	Policy implication
Crowding-in	An increase in one EU stream is followed by a parallel rise in national R&D budgets or receipts from the other EU instrument.	Justifies coordinated programming and the design of additionality safeguards that reinforce synergies.
Neutrality	The shock to one channel leaves the others unchanged.	Allows each instrument to be designed and administered independently.
Crowding-out	EU funding substitutes for national R&I investment (or vice-versa), reducing complementary spending.	Calls for built-in additionality safeguards to prevent substitution.

Source: Authors' own elaboration.

Most recent evaluations have focused on the relationship between public R&D subsidies and private R&D at the firm level, yielding mixed results across countries and programs. For example, the European Parliament's Stairway to Excellence (S2E) project (JRC, 2018) showed that Cohesion Policy investments in research infrastructure and human capital facilitate participation in framework programmes, particularly in the EU 13 countries. More recently, Hegerty *et al.* (2023) demonstrated that different forms of additionality (input, behavioural, output) among users of EU research infrastructures reinforce one another, suggesting the need for joint assessment. It is therefore important to study how distinct streams of public investment influence each other.

Recent evidence on the response of an R&I investment when another R&I funding stream expands

The empirical analysis suggests that EU funds do not crowd out national funds for R&I; instead, they reinforce each other. Table 2.2-3 and Figure 2.2-3 present the Local Projections instrumental variable (LP-IV) estimates[4] obtained from the observed investment flows[5]. The R&I-specific strand of Cohesion Policy generates the strongest vertical synergy: a EUR 1 000 increase in R&I Cohesion Policy spending in a Member State is associated with an additional EUR 385 of Horizon funding in the following year (coefficient +0.385, $p < 0.01$) and EUR 388 two years later (+0.388, $p < 0.10$).[6] Then, an additional EUR 1 000 of national R&D budget is followed by roughly EUR 58 of extra Horizon funding after two years (Table 2.2-3), showing the important complementarity between EU and national funds for R&D.

These results suggest that vertical coherence in the EU R&I system is characterised by selective crowding in. The three main sources of public investment in R&I reinforce one another rather than competing for the same fiscal envelope. The remaining channel pair estimates (notably the response of national R&D budgets [GBARD] to shocks in the framework programme, and several symmetric specifications with ERDF as the outcome) are not statistically different from zero, providing strong evidence that EU instruments do not crowd out national investment[7]. The findings together describe the interaction of these distinct streams of public investment in the EU R&I system. In particular, R&I under Cohesion Policy builds the institutional and infrastructural absorptive capacity that allows Member States to compete more effectively for Horizon Europe resources, while stronger national R&D budgets are themselves associated with higher Horizon receipts. Taken together, the estimates point to a single mechanism: domestic capacity, whether built through Cohesion Policy or funded from national budgets, translates into a greater ability to attract EU-wide competitive funding.

4 A central concern in the design of the estimator is the macroeconomic cycle. The three funding streams may co-move with the business cycle for reasons unrelated to programme design: during recessions, national discretionary R&D budgets tend to be cut, whereas EU funds follow pre-set schedules under the seven-year budget cycle. Ignoring this co-movement would create the illusion of crowding-out. To mitigate the bias, each specification includes three macro controls: the change in GDP captures the immediate business cycle effect; the change in the trade balance reflects external constraints on domestic investment; and the change in gross fixed capital formation absorbs broader public investment cycles. With these controls, the residual variation that identifies the LP-IV coefficients is plausibly orthogonal to macroeconomic fluctuations, allowing the estimator to capture the structural response of one funding channel to an exogenous shock in another.

5 For the specific purpose of this exercise, we use a panel covering 28 EU Member States from 2002 to 2023, except for 2009, which is excluded because the financial crisis shock to all three channels generates outlier observations that would dominate identification. The outcome at horizon h is the cumulative change in funding at year t+h relative to year t, expressed in constant 2015 euro. In order to reduce potential additional biases, the 'leave one out' instrumental variable (IV) approach adopted is chosen.

6 The result is robust to weak instrument diagnostics (Anderson Rubin 95 % CI [+0.221, +0.550]).

7 Few caveats are worth mentioning: (1) the headline R&I Cohesion Policy → Horizon estimate is derived from a short panel (T = 7); consequently, confidence intervals widen at medium horizons. (2) Results capture relative gains within the fixed Horizon Europe envelope, not absolute growth in EU R&I resources. (3) While the evidence is robust for the three identified crowd in channels, further research could extend the framework to sectoral and technology readiness level dimensions to verify whether similar synergies hold across different parts of the economy.

Table 2.2-3 LP-IV and impulse responses for R&I-Cohesion Policy, observed ESIF panel 2016–2023

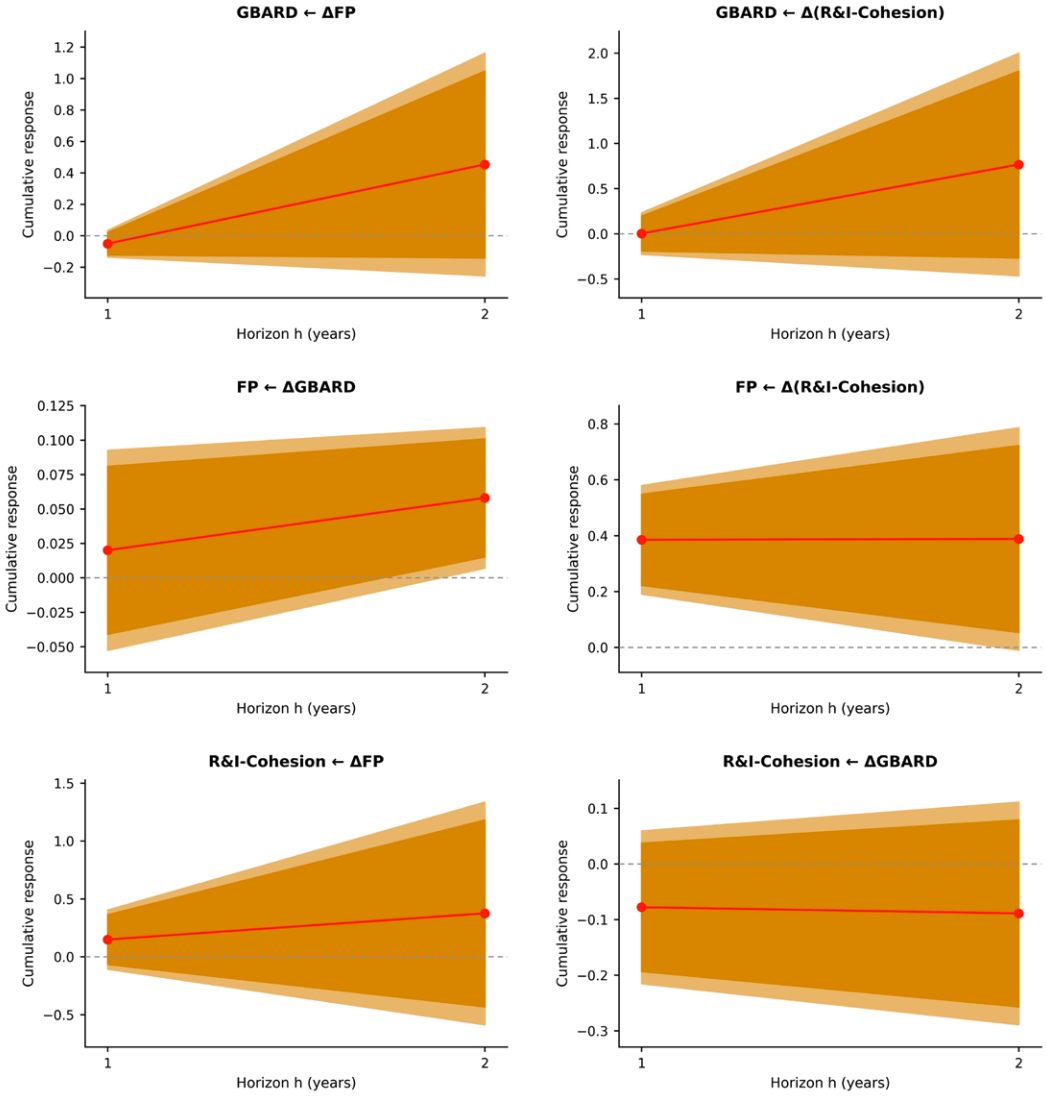
Specification	h = 1	h = 2
Panel A – GBARD (national R&D budget)		
GBARD ← ΔFP shock	−0.051	+0.453
	(0.043)	*(0.361)*
GBARD ← Δ(R&I-Cohesion Policy) shock	+0.003	+0.767
	(0.117)	*(0.628)*
Panel B – EU framework programmes (FP)		
FP ← ΔGBARD shock	+0.020	+0.058**
	(0.037)	*(0.026)*
FP ← Δ(R&I-Cohesion Policy) shock	+0.385***	+0.388*
	(0.099)	*(0.203)*
Panel C – R&I-Cohesion Policy (observed ESIF TO01)		
R&I Cohesion Policy ← ΔFP shock	+0.149	+0.375
	(0.130)	*(0.490)*
R&I Cohesion Policy ← ΔGBARD shock	−0.078	−0.089
	(0.070)	*(0.102)*

Science, Research and Innovation Performance of the EU 2026

Source: Joint Research Centre based on Eurostat (DOI link: https://doi.org/10.2908/GBA_NABSFIN07), DG Research and Innovation (framework programme allocations) and DG Regional and Urban Policy (ESIF Thematic Objective 01).

Note: Coefficients with standard errors in parentheses. Short panel 2016–2023 (T=7), 27 EU Member States. Similar results hold for a longer time period covering three waves of FP/Horizon funding (21 years) and GBARD. Macro controls included. Standard errors clustered by country. The headline result is the FP ← Δ(R&I Cohesion Policy) shock at h=1 (highlighted). *** p<0.01; ** p<0.05; * p<0.10.

Figure 2.2-3 Vertical coherence of R&I investment in the EU, impulse responses, 2016–2023



Science, Research and Innovation Performance of the EU 2026

Source: Joint Research Centre based on TEDAM LP-IV estimates.

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CHAPTER 3

EUROPEAN SCIENCE SYSTEM

CHAPTER 3.1

SCIENTIFIC PERFORMANCE

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KEY QUESTIONS

- What is the EU's position relative to global competitors in scientific output and excellence, and how has it evolved over time?
- In which scientific fields does the EU show comparative strengths or weaknesses?
- What structural trends characterise the EU scientific ecosystem (e.g. collaboration patterns, gender representation, open science)?

HIGHLIGHTS

- The EU maintains a strong research base and ranks second globally in scientific output. Despite a declining global share, output increased again in 2024 after several years of decline, possibly reflecting the fading impact of COVID-19.
- The distribution of scientific output across Europe is gradually shifting, with traditionally strong performers in north-western Europe experiencing a small decline in their shares, while countries in southern and eastern Europe are increasing theirs.
- The EU shows strong scientific output across most broad domains, in particular less technological fields such as arts and humanities, and economic and social sciences. However, its relative position is weaker in some strategic technology-related fields where global competition is intensifying.
- China continues to expand rapidly in publication output, while the US maintains a strong lead in scientific impact and excellence.
- Supported by EU initiatives, scientific collaborations, as measured by international co-publications, have continued to increase, accounting for 57% of the EU's publication output in 2024.

POLICY INSIGHTS

- While the EU maintains a leading position in the global scientific landscape, strengthening scientific performance and excellence in strategic technology-related fields will be essential to remain competitive.
- The growing internationalisation of EU research highlights the important role of the European Research Area (ERA)in building and strengthening a single, borderless market for research, innovation and technology.
- Retaining senior women researchers, particularly in fields such as STEM (i.e., Science, Technology, Engineering, and Mathematics) where women are underrepresented, is important not only for their direct contributions to scientific output but also for their role as mentors, in encouraging greater participation of women in science.
- The EU remains specialised in several fields linked to societal challenges, particularly climate and health. Continued support for research and innovation (R&I) in these areas will be important to strengthen Europe's resilience and sustainability transitions.

Science plays a central role in our societies as it addresses global challenges and drives technology and innovation, which increases competitiveness and enables evidence-based policy decisions. Research, as the process of generating scientific knowledge, has been at the core of the EU policy initiatives for more than 25 years since the launch of the European Research Area (ERA), with the aim to 'create a single, borderless market for research, innovation and technology across the European Union'. With a number of concrete actions, the ERA prioritises open science, access to research infrastructures, researchers' careers and mobility, knowledge transfer, gender equality, as well as cooperation, scientific excellence and global leadership. To tackle persistent challenges, the European Commission will adopt the *ERA Act* in 2026, building on the progress made so far[1].

The EU Framework Programme for Research and Innovation is the main EU funding instrument to boost scientific excellence and foster collaborations. The current programme, Horizon Europe, with a budget of EUR 95 billion, aims to strengthen Europe's global position and address pressing societal challenges. On 16 July 2025, the European Commission put forward a proposal for the next Horizon Europe Framework Programme, which will cover the period of 2028 to 2034. With a proposed budget of EUR 175 billion and close links to the European Competitiveness Fund, the programme aims to boost scientific excellence, innovation and competitiveness, while strengthening the ERA.

In this context, the analysis of bibliometric indicators (scientific publications and their impact) as presented in this chapter provides strong evidence of the EU's scientific performance, global positioning and evolution over time. To ensure a well-balanced representation of countries and disciplines, the peer-reviewed documents included in the bibliometric indicators comprise journal articles, reviews and conference papers. The bibliometric analysis looks at the performance of the EU compared to a selection of global players, as well as across its Member States individually. The analysis reveals the EU's strengths and weaknesses in specific fields, including emerging technologies, and provides evidence of the openness of its scientific system.

1. Structural changes in the global distribution of scientific output

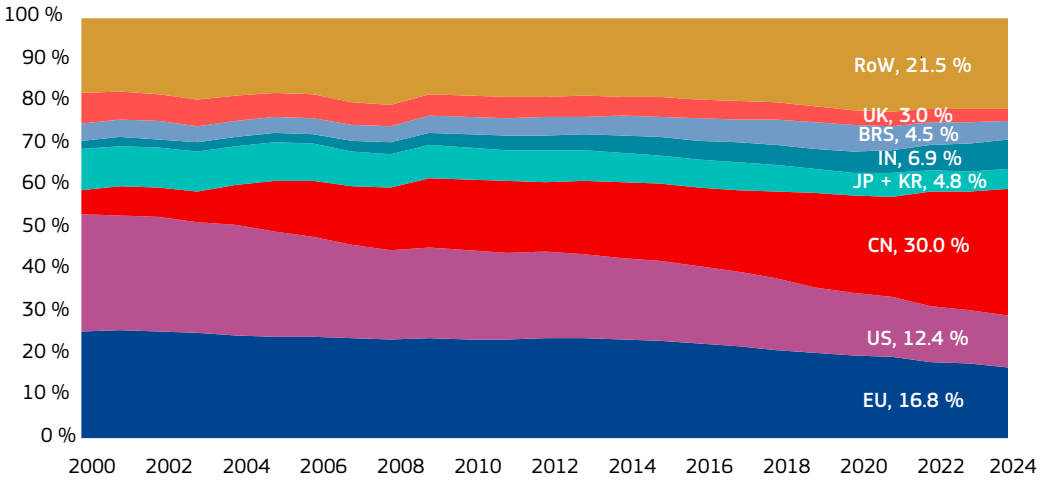
The EU maintains a leading position in the global scientific landscape. The EU is the second-largest producer of scientific output. In 2024, the EU accounted for 16.8% of global scientific output, ranking second after China (30.0%) and ahead of the US (12.4%), as shown in Figure 3.1-1.

Global scientific output continues to increase and be dominated by three major producers: China, the US and the EU. However, the balance among them has shifted significantly, driven by a substantial expansion of China's share since 2000, largely at the expense of the US and, to a lesser extent, the EU (Figure 3.1-1). This trend persisted from 2022 to 2024, during which China gained a further

1 https://research-and-innovation.ec.europa.eu/strategy/strategy-research-and-innovation/our-digital-future/european-research-area_en

2.6 percentage points of global share, accounting for 30% of all scientific publications in 2024. Another notable development is the continued increase in India's scientific output, which rose from less than 2% of global output in 2000 to around 7% in 2024. Evidence suggests that the rapid adoption of artificial intelligence (AI) across various scientific areas has contributed to the increase in global publication volume (Hao *et al.*, 2024). At the same time, generative AI (GenAI) is helping researchers to increase their productivity by shortening the time required to produce scientific results and prepare their publications.

Figure 3.1-1 Evolution of global shares of scientific publications, 2000–2024



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

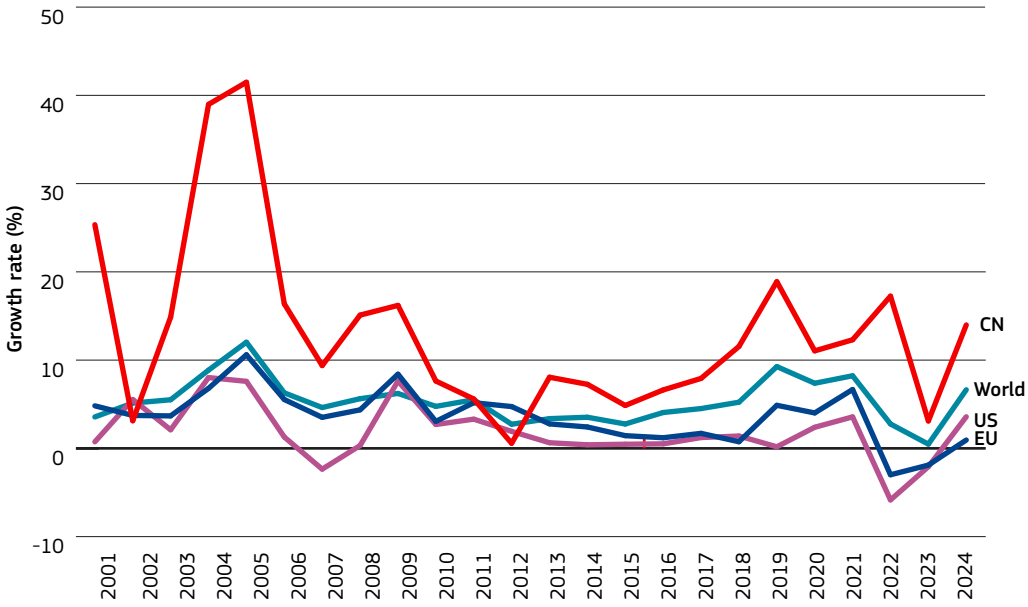
Notes: Fractional counting was used to assign publications to countries/aggregates. BRS: Brazil, Russia and South Africa.

After two consecutive years of decline in the number of scientific publications, the EU has returned to a positive trajectory. From 2021 to 2023, publication output in the EU decreased by nearly 5%, which, combined with the expansion of publication volumes in China and India, explains the EU's decline in global share. Compared to 2022, the EU lost a larger share than the US, which has suffered the biggest overall loses since the beginning of the Chinese rise. However, evidence suggests that this negative trend, most likely linked to the COVID-19 pandemic, began to reverse in 2024 (0.9% increase between 2023 and 2024).

Similar to the EU, the US experienced an increase in the total number of scientific publications in 2024, reaching levels approximately equal to those observed in 2020. Overall, from 2000 to 2024, the US recorded a Compound Annual Growth Rate (CAGR) in scientific publications of 1.8%, compared to 3.4% for the EU and 12.3% for China. Scientists have expressed concerns that recent cuts to university and research funding could further weaken the US position in the global scientific landscape[2].

2 https://www.nature.com/nature-index/news/nature-index-research-leaders-united-states-losing-ground-china-lead-expands-rapidly; https://www.aau.edu/key-issues/federal-research-cuts-threaten-us-innovation-and-leadership

Figure 3.1-2 Annual growth rate of scientific publications, 2000–2024



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

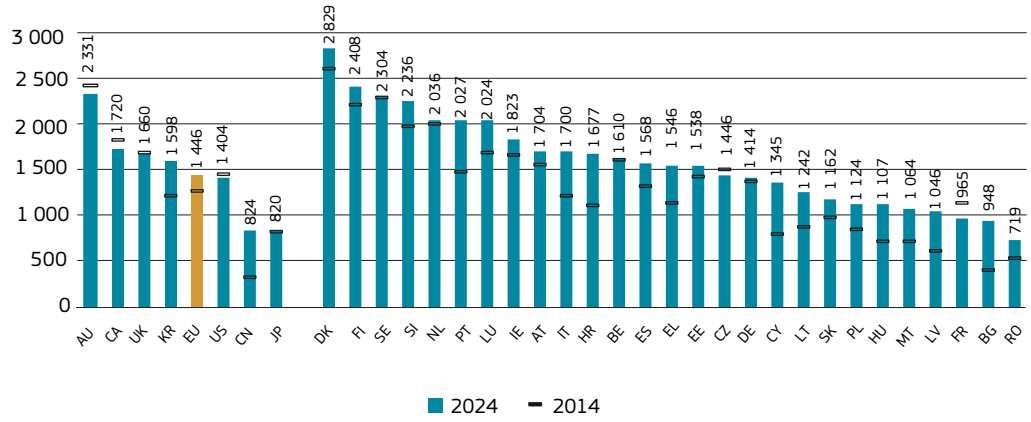
Over the past two decades, China's[3] annual growth rate has consistently outpaced other global players, remaining resilient to global crises and reflecting the effectiveness of relevant policy measures (Figure 3.1-2). The expansion of China's scientific output reflects both a rapid increase in the number of researchers and a rise in publication productivity per researcher (Nagaraj and Yao, 2026). Studies (Pisani *et al.*, 2025; Liang *et al.*, 2022) suggest that one key driver has been the adoption of policies that encouraged scholars to publish both domestically and internationally, incentivised potential returnee researchers and fostered collaborations. A further potential driver was the introduction of the requirement for graduate students (including master's students) to publish academic papers before receiving their degrees, which was adopted independently by universities across China (Stanley and Yan, 2007; Tang and Jia, 2023; Wang, 2007; Zhang and Zhu, 2016). While these measures significantly increased the volume of scientific output, after 2020, policy reforms have shifted the focus towards improving research quality.

The EU's scientific output relative to population exceeds that of both the US and China and has continued to increase over time. In 2024, the EU recorded 1 446 publications per million capita, slightly more than the US (1 404) and significantly more than China (824). However, the EU is still behind several key competitors such as Australia (2 331), Canada (1 720), the UK (1 660) and South Korea (1 598). Contrary to these countries, with the

3 Publication volume counts for China, Japan and South Korea presented in this analysis are likely to underestimate the weight of these countries' national publication sets in the global scientific system. This is particularly true of the social sciences and humanities (European Commission, 2026b).

exception of South Korea, the EU has shown an increase of 15.7% since 2014. This upward trend is driven not by demographic decline (the population increased by 1.6%), but by an increase in scientific output (17.6%). As illustrated in Figure 3.1-3, almost all Member States have improved their research intensity over the past decade. The strongest improvements are observed in southern and eastern European countries, including Bulgaria, Cyprus, Greece, Italy and Portugal, as well as Latvia, Lithuania and Poland, among others. France recorded a significant decline in this indicator (-14.5%) due to a 3% increase in the population and a 12% decrease in scientific publications.

Figure 3.1-3 Publications per million population, 2014 and 2024



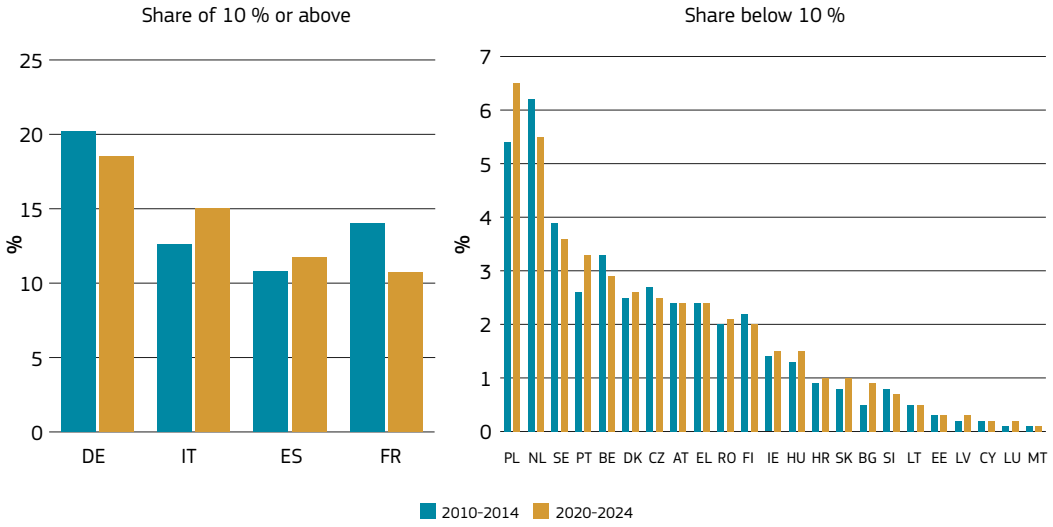
Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on World Bank and Science-Metrix using Scopus (Elsevier).

Note: Fractional counting was used to assign publications to countries/aggregates. Data labels correspond to 2024.

Within the EU, the distribution of scientific output is progressively becoming more balanced, with a gradual convergence between traditionally strong research performers and less research-intensive Member States. While the largest Member States still account for most EU publications, the overall landscape is evolving. North-western European countries such as Germany, France, the Netherlands, Sweden and others remain top contributors, although their shares have declined. At the same time, southern and eastern European countries, including Spain, Italy, Poland and Portugal, have recorded significant increases (Figure 3.1-4).

Figure 3.1-4 Member States' share of total EU scientific publications, 2010–2014 and 2020–2024



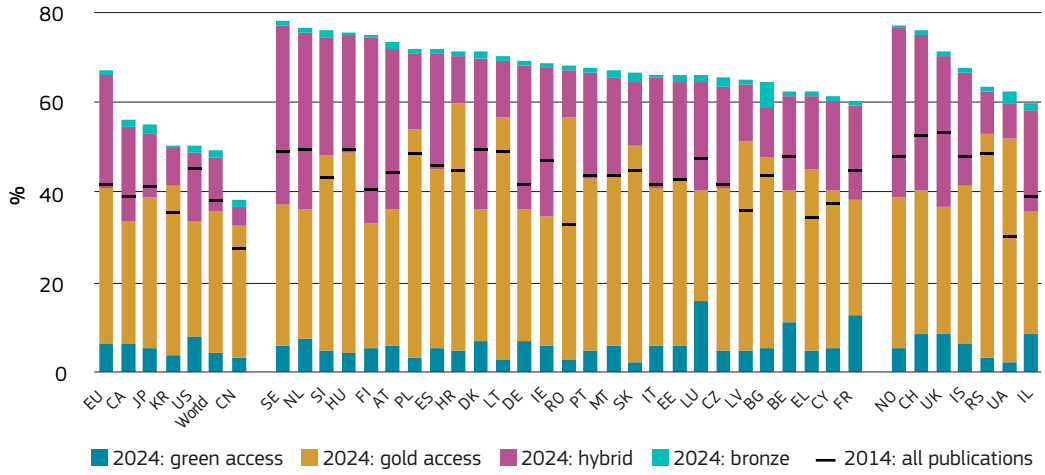
Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

Note: Fractional counting was used to assign publications to countries/aggregates.

The share of open access (OA) publications has increased significantly worldwide over the past decade. OA refers to the practice of providing online access to scientific publications that are free of charge to the user and reusable. In the EU, OA publications accounted for around 67% of peer-reviewed publications in 2024, above the US (50%), the global average (49%) and China (38%). However, important differences persist across Member States, ranging from around 60% in France to almost 80% in Sweden. Most OA publications in the EU are published through gold OA, where articles are immediately available via the publisher, or hybrid OA, where individual articles are made OA in otherwise subscription-based journals, typically against a fee. Green OA, where authors deposit a version of the article in a repository, and bronze OA, where articles are free to read on the publisher's website but lack a clear open licence, account for a smaller share in most countries (Figure 3.1-5).

Figure 3.1-5 Open Access (OA) peer-reviewed publications as % of total peer-reviewed publications with digital object identifier (DOI), 2014 and 2024



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

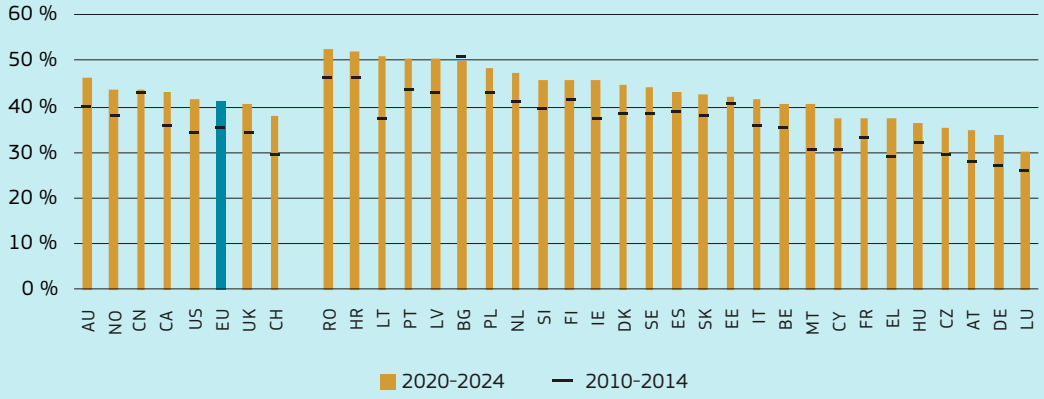
Note: Full counting used. Green OA: Published version or accepted manuscript available in an OA archive. Gold OA: Article on the publisher platform with an open licence available and published in a full OA journal. Hybrid OA: Article on the publisher platform with an open licence available. Bronze OA: Article freely available on the publisher platform for which no open licence is confirmed.

The European Commission has actively promoted OA through several initiatives. Under Horizon Europe, beneficiaries must ensure OA to peer-reviewed scientific publications. The *ERA Policy Agenda 2025-2027* includes a dedicated action on enabling open science through data sharing and reuse, notably via the European Open Science Cloud (EOSC), which provides a trusted environment for accessing and reusing research outputs. In addition, Open Research Europe, launched in 2021, serves as an OA publishing platform for EU-funded research. More information on open science can be found in chapter 3.3.

Box 3.1-1 Gender gap in scientific output

Women's leadership in scientific output has improved steadily over time, but gender balance has not yet been achieved across all EU countries and research fields. First authorship of a scientific publication is commonly used as an indicator of research leadership, particularly among early-career researchers, as it reflects the individual who made the largest contribution to the research and paper writing[4]. At the EU level, the share of scientific publications with a woman as first author increased from 27.5% in 2000 to 42.6% in 2024. Similarly, at the EU level from 2018 to 2022, women accounted for 35% of corresponding authors, usually senior researchers or group leaders responsible for the submission and publishing process. Although there is no gender difference in the impact of citations (European Commission, 2025a), women's leadership among the highly cited publications follow similar trends (from 25% in 2000 to 39.3% in 2022). Despite progress over time, women's leadership in the EU's scientific output remains below that of Australia, Norway, China and Canada, but is comparable to the US and UK. Within the EU the shares vary significantly, from almost 53% in Romania to 30% in Luxembourg.

Figure 3.1-6 Proportion of women first authors, 2010–2014 and 2020–2024



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

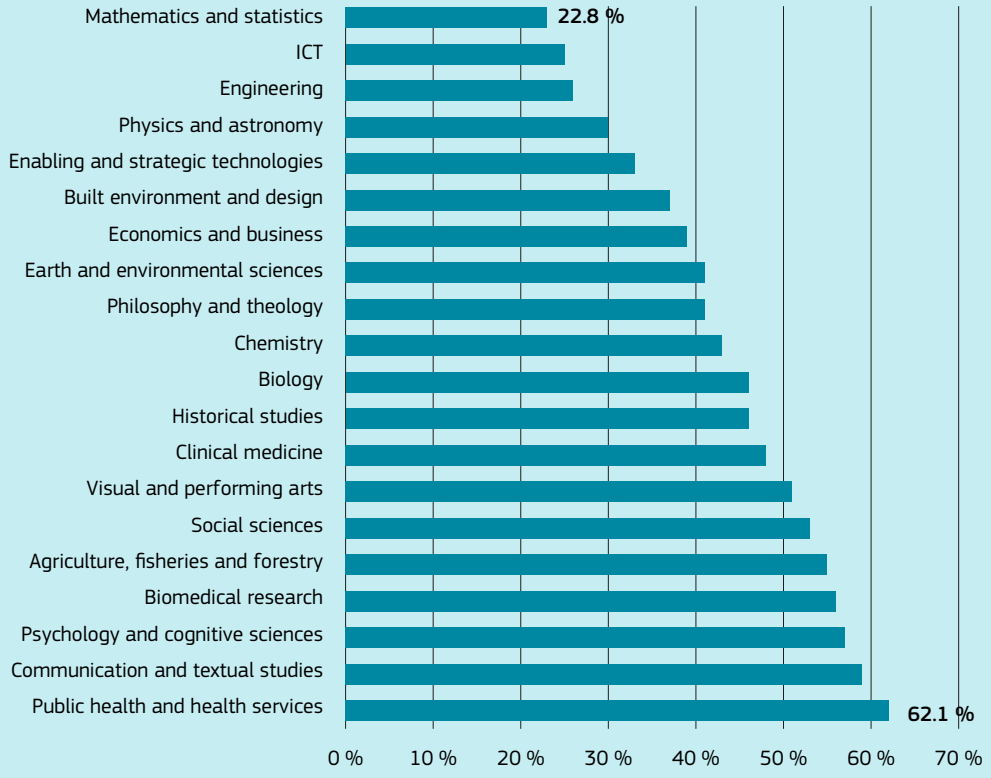
Women's leadership in scientific output varies considerably across scientific fields, with women remaining underrepresented in STEM-related areas. The lowest shares of women first authors are observed in mathematics and statistics, ICT, engineering, physics and astronomy, where women account for less than 30% of first authorships. By contrast, women's leadership is considerably higher in fields related to public health, communication, psychology and biomedical research, where the share of publications with a woman as first author exceeds 55%. The observed differences across scientific fields are closely related to gender disparities earlier in the researchers'

4 https://scientific-publishing.webshop.elsevier.com/publication-recognition/what-corresponding-author/

careers. First authorship is often associated with doctoral candidates and early-career researchers. Evidence from She Figures 2024 (European Commission, 2025a) shows that women remain underrepresented among doctoral graduates in several STEM fields. This underrepresentation at doctoral level is reflected in the lower shares of women first authors observed in these disciplines.

In STEM related areas, where women are usually underrepresented, same gender mentor–mentee pairs are more common. A recent study (European Commission, 2026a) suggested that the importance of gender match in research mentoring is more critical for women than for men, due to women's lower representation in most areas of science. It was also found that having a mentor of the same gender may slightly benefit the scientific performance of women mentees, although these benefits are less evident as representation of women in science increases.

Figure 3.1-7 Proportion of women first author by scientific field in the EU, 2020–2024



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

2. Analysing the scientific impact of EU's publications

Scientific leadership reflects not only the scale of publications but also their scientific impact. Countries with large publication volumes do not necessarily achieve the highest levels of scientific impact. China dominates in volume, accounting for around 30% of global scientific publications. However, its citation impact, measured by the citation distribution index (CDI), remains only moderately above the world average, despite strong improvements over the past decade. The EU combines a large publication share (around 17%) with only moderate citation impact, slightly above the world average and broadly stable over time. This points to scope for further strengthening of scientific impact. By contrast, the US combines a relatively strong global share of output with maintaining a leading position in scientific impact, despite signs of decline in the past decade (Figure 3.1-8).

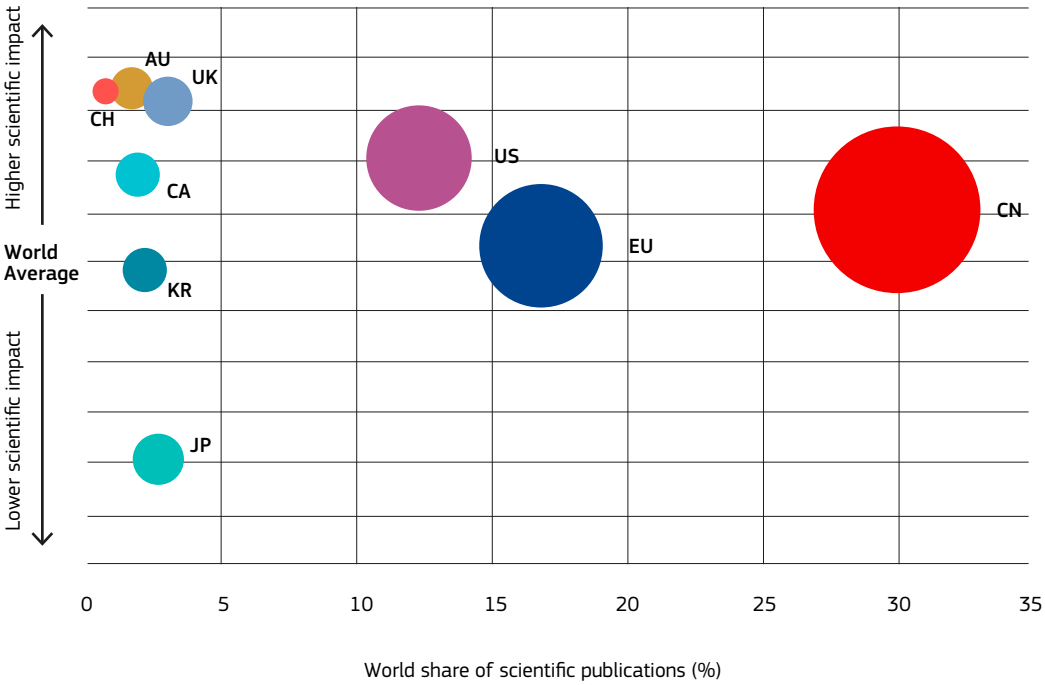
Smaller research systems, such as Switzerland, Australia, the UK and to a lesser extent Canada, achieve high impact despite their limited scale. This reflects strong international collaboration, specialisation and concentration of excellence. Finally, Japan shows comparatively low citation impact despite a solid publication base, while South Korea remains closer to the world average. This is associated with lower levels of international scientific collaboration for these two countries. Overall, evidence suggests that strengthening scientific excellence remains central to the EU's global position in science. This underlines the importance of maintaining strong excellence-based instruments, notably under Pillar I: 'Excellent Science' of Horizon Europe, including the European Research Council (ERC), whose role is foreseen to be further strengthened in the next EU Framework Programme for Research and Innovation (European Commission, 2025c).

In terms of global contribution to highly cited publications[5], China has strengthened its position as the leading global contributor to highly cited scientific publications, while the shares of the EU and the US have declined in the past decade. In 2022, China accounted for around one-third of the top 10% (31.4%) and top 1% (32.4%) most-cited publications. The EU follows with 17.2% of the top 10%, while the US remains ahead of the EU in the top 1% (18.4%). Over the past decade, the increase in the share of China has been at the expense of the US and, to a lesser extent, the EU. The US share fell from around 30% in 2012 to 16% in 2022 in the top 10%, and from 37% to 18% in the top 1%. The EU also declined, though less significantly, from around 25% to 17% for the top 10%, and from 23% to 15% for the top 1% (Figure 3.1-9).

In 2021, the EU overtook the US in the share of the top 10% most-cited scientific publications, becoming the second-largest global contributor after China. China's rise reflects both increasing scale and improving scientific impact, but differences in citation patterns point to varying degrees of global integration. A significant share of citations to Chinese publications originates domestically. By contrast, publications produced in the EU and the US tend to receive citations from a more geographically diverse set of countries, indicating stronger integration into global scientific knowledge networks (Nagaraj and Yao, 2026).

5 Measured by the share of a country's highly cited publications in the total number of most-cited publications globally.

Figure 3.1-8 Scientific impact and world share of scientific publications, 2024

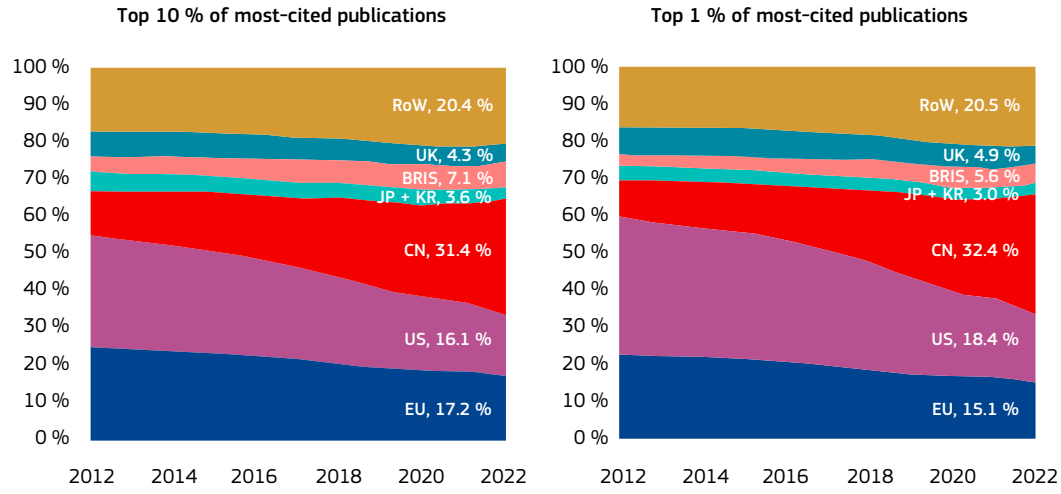


Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

Notes: Scientific impact is assessed using the Citation Distribution Index (CDI). A higher CDI indicates greater scientific impact, as measured by citation performance. CDI evaluates how papers are distributed across citation deciles, providing a more nuanced measure than average-based metrics, which can be skewed by a few highly cited papers. Bubble size represents the absolute number of scientific publications based on fractional counting.

Figure 3.1-9 Evolution of global shares of most-cited scientific publications, 2012 (citation window: 2012–2014) to 2022 (citation window: 2022–2024)



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

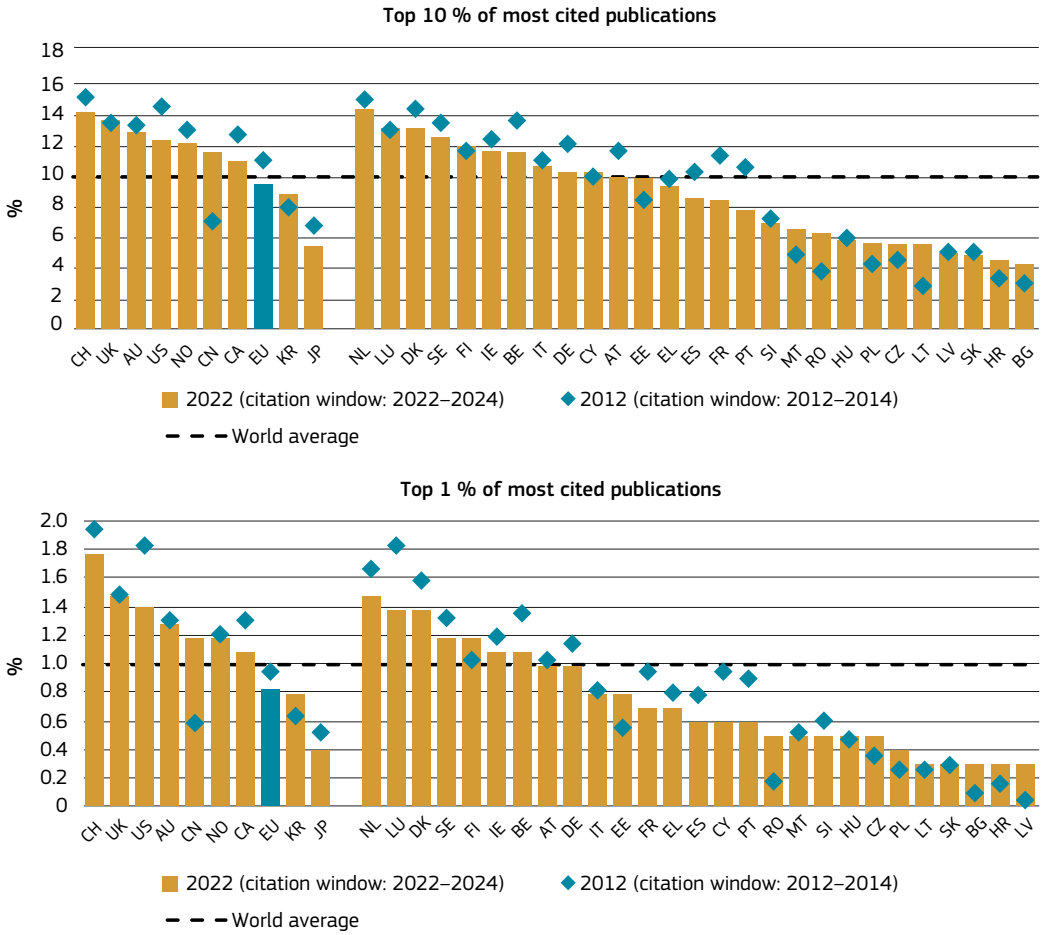
Notes: Scientific publications within the 10 % and 1 % most cited scientific publications worldwide. Fractional counting was used to assign publications to countries/aggregates. BRIS: Brazil, Russia, India and South Africa.

Looking at scientific excellence as proxied by highly cited publications, the EU as a whole shows solid but uneven performance. When measured as the share of each country's own publications that fall within the world's top 10 % and top 1 % most-cited publications, the EU remains close to the world average but lags behind leading global performers, particularly in the top 1 % most-cited publications (Figure 3.1-10). Within the EU, the performance in terms of share of publications in the top 10 % and top 1 % varies significantly across Member States. Countries like the Netherlands, Luxembourg or Denmark perform consistently among the global leaders, while many others remain below the world average. At the same time, several lower-performing countries have improved their position over the past decade, suggesting a degree of catching up in scientific excellence. Globally, the US continues to lead in producing highly cited research, especially in the top 1 %, although its share has declined over time. China has increased its share significantly and now performs above the world average in both the top 10 % and top 1 % of publications. Other European research systems, notably Switzerland, the UK and Norway, also perform strongly.

The Nature Index[6] also shows that China has rapidly strengthened its position to become the leader in high-quality scientific publications, while the US and several European countries continue to perform strongly in scientific excellence. The Nature Index ranks countries according to their contributions to articles published

6 https://www.nature.com/nature-index/

Figure 3.1-10 Percentage of publications in the top 10 % and top 1 % of most-cited publications worldwide, 2012 (citation window: 2012–2014) and 2022 (citation window: 2022–2024)



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

Notes: Scientific publications within the top 10 % and 1 % of most cited scientific publications worldwide as a share of the country's total number of scientific publications. Fractional counting was used to assign publications to countries/aggregates. The top 10 % (respectively top 1 %) most-cited scientific publication percentage measures the quality of publications for a given country and year. It is calculated as the ratio of the number of publications in the top 10 % (respectively 1 %) most-cited worldwide to the total number of publications from that country in the same year.

in a selected set of around 145 high-quality journals in natural and health sciences. At the institutional level, the Chinese Academy of Sciences (CAS) ranks first globally. Chinese organisations also dominate the ranking, with 9 institutions in the top 10. The only non-Chinese institution in the top 10 is Harvard University, while the first European institution (Max Planck Society) appears only at rank 12 in 2025. This underlines China's strength in high-impact scientific publications, particularly in chemistry, earth and environmental science, and physical sciences, even though the US and EU remain strong. More information on the European Higher Education System can be found in chapter 3.2.

Box 3.1-2 European Commission-funded (EC-funded) publications show higher societal engagement than non-funded EU research in altmetrics indicators

Lili Wang, Ad Notten (UNU/MERIT, Maastricht University), David Campbell, Paul Khayat (Science-Metrix, Elsevier)

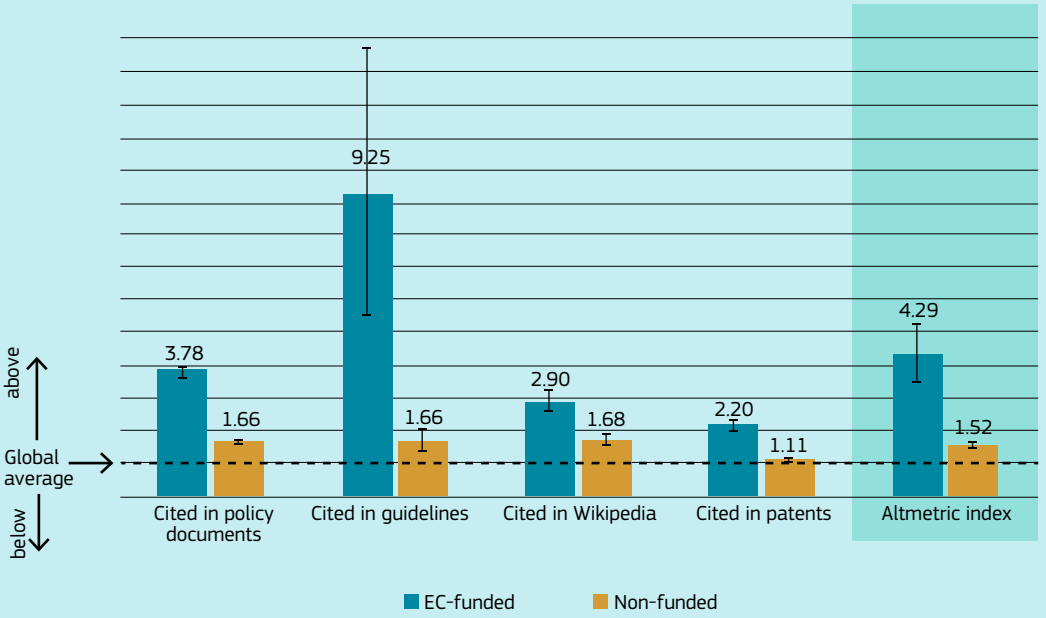
Scientific research generates value not only within academia but also through its broader societal uptake. This broader dimension of impact can be captured through altmetrics indicators, which show how research outputs are used and discussed beyond the scientific community, complementing traditional citation-based measures.

EC-funded publications in the EU outperform non-funded publications across all four altmetrics indicators: citations in policy-related documents, clinical guidelines, Wikipedia and patents. Indicators are normalised by subfield, year and document type (global average = 1.0) and averaged across EU countries and fields. Each country-subfield combination is given equal weight, regardless of publication volume (unweighted averages). This approach helps assess how widespread the altmetric citation advantage, if present for EC-funded publications, is across countries and subfields.

The strongest differences are observed in policy and clinical guidelines citations, where EC-funded research is substantially more influential. EC-funded publications are more than twice as likely to be cited in policy-related documents than the non-funded EU research. In clinical guidelines, citation rates are particularly high, reaching around nine times the global baseline and five times the level of non-funded publications. They also receive more attention in Wikipedia (around three times the global average and 1.7 times higher than non-funded outputs) and are cited in patents at roughly twice the rate of both the global baseline and non-funded research. Overall, EC-funded research is consistently more visible and used.

These findings underline the importance of assessing research performance beyond traditional bibliometric indicators. This is reflected in ongoing reforms to research assessment under the Coalition for Advancing Research Assessment (CoARA), which promotes broader criteria beyond traditional bibliometrics (for more details, see chapter 3.3).

Figure 3.1-11 Public-engagement metrics of EC-funded versus non-funded publications during the most recent analysis period, 2017–2021



Science, Research and Innovation Performance of the EU 2026

Source: Wang *et al.* (2026).

Note: Bars report the mean normalised shares of publications cited in each altmetric source and the altmetric index (a composite score combining all four sources), calculated using unweighted averages. Error bars indicate the 95 % bootstrap confidence intervals for each score. For each indicator, the differences between publication groups (funded vs not) are statistically significant ($p < 0.001$, paired t-test).

3. Mapping strengths and weaknesses of the EU's scientific output

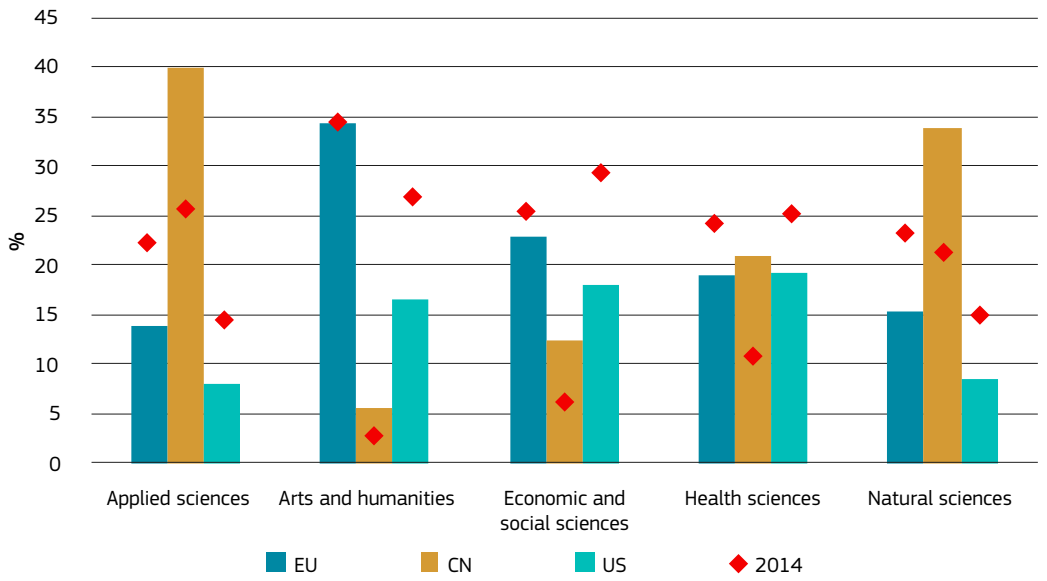
The EU remains a leading contributor to global scientific publications in arts and humanities along with social sciences, but its relative position has weakened in several science and engineering fields over the past decade (Figure 3.1-12). The EU still accounts for the largest global publication shares in arts and humanities (34.2%), economic and social sciences (22.9%), and remains broadly on par with the US and China in health sciences (19.0%). By contrast, the EU has lost ground more clearly in applied sciences (13.8%) and natural sciences (15.4%), where publication growth has been slower. Overall, this reflects a changing global research landscape in which the EU retains clear strengths and specialisation in less technological fields, while facing increasing competitive pressure in fields more closely linked to technological development.

This decline across several science and engineering fields in the EU has been driven primarily by the rapid rise of China, which became the largest contributor to publications in applied sciences (39.9%), natural sciences (33.8%) and health sciences (20.9%) in 2024. China has expanded its publication share substantially over the past decade, particularly in fields closely associated with scientific and technological capability. This reflects sustained efforts to strengthen its R&I system and a stronger strategic orientation of public support towards key science and technology domains (Steeman *et al.*, 2025). Over the same period, the US has also seen a gradual decline in publication shares across all broad domains, although it continues to perform strongly in terms of scientific impact according to citation-based indicators, and remains relatively specialised in health sciences, economic and social sciences, and arts and humanities.

At the level of individual scientific fields, the EU shows a broad and balanced profile, with particularly strong shares in arts and humanities along with social sciences, while maintaining a significant presence across a wide range of fields. This reflects the breadth and diversity of the European research system. At the same time, the EU records lower publication shares than China in several engineering and technology-related fields, pointing to stronger global competition in fields closely linked to technological capability and industrial development.

China and the US show more concentrated strengths in various scientific fields. China records particularly high publication shares in engineering, enabling and strategic technologies, and chemistry, highlighting the strong weight of technology-oriented fields in its publication profile. The US, by contrast, is more strongly represented in biomedical and health-related disciplines, including public health and health services, and psychology and cognitive sciences, reflecting the scale and maturity of its biomedical research ecosystem (Figure 3.1-13).

Figure 3.1-12 Shares of world publications by broad domains, 2024



Science, Research and Innovation Performance of the EU 2026

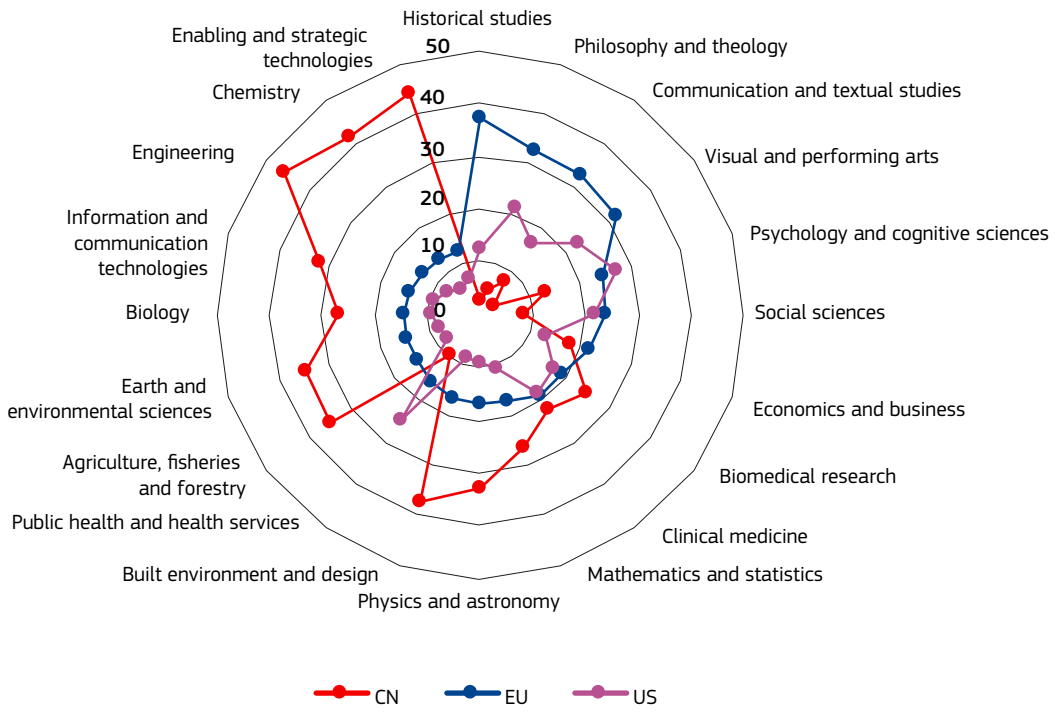
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

Notes: Fractional counting was used to assign publications to countries/aggregates. Scientific fields are grouped according to the Science-Metrix classification. The five broad domains comprise the following sub-fields: applied sciences (agriculture, fisheries and forestry; built environment and design; enabling and strategic technologies; engineering; information and communication technologies); arts and humanities (communication and textual studies; historical studies; philosophy and theology; visual and performing arts); economic and social sciences (economics and business; social sciences); health sciences (biomedical research; clinical medicine; psychology and cognitive sciences; public health and health services); and natural sciences (biology; chemistry; earth and environmental sciences; mathematics and statistics; physics and astronomy).

The EU's distribution of scientific publications[7] has changed over the past decade, with a relative decline in the shares in natural and applied sciences, while social sciences and economics and business have gained relative importance. In 2024, clinical medicine accounted for the largest share of EU scientific publications (around 21.5%), followed by information and communication technologies (9.8%) and enabling and strategic technologies (8.7%). This pattern differs from the US and China. In the US, scientific output is even more concentrated in health-related disciplines, with clinical medicine representing 28.1% and biomedical research 7.3%. By contrast, China's profile is more strongly oriented toward engineering and technology-intensive fields, with the largest shares in enabling and strategic technologies (17.1%), engineering (15.0%) and clinical medicine (17.1%).

7 For each country or region, field shares are calculated as the number of scientific publications in each field as a proportion of that country's total scientific publication output.

Figure 3.1-13 Global share (%) of scientific publications by country/region and field, 2024



Science, Research and Innovation Performance of the EU 2026

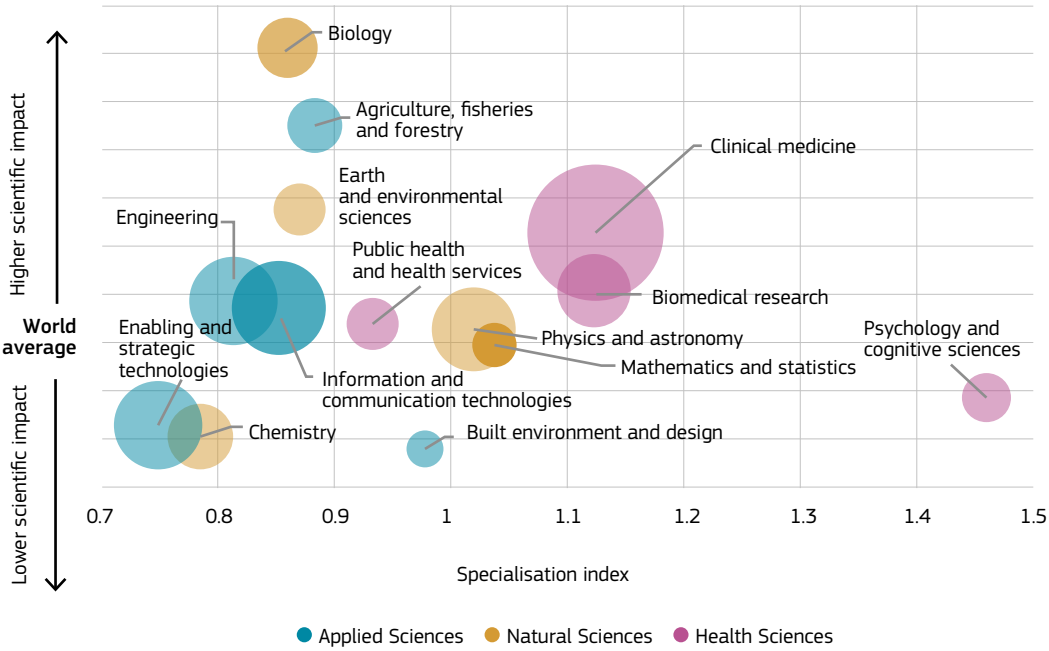
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

Note: Fractional counting was used to assign publications to countries/aggregates.

The EU combines strong scientific impact and scale in some fields of health science, with weaker specialisation and below-world-average impact in some applied technological domains like enabling and strategic technologies, and chemistry (Figure 3.1-14).

Key technologies are critical for competitiveness, and the EU remains a global player in several of them, but its position is generally characterised by lower relative specialisation and more moderate scientific impact than that of the US and China (Figure 3.1-15). This points to a research system that is broad and diversified, but less concentrated in strategic technological domains. Between 2015–2019 and 2020–2024, the EU improved the scientific impact of its research in several areas, including advanced manufacturing, energy harvesting, conversion and storage, artificial intelligence, and next generation computing. The EU also remains comparatively well-positioned in industrial biotechnology, where it combines relatively strong scientific impact with a degree of specialisation.

Figure 3.1-14 EU scientific specialisation and impact across scientific fields



Science, Research and Innovation Performance of the EU 2026

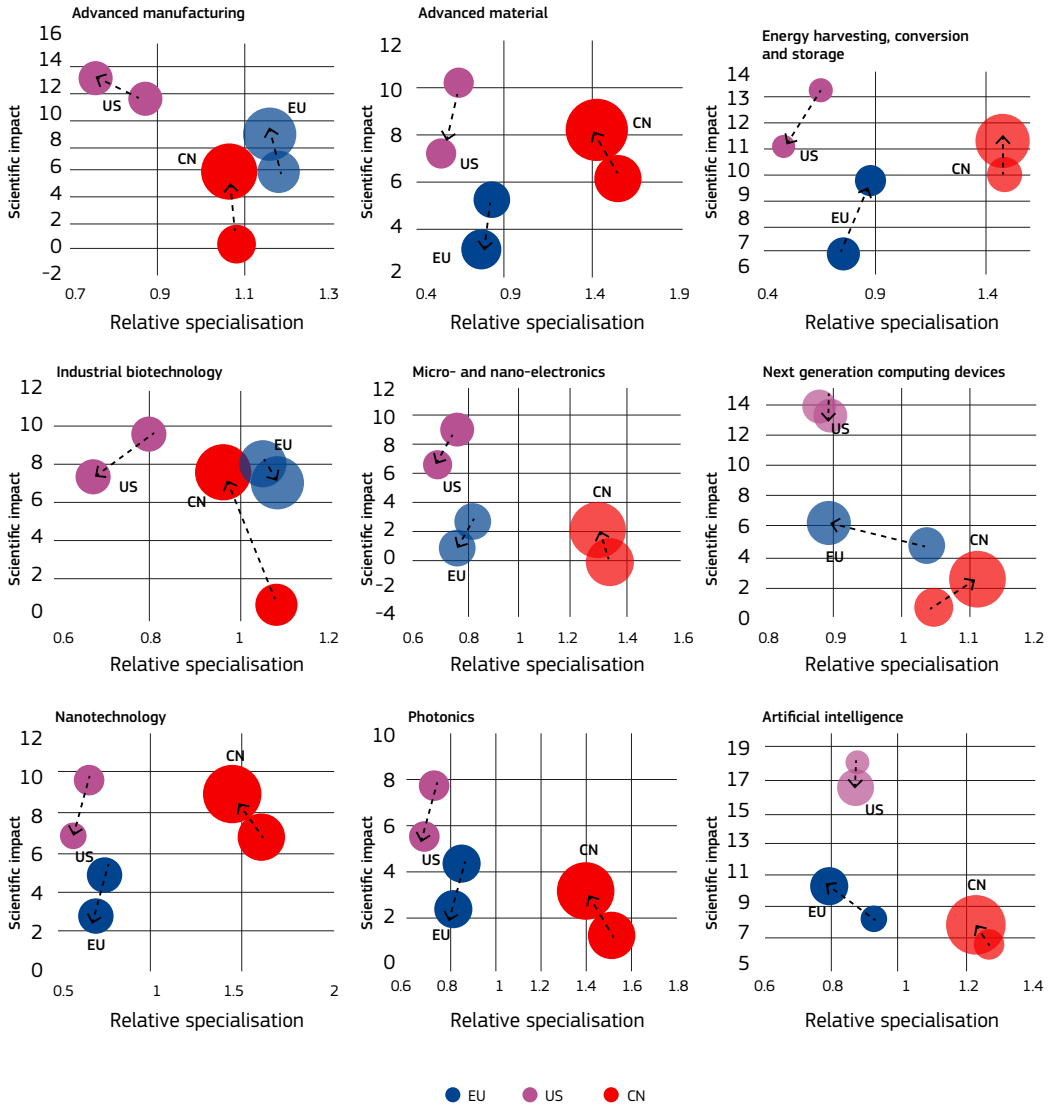
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

Note: Fractional counting was used to assign publications to countries/aggregates. Scientific impact is assessed using the Citation Distribution Index (CDI). Bubble size reflects the absolute number of publications.

By contrast, the US and China display more strengths in different dimensions of key technologies. The US remains the strongest performer in terms of scientific impact across most key technologies, particularly in AI, next generation computing and advanced manufacturing, although in several cases its impact has decreased over time. This is consistent with broader evidence showing continued US leadership in frontier AI model development and private AI investment, despite a narrowing technological gap with China (Stanford AI Index Report, 2026). China, meanwhile, combines high or rising relative specialisation with rapidly improving scientific impact across a number of key technologies, including energy harvesting, conversion and storage, industrial biotechnology, nanotechnology and photonics. Overall, the figure suggests that while the EU retains scientific capabilities across a broad set of key technologies, the US and China tend to occupy stronger or more specialised positions in key technologies.

The EU remains a major contributor to scientific research addressing societal global challenges. The EU shows a relatively strong scientific specialisation in publications related to climate, and to a lesser extent health, with both fields gaining importance over the past decade. By contrast, the EU's relative specialisation in mobility and the environment has declined in recent years, reflecting in part the rapid rise of China in these fields. The EU also remains comparatively less specialised in space, digital and industry, and especially energy, despite the growing strategic importance of these fields for Europe's long-term competitiveness and resilience (Figure 3.1-16).

Figure 3.1-15 Dynamic positions in scientific impact and specialisation in key technologies, 2015–2019 and 2020–2024

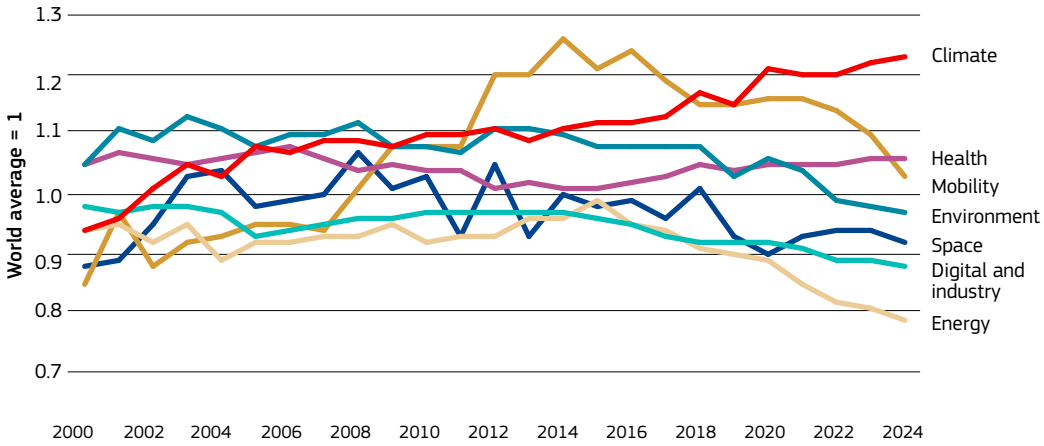


Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

Note: Scientific impact is measured using the Citation Distribution Index (CDI), where a higher score indicates greater scientific impact. Relative specialisation is expressed relative to the world average (=1): values above 1 indicate above-average specialisation, while values below 1 indicate below-average specialisation. Bubble size reflects the number of publications, and the arrows indicate changes between 2015 and 2019, and 2020 and 2024.

Figure 3.1-16 EU Specialisation Index by selected Horizon Europe Global Challenge, 2000–2024



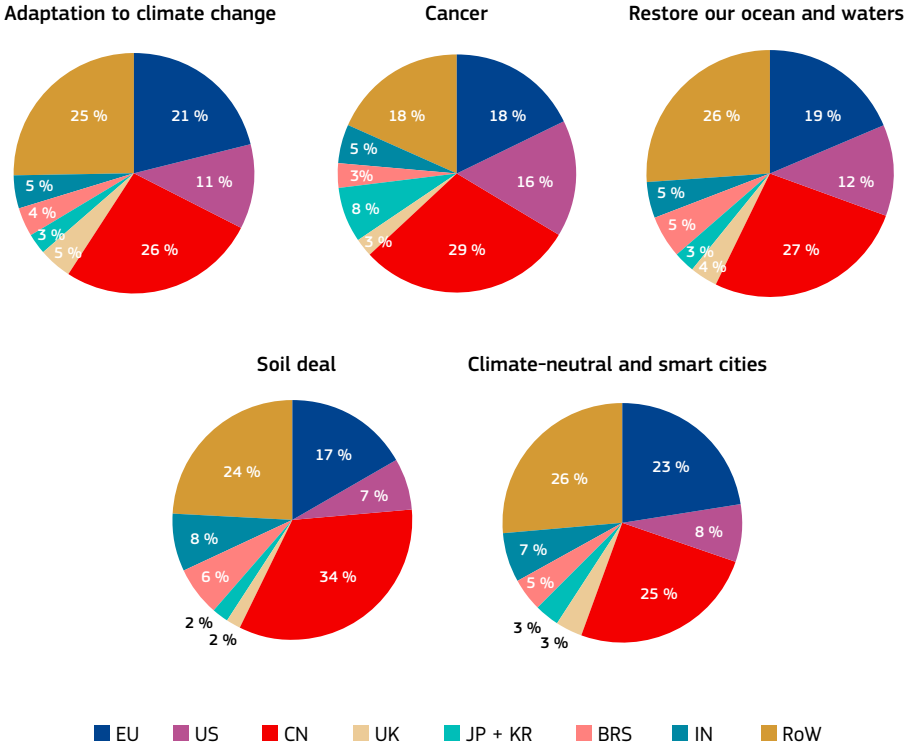
Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

Note: The specialisation index (SI) is an indicator of research intensity in a given entity (e.g. a country) for a given research area (e.g. one of the Horizon Europe Global Challenges), relative to the intensity in a reference entity (e.g. the world) for the same research area. In other words, the SI of a country in a given research domain shows how much emphasis that country places on research in that domain relative to overall global emphasis. Comparisons are meaningful only between countries of similar size.

The EU contributes significantly to scientific publications related to the five EU Missions, accounting for between 17% and 23% of world scientific publications from 2020 to 2024. The EU Missions are large-scale initiatives under Horizon Europe (2021-2027), designed to align research and innovation efforts to deliver concrete solutions to societal challenges by 2030. These shares are above the EU's overall share of world scientific publications, pointing to a relative scientific specialisation in mission-related fields (Figure 3.1-17). A first assessment conducted in 2023, confirmed the relevance of the EU Missions in supporting EU priorities by mobilising broad stakeholder communities and fostering strong citizen engagement (European Commission, 2023). At the same time, China leads in publication shares across all five missions, and in most cases has increased its position over time, underlining the growing role of China in scientific domains that are closely linked to important strategic and societal priorities.

Figure 3.1-17 World shares of scientific publications by country/region and Missions, 2020–2024



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

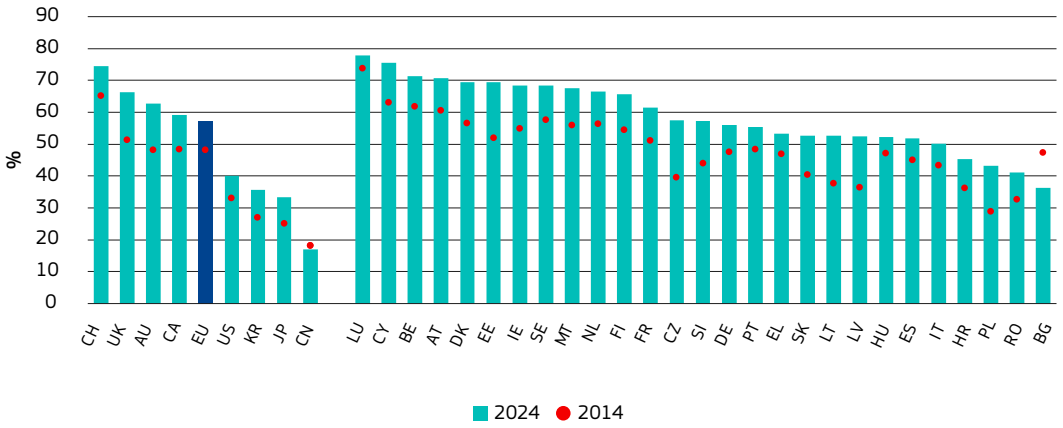
Note: Fractional counting used. BRS: Brazil, Russia, and South Africa.

4. Exploring patterns of scientific collaboration

International scientific co-publications are widely recognised as an important indicator for measuring research collaborations and openness of the research systems. Open science facilitates sharing and collaboration, improves research quality and supports the development of innovative solutions to complex, global challenges. Open science is at the centre of European research policy and as such, is further analysed in chapter 3.3.

The EU remains one of the most internationally connected research systems. In 2024, 57% of publications from the EU involved international co-authorship (Figure 3.1-18). This figure includes both intra- and extra-EU collaborations, with intra-EU co-publications accounting for 59% of all international co-publications originating from the EU. The EU is surpassed only by Switzerland (74%), the UK (66%), Australia (63%) and Canada (59%).

Figure 3.1-18 Share of international scientific co-publications in total scientific publications, 2014 and 2024



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

Note: Full counting method used. The EU average includes intra-EU international co-publications, which account for 59.0 % of EU international co-publications.

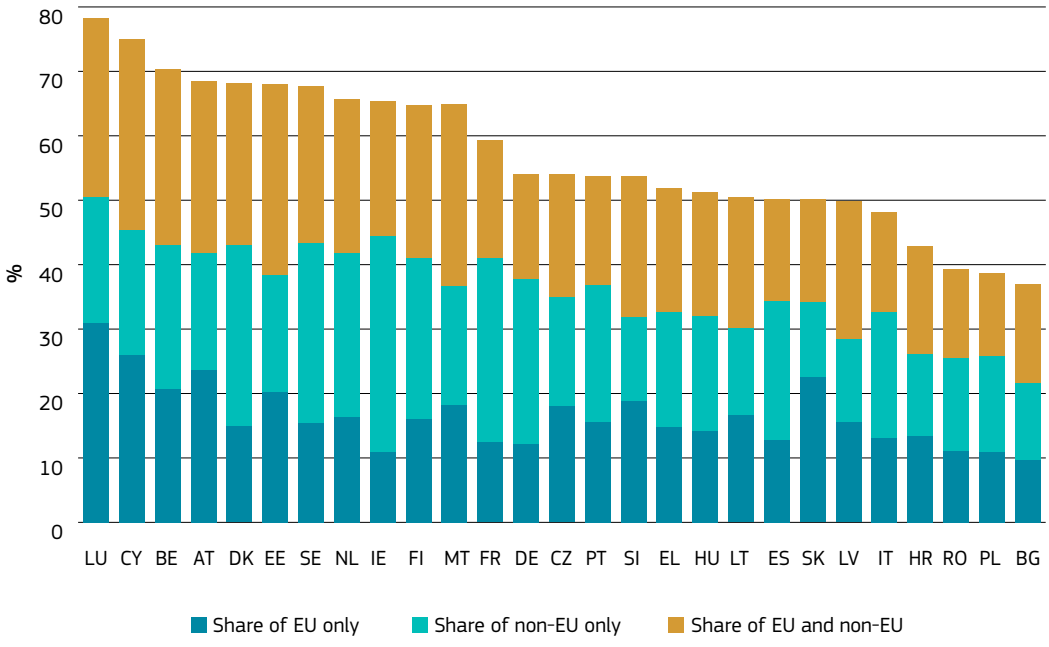
International scientific collaborations have intensified over the last decade. Studies, using bibliometric evidence, point to a substantial increase in cross-border co-authorship (Dong *et al.*, 2017; Pei *et al.*, 2024). Figure 3.1-18 confirms this trend from 2014 to 2024 and provides evidence of the magnitude of these changes. The UK, Australia and Canada recorded increases of more than 10 percentage points in the share of international co-publications, followed by Switzerland, the EU and South Korea. China shows a slight decline (–1.3 percentage points), which does not reflect a reduction in international collaboration in absolute terms, but a substantial increase in the overall volume of scientific publications. In other words, total scientific output in China has grown faster than its international co-publications.

Across the EU, the share of international collaborations ranges from 36 % to 78 % and has increased in nearly all Member States, but at varying rates (Figure 3.1-18). Smaller European countries such as Cyprus and Luxembourg rely more on international scientific co-publications, as reflected in their national shares, which both exceed 75 %. Due to their small size, the number of domestic researchers is also limited, making engagement in international collaborations essential for increasing visibility and reputation, which will help attract foreign researchers and retain domestic talent. The most significant increases between 2014 and 2024 were observed in Czechia (+18 percentage points), followed by Estonia (+17) and Latvia (+16). Bulgaria is the only EU country showing a decline in the international co-publications rate by 11 percentage points from 47 % in 2014 to 36 % in 2024. However, like China, the cause of this decrease is not a reduction in the absolute number of international co-publications, but a strong increase in the total volume of publications, which grew by approximately 130 % over the same period (Figures 3.1-2 and 3.1-4). Beyond co-publication patterns, recent citation-based evidence

also suggests that knowledge flows between countries in the ERA have strengthened over time, while national self-citations have declined. However, this trend remains uneven across national research systems (Wagner *et al.*, 2026).

All EU Member States participate in both intra- and extra-EU research collaborations, demonstrating the internationalised nature of their research systems. Figure 3.1-19 shows that the geographic composition of the research groups differs across Member States. Some countries rely more heavily on intra-EU collaborations, while others have stronger links with researchers outside the EU. In particular, the share of collaborations with non-EU countries ranges from 33.5 % of total publications in Ireland to 12 % in Slovakia. Conversely, collaborations exclusively within EU Member States account for between 30 % of total publications in Luxembourg and 10 % in Bulgaria. Overall, smaller Member States, such as Luxembourg, Cyprus and Estonia, tend to rely on a combination of both intra- and extra-EU collaborations, while countries with strong research systems, for example France, Germany, Denmark, Sweden, Ireland and others, are more actively engaged in international collaboration networks.

Figure 3.1-19 Shares of intra and extra- EU scientific co-publications, 2020–2024

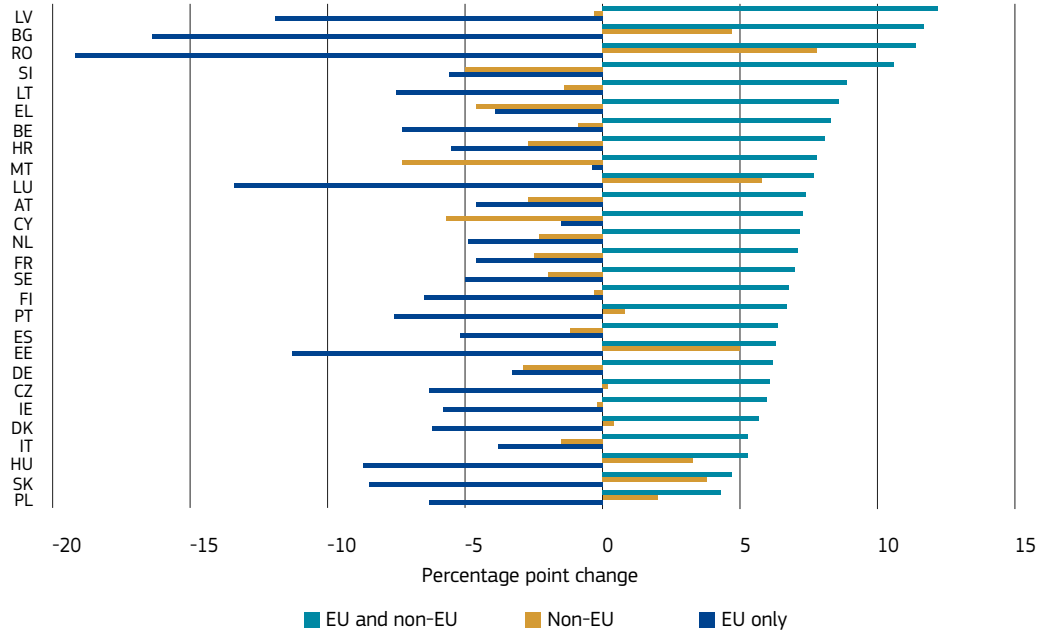


Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

EU Member States are increasingly engaging in global research collaborations. As shown in Figure 3.1-20, all Member States have expanded their cooperation with mixed teams of researchers from both EU and non-EU countries over the past decade. R&I funding programmes have significantly contributed to this achievement. Projects signed in the first four years of Horizon Europe involved researchers from 171 different countries (European Commission, 2025b). This type of co-publications as a share of total international co-publications increased from 12.2 percentage points in Latvia to 4.3 in Poland. At the same time, the share of co-publications conducted exclusively within the EU declined, with reductions ranging from 19.2 percentage points in Romania to less than 1 percentage point in Malta. This trend is particularly evident in southern and eastern European countries such as Bulgaria, Estonia, Latvia and Romania, but also Luxembourg, and may reflect the growing openness of their research systems to new collaborations across the globe.

Figure 3.1-20 Evolution of the shares of intra- and extra-EU scientific co-publications out of a country's total international co-publications, between 2010–2014 and 2020–2024

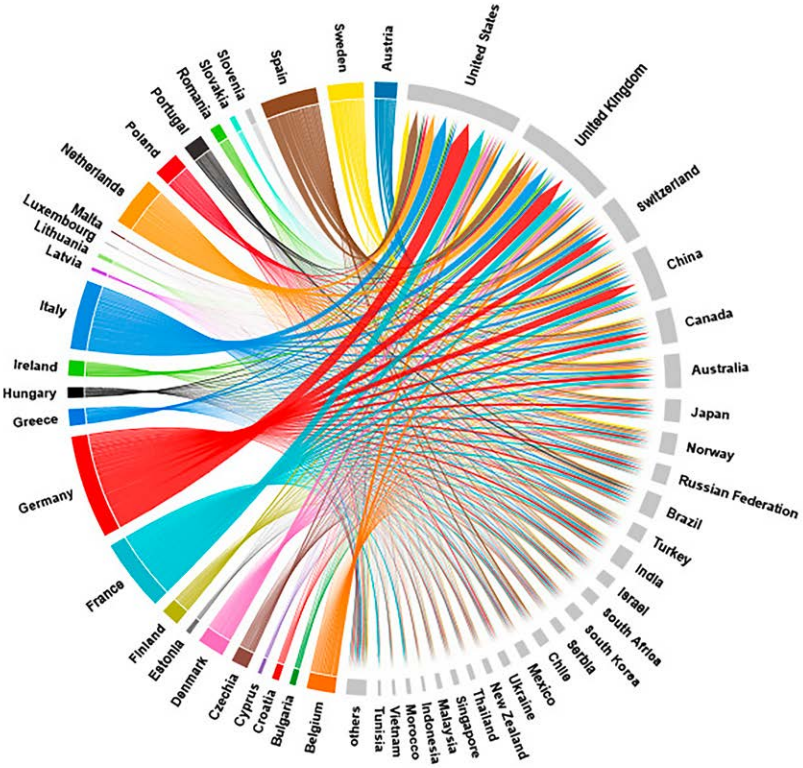


Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

The top three international research partners for the EU are the US, the UK and China. Between 2020 and 2024, these three countries accounted for the highest number of scientific co-publications in 16 of the 27 Member States, although their position in the top 3 varies. However, geographic proximity, cultural and linguistic similarities continue to play an important role in shaping research networks and cross-border collaborations. This is reflected in the number of co-publications between Portugal and Brazil, Italy and Switzerland, and Croatia and Serbia. Figure 3.1-21 illustrates the connections between the Member States and their international partners. It demonstrates the central role of the three main collaborators, the relative weight of each Member State and, most importantly, the openness and complexity of the research networks. More information on the EU's global R&I cooperation can be found in chapter 6.3, and a detailed analysis of the intra-EU collaborations is presented in chapter 6.2.

Figure 3.1-21 Flows of extra-EU international collaborations for the 27 Member States, 2020–2024



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

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CHAPTER 3.2

PEOPLE, ORGANISATIONS, AND INFRASTRUCTURES FOR THE EUROPEAN SCIENCE RESEARCH SYSTEM

Nicola Francesco Dotti

KEY QUESTIONS

- What are the trends in the international mobility of researchers, and what are the weak signals of emerging change?
- What are the challenges for attracting and retaining research talent in the EU?
- What are the structural characteristics of Europe's scientific research ecosystem?

HIGHLIGHTS

- The Choose Europe for Science strategy aims to attract and retain researchers to establish the EU as the premier scientific powerhouse in a context of global uncertainty.
- After decades of growing researcher mobility at the global level, geopolitical turbulence and US recent changes indicate an inversion, but the EU keeps a competitive position attracting researchers.
- Research careers are still a challenge for Europe because of a significant share of precarious contracts, the 'publish or perish' culture and the need for reforming research assessment systems.
- Europe has a well-established and varied system of higher education institutions (HEIs) and research-performing organisations, supported mainly by public funding and complemented by world-level research and technology infrastructures.

POLICY INSIGHTS

- The Choose Europe for Science strategy is rapidly growing, mobilising Member States in a systemic initiative to attract and retain research talent.
- The European research model is characterised by a strong public role, closer in structure to China than to the US, where the private sector is more prominent.
- Analysing the scientific research sector requires more advanced data collection to track researcher mobility, HEIs and infrastructures.

The Choose Europe for Science strategy, launched in May 2025, is the new flagship initiative to attract and retain talent to enhance Europe's scientific position. Europe can leverage a stable, publicly driven research funding system, a diverse and well-developed pool of Higher Education Institutions (HEIs), and world-leading research and technology infrastructures. These systemic conditions offer unique opportunities for researchers to push the scientific frontier, promote innovative research, turn ideas into concrete solutions and tackle today's most pressing societal challenges.

The higher education system is a foundational element of Europe's research and innovation (R&I) system. While the Draghi report acknowledges that Europe has a higher average quality of its universities and research organisations, it warns of limited capacity at the scientific frontier and a lack of critical mass to support economic competitiveness vis-à-vis the US and China (Draghi, 2024). This systemic approach is also developed by the Letta report's proposed 'fifth freedom', which integrates research, innovation, knowledge and education into the EU Single Market to overcome the current fragmentation (see Letta, 2024). Complementing these perspectives, the Heitor report (2024) reinforces the emphasis on the need to turn European 'brain drain' into 'brain gain' to promote scientific excellence. Against this background, the *Choose Europe for Science* strategy is a systemic intervention for enhancing Europe's scientific system.

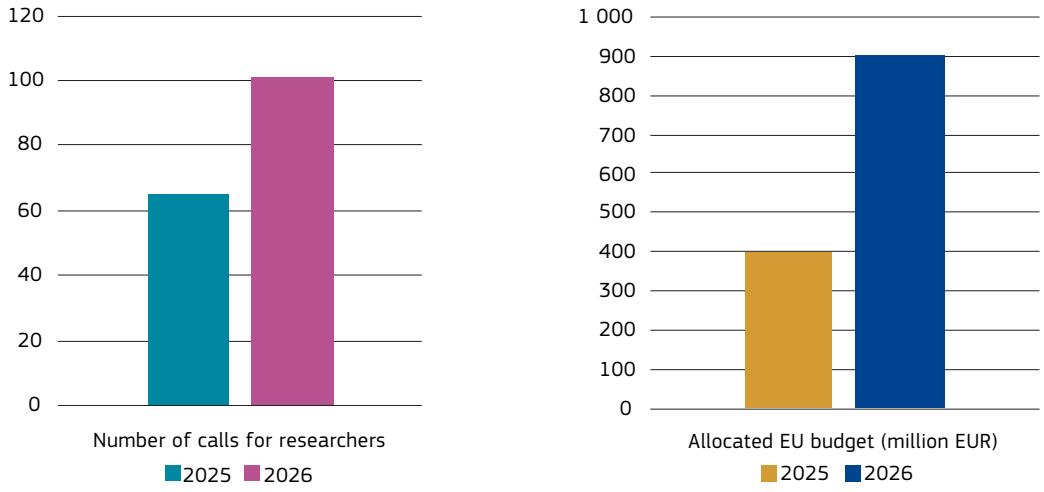
1. Attracting and retaining talent for science

The Choose Europe for Science strategy

The Choose Europe for Science strategy aims to consolidate Europe's scientific leadership by upgrading its support for attracting and retaining researchers. Launched in May 2025, this strategy aims to offer stable funding and better professional pathways, mitigating the uncertainties and precarity often associated with scientific careers. The EU has promoted talent circulation for decades as a fundamental pillar of the European Research Area (ERA), but several Member States are still experiencing 'brain drain' and struggle to improve their research capacity (Heitor *et al.*, 2026).

The Choose Europe for Science initiative was launched in a complex geopolitical context, especially for the US research system experiencing major reductions (Witze, 2025; Kozlov *et al.*, 2026). This initiative builds on the strategic frameworks of the Draghi and Letta reports: Europe must address the 'innovation gap', a persistent hurdle to maintaining competitiveness on the global stage, specifically the challenge of retaining talent that moves elsewhere in search of better career prospects. The free movement of knowledge and research, the so-called 'fifth freedom', was proposed as a necessary evolution for Europe, positing researcher mobility as a cornerstone of Europe's scientific and economic dynamism. By enhancing the intra-European circulation of researchers and knowledge and by promoting attractive research careers, this initiative intends to address these geopolitical challenges and boost European competitiveness.

Figure 3.2-1 Choose Europe for Science strategy, number of calls and allocated budget



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on European Commission data.

The European Commission and Member States have launched 101 dedicated calls with the common objective of attracting and retaining talent in Europe. The number of funding instruments is increasing rapidly, from 65 in 2025 to 101 in 2026, including European, national and regional calls. The overall allocated budget has more than doubled over the same period, reaching EUR 900 million (Figure 3.2-1). The main EU instrument is based on the Marie Skłodowska-Curie Actions (MSCA), with a budget of EUR 22.5 million in 2025, rising to EUR 51.25 million in 2027. This MSCA pilot targets postdoctoral researchers and encourages host institutions to provide longer-term employment opportunities, thereby making Europe more attractive as a research destination and counteracting the problems of precarious research careers. Furthermore, the European Research Council (ERC) is launching the *ERC Super Grant* initiative with an extended duration of seven years to enable recipients to undertake truly visionary and groundbreaking scientific projects in Europe. An additional EUR 2 million is available for researchers moving to Europe to cover extra personnel expenses, equipment and access to large facilities (European Research Council, 2026).

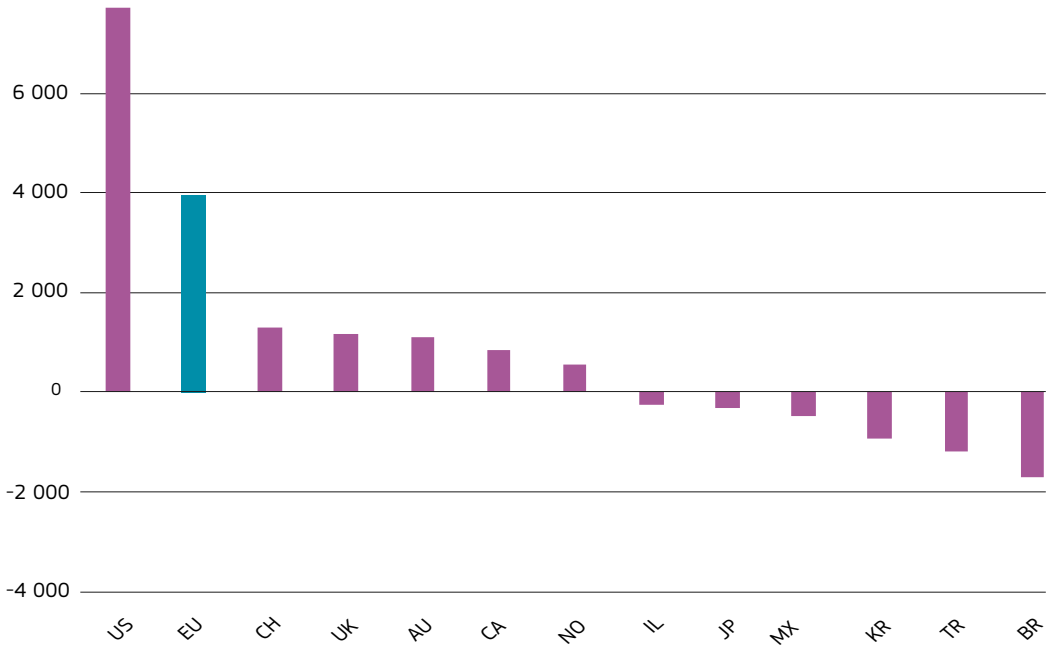
The first MSCA pilot call received 49 eligible proposals, and 16 projects were selected. These projects will be coordinated by organisations in nine countries: four in Spain, three each for France and Latvia, and one each for Austria, Belgium, Germany, Ireland, Portugal and the UK (for more details, see European Commission, 2026b). These 16 projects will involve a total of 84 partner organisations from across 25 countries, including non-member countries, namely Australia, Japan, Kenia, Serbia and the US. This first pilot call aims to set a new standard, providing more stability to postdoctoral researchers (for more details, see European Commission, 2025c). Other initiatives at the level of Member States are, as examples, Germany's Global Minds Initiative; France's Choose France for Science; the Tulip Fund managed by the Dutch Research Council

(NWO); Spain's programmes such as Beatriu de Pinos, Juan de la Cierva and Ramón y Cajal; and Belgium's programmes Odysseus and Ulysse. These examples are just an illustration of the variety of instruments and opportunities available to researchers seeking to pursue their scientific careers in Europe. Finally, a dedicated ERA structural action aims to improve researchers' careers in the long run by standardising training, improving mobility and job security, and tackling mental health problems caused by an overly competitive system (Dreisoerner *et al.*, 2026).

The changing landscape of researchers' international mobility

The international mobility of researchers is rapidly shifting in response to structural adjustments, emerging scientific powerhouses and new geopolitical instability, mainly related to the US. Traditionally, the US is the main attractor of researchers, with the EU as the second-largest destination (see Figure 3.2-2 using 2024 data). Other major scientific powerhouses, such as Switzerland, the UK, Australia, Canada, and Norway, also show positive net migration. On the contrary, Brazil, Türkiye, and South Korea continue to suffer from 'brain drain'. Taking a longer-term and more granular perspective, Iversen *et al.* (2026) highlight a shift towards a 'multipolar' model: China, India, and South Africa are experiencing rapid growth in their researcher populations and reducing outmigration, while established systems like the US and Japan remain stable or face slight declines. These new international mobility patterns are combined with structural demographic changes, with Europe having smaller younger generations than many other parts of the world (see box 3.2-1).

Figure 3.2-2 Net migration flows of publishing researchers among major scientific areas, 2024



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on OECD Research and Innovation Careers Observatory (ReICO), 2026.

Note: Missing data are not displayed.

Box 3.2-1 The demographic challenge for Europe's R&I system: a call for long-term thinking

Europe's R&I system is entering a period of structural risk as a combination of ageing, low fertility and migration trends leads to a permanent shift toward a declining population. With the EU population projected to peak in 2026 at 453.3 million, the EU 'demography toolbox' offers an essential policy framework to mitigate socio-economic impacts without compromising strategic autonomy (European Commission, 2023). Implementing these strategic actions is vital to ensuring that the contraction of the EU population does not compromise Europe's capacity for high-level research.

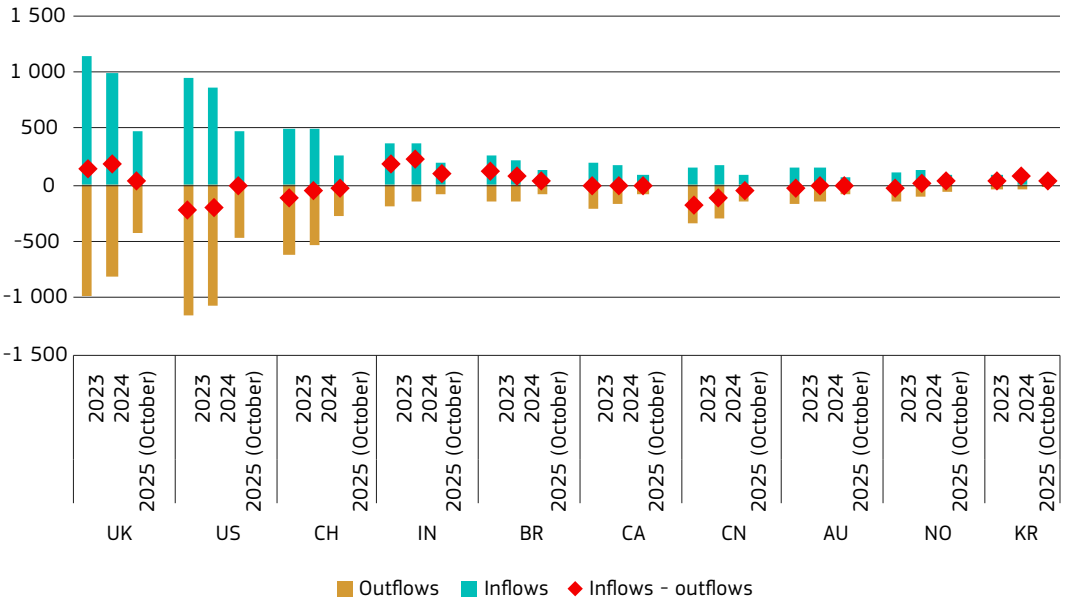
The most acute challenge for the research ecosystem is a sharp contraction in the supply of high-level human capital required to sustain long-term R&I capacity. Projections indicate that the total EU labour force will decline by 12 %, representing a loss of approximately 25 million people, which will inevitably intensify the competition for talent (cf. Nadziak *et al.*, 2026). More critically for the scientific pipeline, the population aged 21 to 26 – the primary cohort for doctoral recruitment – is expected to decrease by almost 2.5 million individuals by 2050. An ageing society further challenges this shrinking talent pool, likely to shift policy priorities towards pensions and healthcare, reducing resources for long-term R&I investments (Nadziak and Figiel, 2025).

The Strategy on Intergenerational Fairness addresses this challenge by promoting the use of strategic foresight into policy design. Launched in March 2026, this strategy aims to promote, among other objectives, a 'youth check' and future-oriented approach, as well as address the risk of age discrimination (European Commission, 2026a), moving beyond simple trend extrapolation.

In recent years, major concerns have emerged due to the evolution of the US research system, which has undergone a significant contraction, potentially undermining its leading scientific position. Since 2025, the US has been experiencing major reductions in federal public funding for science (Kozlov *et al.*, 2026), and the scientific community has raised significant concerns, warning of the risk of undermining the US's scientific leadership (Tollefson *et al.*, 2025). Several surveys showed the willingness of US scholars to relocate, including to Europe (Udesky and Leeming, 2025; Witze, 2025; Gibney and Kozlov, 2026).

The changing conditions in the US, the emergence of new scientific powerhouses and the rising geopolitical tensions are affecting researchers' international mobility but tracking it remains challenging. The problem rests on the monitoring indicators based on scientific publications: the delay from when a researcher conducts research and when it is published in a scientific journal is usually around 2-3 years (Moed *et al.*, 2013; Hanson *et al.*, 2024). Furthermore, publication output is strongly heterogeneous across disciplines and countries (see chapter 3.1). Therefore, alternative methods are needed to identify the 'weak signals' of the changing international mobility landscape.

Figure 3.2-3 Net migration flows of publishing academics between the EU and other scientific powerhouses, 2023–2025



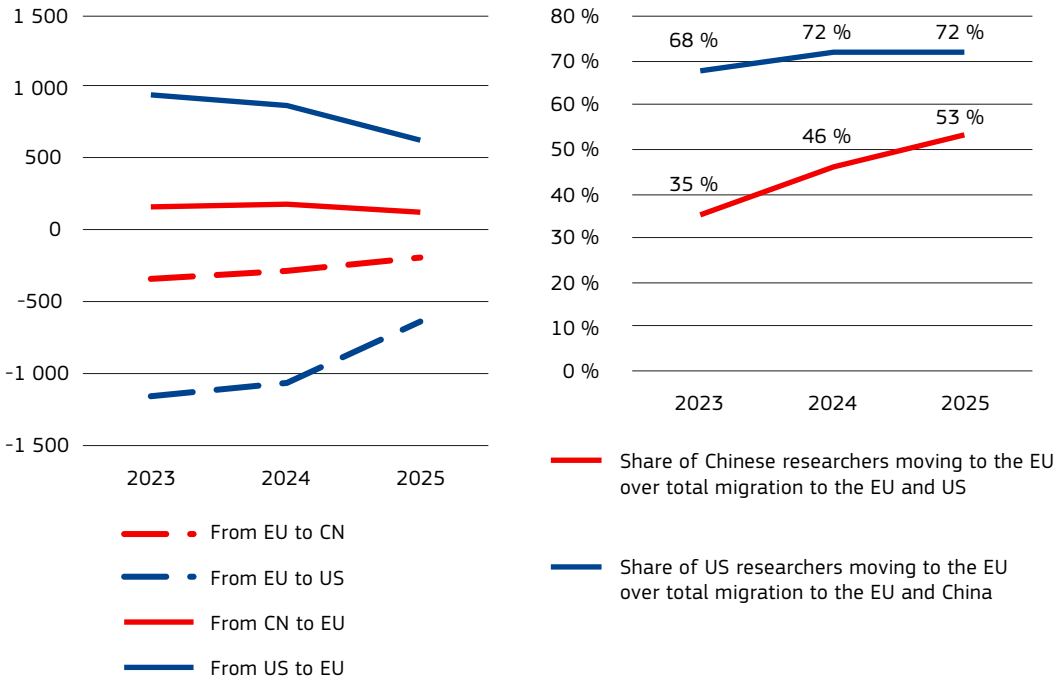
Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on ORCID institutional affiliation data.

Note: Only researchers with at least one scientific publication in OpenAlex are considered. Data for 2025 are available only up to October. The graph shows positive values for inflows to the EU and negative values for outflows from the EU.

Early signals show that the EU is becoming more attractive to internationally mobile researchers, moving from a negative to a neutral balance with the US improving its attractiveness relative to many other scientific partners. Figure 3.2-3 shows the net flows of internationally mobile researchers between major scientific blocs for the last three available years. Data are based on changes in institutional affiliation for ORCID-registered researchers with at least one scientific publication in OpenAlex (for a similar approach, see Gomez *et al.*, 2020; Moreno-Delgado *et al.*, 2024; Kim, 2025). Even though the data are less exhaustive than publication-based indicators, this approach enables the identification of early signals up to October 2025. Among the most relevant findings, the EU is improving its balance with Norway, South Korea, Switzerland and China (though the latter still shows brain drain for the EU). On the other hand, the EU is reducing its positive balance with countries like Australia, Brazil and India, where outgoing mobility is generally decreasing.

Figure 3.2-4 Comparison of researcher flows of the EU with the US and China, 2023–2025, absolute and relative values



Science, Research and Innovation Performance of the EU 2026

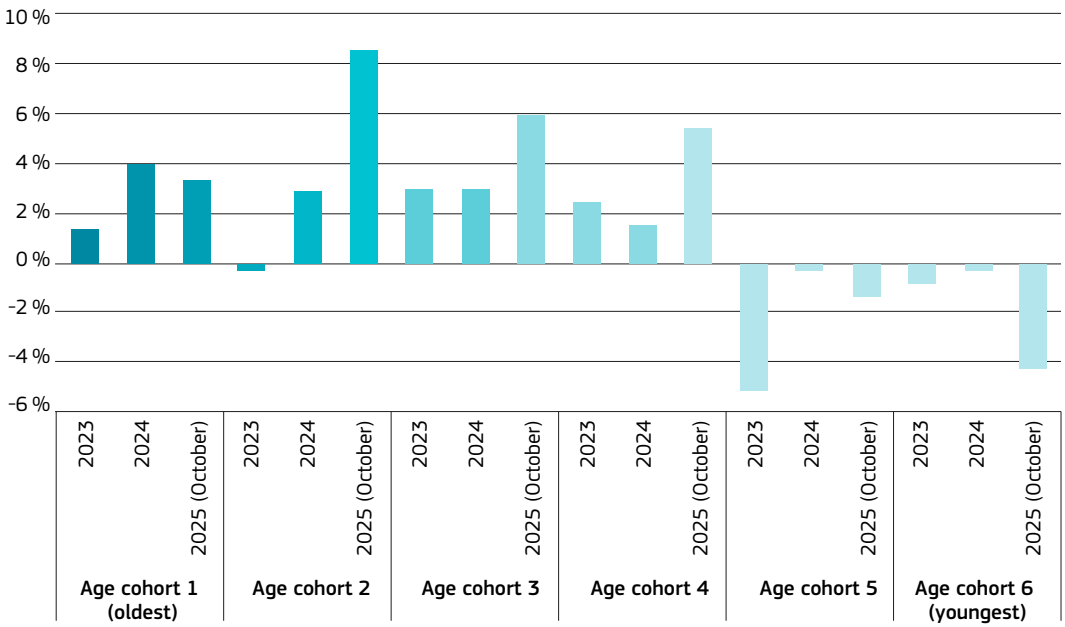
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on ORCID institutional affiliation data.

Note: Only researchers with at least one scientific publication in OpenAlex are considered. The graph shows positive values for inflows to the EU and negative values for outflows from the EU.

Mobility patterns among the EU, the US and China show signs of change in favour of the EU. Flows among the world's three largest scientific powerhouses are changing, both in absolute and relative terms (Figure 3.2-4). From a general perspective, researcher mobility between these three blocks is experiencing a sharp contraction. Between 2023 and 2025, researcher flows from the EU to the US declined by 45%, while the reverse flow (from the US to the EU) fell by one-third. A similar trend is visible between the EU and China: mobility from the EU to China decreased by 41%, compared with a 24% decrease in the opposite direction over the same period.

Despite this global downturn, the EU is consolidating its position as a preferred destination for US and Chinese mobile researchers. Considering the relative preference of mobile researchers, US researchers have shown a strong and stable preference for the EU over China (remaining stable around 70%), while Chinese mobile researchers are changing preferences, with a growing share of them preferring the EU over the US. For the first time in 2025, the EU has become the preferred destination for outgoing Chinese researchers, overtaking the US.

Figure 3.2-5 Net flows of publishing academics for the EU with other major scientific powerhouses by cohort



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on ORCID institutional affiliation data.

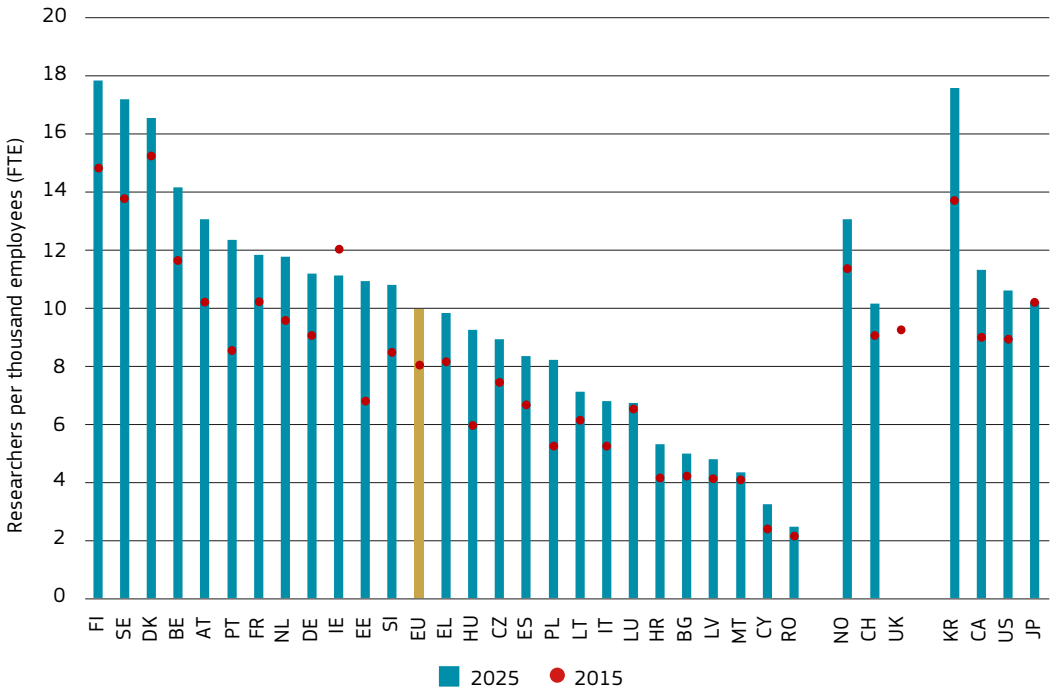
Note: Only researchers with at least one scientific publication in OpenAlex are considered. Data for 2025 are available only up to October. Cohorts are defined by the year of first publication: age cohort 1 - before 2001; age cohort 2 - 2001–2005; age cohort 3 - 2006–2010; age cohort 4 - 2011–2015; age cohort 5 - 2016–2020; age cohort 6 - 2021–2025 (October).

The EU's capacity to attract established researchers is growing. Figure 3.2-5 shows the net flows of researchers, broken down by cohort based on the year of their first recorded publication. Since 2023, the EU has attracted a growing number of researchers with first publications before 2015; that is, those with 10 or more years of experience. On the contrary, the balance for younger researchers tends to be negative, with significant volatility from year to year, indicating important variations that are presumably due to the unstable geopolitical context. Finally, the overall balance (as shown by the yellow line in Figure 3.2-5) shows signs of 'brain gain' for the EU, given the fact that inflows are quantitatively larger than outflows.

Choosing research in Europe

In a changing global context, promoting research careers is crucial for Europe's future. The *Choose Europe for Science* strategy gives specific emphasis on this need, and it builds on the Council Recommendations adopted in December 2023, providing a common definition of researchers as "professionals engaged in the conception or creation of new scientific knowledge based on original concepts or hypotheses" (Council of the European Union, 2023, p. 8). The challenges of research careers are recognised as crucial for the ERA and European competitiveness.

Figure 3.2-6 Researchers in full-time equivalent (FTE) employment per thousand, EU and other scientific powerhouses



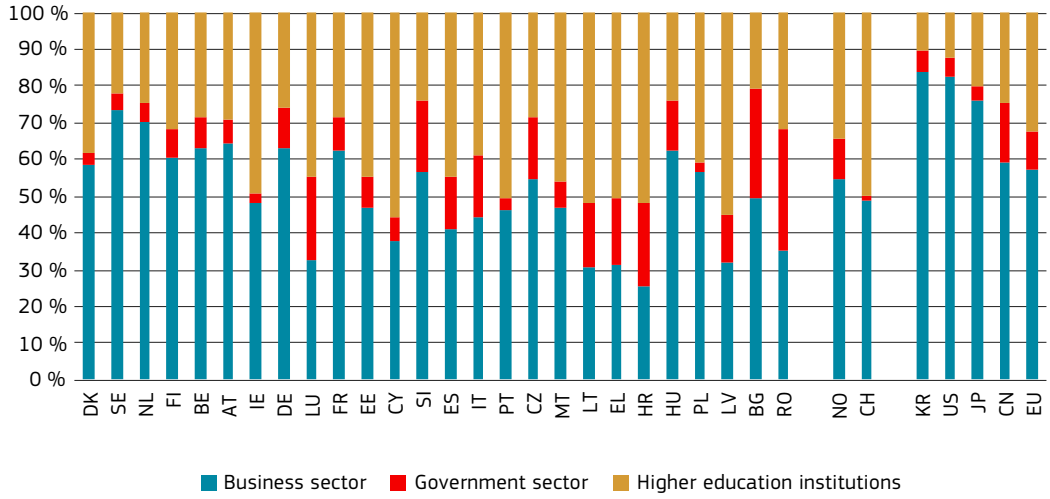
Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on OECD Research and Innovation Careers Observatory (ReICO), 2026.

Note: Missing values not displayed.

The role of researchers is growing everywhere as a sign of the transition to a knowledge-based economy. Figure 3.2-6 shows the growth of researchers as a share of employment in the EU and other major world economies. Almost all countries have increased their share of researchers, except Ireland. Several EU Member States score very high, namely Finland, Sweden, Denmark, Belgium, and Austria, with more than 13 researchers (in FTE) per thousand employments, while in the US the value is 10.6. In this perspective, several Member States have among the highest values in the world, also compared with major international benchmarks. In a dynamic perspective, the greatest increase is observed in Estonia, from 6.7 to 10.9, followed by Portugal (from 8.4 to 12.4) and Hungary (from 5.89 to 9.27). However, several Member States still score very low, with a limited share of researchers in Romania and Cyprus.

Figure 3.2-7 Distribution of researchers by sector, EU and other scientific powerhouses, 2023



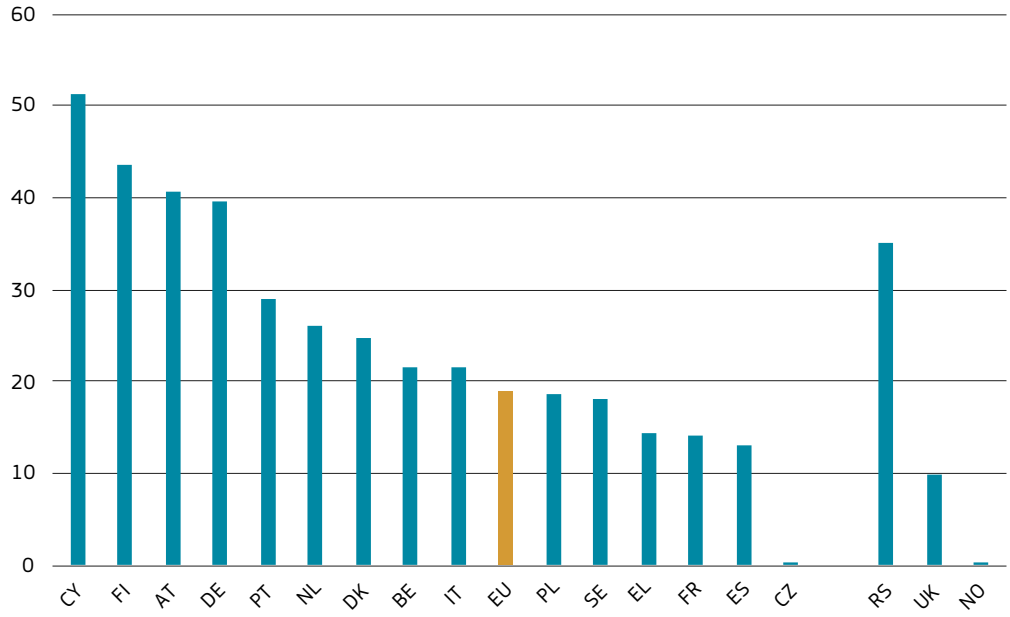
Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on OECD Research and Innovation Careers Observatory (ReICO), 2025.

Note: Member States are sorted by performance in the European Innovation Scoreboard (EIS) in 2023. Missing values not displayed.

European researchers are distributed between the private and public sectors, with HEIs representing a particularly large share compared to international benchmarks. In Figure 3.2-7, the Member States are sorted by their performance in the 2023 EIS, with shares of researchers by sector and comparisons with major science powerhouses. A first feature is that the EU average distribution is more similar to China than the US: European and Chinese researchers tend to be distributed between private (business) and public sectors (government research organisations [GOVs] and HEIs), whereas in the US, South Korea and Japan, more than 75% of the researchers work for the business sector. A second relevant element is the distribution within the EU: Member States with higher innovation performance do not correspond to those with a larger share of researchers in the business sector. On the contrary, the landscape is more articulated, as discussed in the second part of this chapter.

Figure 3.2-8 Proportion of researchers in the higher education system working under 'precarious' contracts, 2022



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on European Commission (2025b).
Note: Missing values not displayed.

The key challenge for research careers in Europe is the 'precarity' of working conditions, especially for the younger generations (OECD, 2021). The She Figures report, regularly published by the European Commission, provides an estimate (see European Commission, 2025e). Evidence of strong disparities across Member States and other European countries is reported, with an EU average rate of around 20% of precarious researchers in 2022 (see Figure 3.2-8). This value is concerning, given that precarious contracts are concentrated in the postdoctoral stage, that is, the career stage just after the PhD and before obtaining a tenure-track or permanent position (Castellacci and Viñas-Bardolet, 2021; van Tienoven *et al.*, 2024; Selenko, 2025). Precarious working conditions are particularly critical for those from more vulnerable backgrounds and with parental roles, especially women (e.g., Sim and Bierema, 2025)

Precarious research careers lead to instability, reducing scientific quality and increasing mental health problems (Levecque *et al.*, 2017; Heitor *et al.*, 2026). These issues are commonly tied to the 'publish or perish' culture, pushing researchers to maximise publication numbers even if it compromises scientific quality and rigour (Dreisoerner *et al.*, 2026; van de Weijden and Teelken, 2023; Udesky, 2025). Such pressure to maximise productivity undermines overall research quality, and is a factor driving talent away from research careers, particularly for women (Murgia and Poggio, 2018; Jones, 2023). While this is a global problem, Europe has engaged in reforms to research assessment and incentive mechanisms, as discussed in chapter 3.3.

The lack of a systemic tracking system for researcher careers is a structural problem, and several initiatives aim to improve

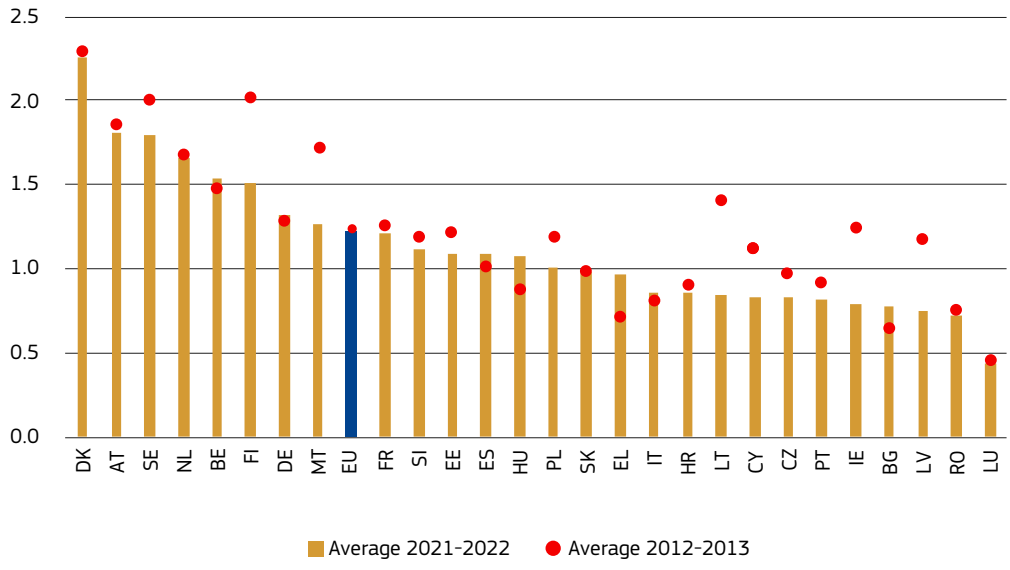
data availability. The 2025 Eurydice report on EU academic staff highlights that over 20% of European higher education systems cannot supply consolidated data on academic contracts (European Commission, 2025a). Initiatives such as the OECD REICO database and the European Higher Education System Observatory (EHESO, see more below) are developing comparable indicators on research systems to improve data availability and support evidence-based policy (cf., Heitor *et al.*, 2026).

2. Funding, organisations, and infrastructures of the European science system

Funding scientific research

The allocation of public research and development (R&D) expenditure across Europe reveals a consistent prioritisation of the higher education sector (HES) and public research organisations. As shown in chapter 2.1, the largest share of public R&D funding is for the HES, while GOVs receive a variable share depending on the country. By directing most R&D expenditures to public organisations, Member States aim to foster the long-term knowledge creation necessary for economic competitiveness, resilience and societal benefit. This structural preference for public funding of research is characteristic of the European science system, which differs from the US system but is similar to that of China.

Figure 3.2-9 Public expenditures for tertiary education as a share of national GDP, 2012–2023 and 2021–2022



Science, Research and Innovation Performance of the EU 2026

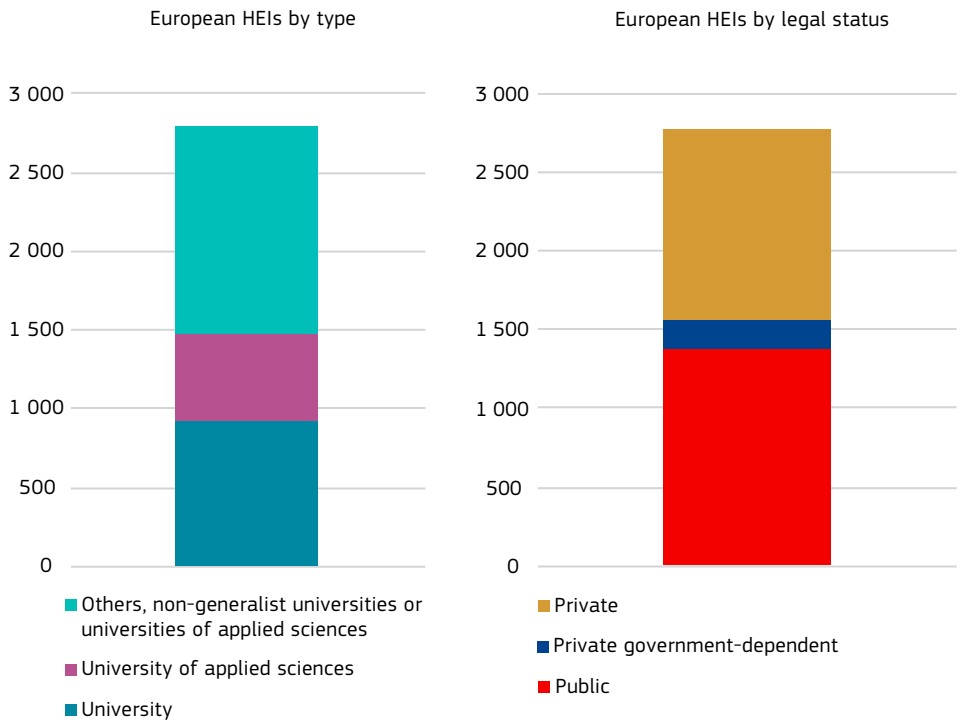
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Eurostat (DOI link: https://doi.org/10.2908/EDUC_UOE_FINE06).

Expenditures on tertiary education have generally declined in most Member States over the last decade, with few notable exceptions. Figure 3.2-9 shows this trend of reducing public expenditures on tertiary education, except in Greece, Hungary and Bulgaria, where they increased by more than 0.2% of their national GDP. Limited increases are observed in Spain, Italy, Belgium and Germany. In general, these investments primarily support the HES, providing the resources needed to train talent and develop technologies and capacities to support EU competitiveness and resilience. Despite this negative trend, the most innovative European economies correspond to those with a higher share of investments in the tertiary education system (for more details, see the EIS).

The multiplicity of the European higher education system

The European higher education landscape is defined by a significant institutional diversity that reflects the historical and national traditions of each Member State. Data from the European Higher Education System Observatory (EHESO) identified over 2 790 institutions in 2023, with traditional universities accounting for the largest share at 33% (Figure 3.2-10). These generalist, research-oriented institutions are complemented by universities of applied sciences, which account for 20% of the total and prioritise technical disciplines and industry-oriented teaching, although this binary distinction is not present in all Member States (Lepori, 2022).

Figure 3.2-10 European HEIs by type and legal status



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on European Higher Education Sector Observatory (EHESO).

Note: Only EU Member States considered. Missing values not displayed.

The 'others' category in Figure 3.2-10 is quantitatively significant and includes mono-disciplinary universities, university colleges, business schools and HEIs for the arts and music. All these HEIs contribute to providing Europe with a multifaceted set of talents across all disciplines. Finally, the system includes a significant share of private institutions, complementing the predominantly public landscape of HEIs. The presence of these varied entities calls for a nuanced approach to higher education policy and funding that integrates universities with other tertiary education institutions.

This pluralistic system, comprising research universities, universities of applied sciences and other specialised institutions, as well as public and private regimes, is the result of long-standing, country-specific historical processes. Such a varied model balances generalist, research-oriented universities with professional training and technology transfer, often in cooperation with industries, as well as societal engagement. Despite the efforts of EHESO to harmonise information, policy-relevant data remains limited, particularly regarding academic staff, enrolled students and PhD education (see also European Commission, 2025a). Improving this statistical base is a critical prerequisite for ensuring that European funding models target strategic needs.

Europe may lack 'frontier' HEIs, yet it maintains a significantly higher average research quality across its ecosystem than its global competitors. As highlighted in the Draghi report (2024), the US benefits from a concentration of world-leading universities, China has rapidly reached excellent levels, while the EU's strength lies in its distributed and varied institutional landscape. This lack of top-tier universities is a common argument for explaining Europe's weakness in attracting talent and investors and in producing breakthrough innovations.

University rankings are increasingly contested by the academic community for their reliance on narrow indicators, fuzzy methodologies and commercial rationales that fail to capture the multi-dimensional value of higher education. Critics claim that these rankings de facto incentivise 'gaming' to maximise profit-oriented visibility and attract students and funding (Hazelkorn and Mihut, 2021; United Nations University, 2023). The lack of methodological rigour undermines the credibility of these commercial instruments. The risk, as noted by ranking experts, is to undervalue the crucial functions of HEIs, such as societal impact, regional engagement and scientific publications in non-English journals (Gadd, 2020; Chirikov, 2023; Thorp, 2023). Furthermore, the 'Matthew effect' – where resources accumulate at already dominant institutions – marginalises smaller, specialised or young universities that may be providing relevant contributions in certain niches or contexts (Langfeldt *et al.*, 2015; Kochetkov, 2024). These biases make university rankings unreliable as policy-relevant instruments.

The Coalition for Advancing Research Assessment (CoARA) is promoting a fundamental reform to ensure that research quality is evaluated based on merit and impact rather than the prestige or reputation given by these rankings. Recognising that university rankings are often used inappropriately, CoARA advocates a 'qualitative-first' approach, supported by the responsible use of quantitative indicators (Arentoft *et al.*, 2022). The fundamental idea is to move away from ranking hierarchies and Journal Impact Factors (JIFs) to better recognise diverse research outputs (for more information, see the dedicated section in chapter 3.3). Other relevant policy initiatives in this area are presented in box 3.2-2.

Box 3.2-2 Flagship EU initiatives for the higher education system

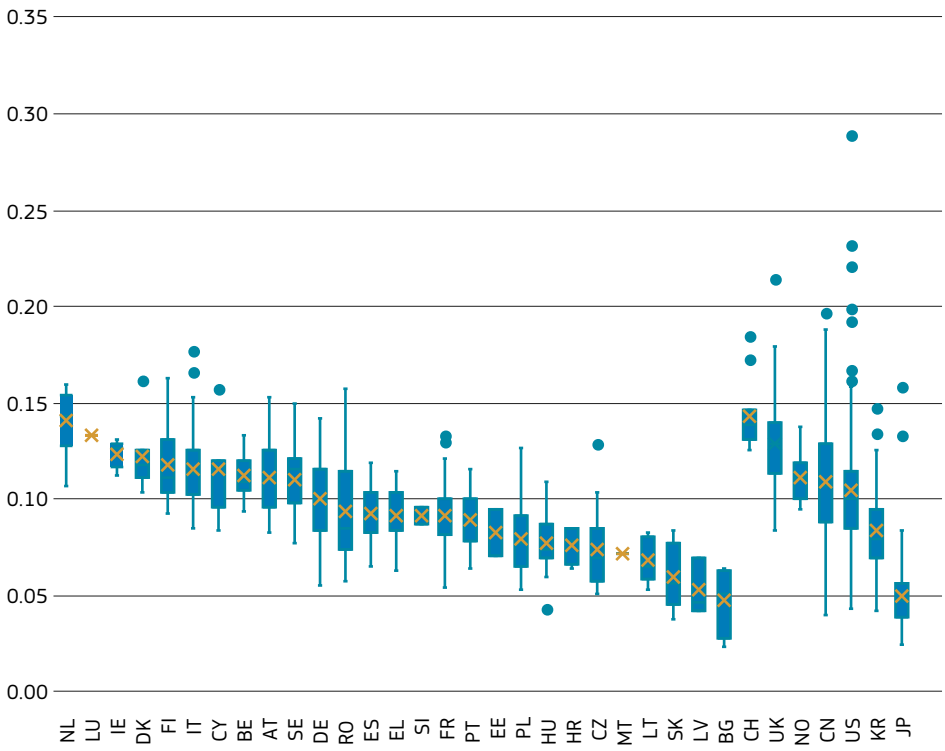
The EU is promoting a coordinated, systemic approach via the European Higher Education Area (EHEA) to facilitate collaboration, mobility and exchanges, complementing the ERA. Erasmus+ is probably the most famous programme for student mobility. The interim evaluation report for the 2021 to 2027 period and the final evaluation for 2014 to 2020 show that more than 7.8 million students went to study abroad between 2014 and 2023. More than 136 000 organisations were involved with demands exceeding the available funding (EUR 16.2 billion for the period of 2014 to 2020 and EUR 10 billion for the period of 2021 to 2023). Broad consensus exists on the opportunities provided for both students and participating institutions (European Commission, 2025d). Student mobility is a cornerstone for the EHEA, and it follows the longstanding 'Bologna process' for harmonising higher education across Europe. The Erasmus Mundus is considered today's main benchmark worldwide for joint master programmes.

The European Universities alliance is a recent, key initiative to shape the future of transnational higher education in Europe. Launched in 2018, 73 alliances exist involving 650 HEIs in 36 countries in 2026, promoting long-term, structural and strategic cooperation between the HEIs. These alliances are progressively evolving into permanent cooperation platforms to improve the quality of higher education and the strategic position of Europe's research system, in line with the 'fifth freedom' (Letta, 2024).

The European Degree Label (EDL) constitutes a major step in streamlining the administrative complexities associated with joint academic programmes across Europe. By establishing a unified set of European criteria for joint programmes at Bachelor, Master and Doctoral levels, the initiative ensures the automatic recognition of qualifications across the EU, thereby significantly enhancing the global competitiveness of European graduates and facilitating talent mobility (European Commission, 2025g).

The CWTS Leiden Ranking Open Edition offers a more reliable comparison by using open, non-profit data and transparent indicators. The main rationale is to overcome reliance on proprietary, commercial data providers and to adopt a transparent methodology with clear indicators. Figure 3.2-11 shows the level of HEIs by country in the EU and other major scientific powerhouses, based on the share of highly cited scientific publications in each institution's total publications.

Figure 3.2-11 CWTS Leiden Ranking Open Edition of HEIs in EU Member States and other scientific powerhouses, top 10% of most cited publications



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on CWTS Leiden Ranking Open Edition 2025.

Note: Based on field-normalised citations, fractional counting and core publications only.

The EU's HES is generally well-positioned, given the high average quality across most Member States, despite the limited number of institutions at the frontier. Figure 3.2-11 confirms that the US, China, Switzerland, and the UK dominate the CWTS Leiden Ranking Open Edition, with the highest values shown at the top of the table. Nonetheless, 10 EU Member States show a higher median value than the US, namely the Netherlands, Luxembourg, Ireland, Denmark, Finland, Italy, Cyprus, Belgium, Austria and Sweden, plus three of the Horizon Europe-associated countries (Switzerland, the UK and Norway). These results confirm the Draghi report, arguing that Europe might lack frontier institutions (i.e., the top part of the graph), but it has a higher average quality (the central part marked with an X in Figure 3.2-11). Significant heterogeneity exists in some large Member States, such as Germany, France and Romania.

The stark contrast among Member States calls for structural policies to address the limited scientific capacity in lower-performing countries. Countries like Bulgaria, Latvia, Slovakia and Lithuania show particularly low values, both in absolute terms and as national averages. The disparities between top-performing and less-performing Member

States call for structural support for 'widening' scientific capacity that can contribute to Europe's R&I ecosystem. Improving research capacity in less-performing countries is among the objectives of the ERA.

European infrastructures for research and technology

The varied pool of research and technology infrastructures is another strategic element for Europe's R&I ecosystem. The *European Strategy on Research and Technology Infrastructures*, launched in September 2025, set the framework to strengthen this ecosystem and keep these infrastructures world-class. This strategic framework aims to invest in building new capacities, facilitate and improve access to these infrastructures, attract and retain talents, improve governance and strengthen Europe's international role (European Commission, 2025b). The main rationale is to overcome fragmentation and promote a cooperative approach by facilitating scientific and technological exchanges across Europe to close the innovation gap, as mentioned in the Draghi and Letta reports (cf., Draghi, 2024; Letta, 2024).

World-class research infrastructures are a strategic asset for the European R&I system, demonstrating the power of supranational scientific collaboration for many decades. The European Organisation for Nuclear Research (CERN) is the global leader in particle physics and the birthplace of revolutionary digital technologies such as the World Wide Web. In the health domain, the Biobanking and Biomolecular Resources Research Infrastructure – European Research Infrastructure Consortium (BBMRI-ERIC) hosts one of the world's largest biobanks of human samples, while the European Life-sciences Infrastructure for Biological Information (ELIXIR) coordinates a distributed network of life-science data resources to enhance the impact of biological research on public health. Other vital centres of excellence include the European Synchrotron Radiation Facility – Extremely Brilliant Source (ESRF-EBS), the first fourth-generation high-energy synchrotron, which enables the characterisation of condensed and living matter at the atomic scale (for an overview with discussion on their socio-economic impact, see Florio, 2019).

The EU plays a major role in overcoming the fragmentation of European research infrastructures. This support has been developed since the *Lisbon Agenda* in 2000, along four main lines. First, the creation of the European Strategy Forum on Research Infrastructures (ESFRI) in 2002 provided a policy platform for the framing of the necessary coordination policy. Moreover, through its strategic roadmaps it has driven more than EUR 25 billion in investments to pan-European research infrastructures (European Commission, 2025b). Second, the EU Framework Programmes for Research and Technological Development (FPs) have provided funding, notably for transnational access and joint technology development. The 2009 enactment of the European Research Infrastructure Consortium (ERIC) is the third element, providing a legal framework for establishing European organisations, enabling the federation of research capacities across Europe. Finally, these elements have substantiated a revamped political narrative that highlights the European added value in supporting research infrastructures (Cramer and Rüffin, 2025).

Europe has a rich and varied system of research infrastructure. In 2024, ESFRI counted more than 40 landmark research infrastructures, recognised for their world-class status and pan-European importance and 22 ongoing projects. The geographical distribution has also grown from 10 single-sited and 17 multi-sited research infrastructures in

2006 to 16 single- and 47 multi-sited in 2024. Their thematic focus has also expanded from the first infrastructures in physical sciences and engineering (12 already operational and 4 in preparation), the thematic coverage is expanding to 'health & food' (12 plus 4), environment (8 plus 3), energy (3 plus 2), digital (1 plus 3) and social sciences and humanities (5 plus 6). This growing trend, at the same time, reflects the investment in upgrading European research infrastructures and the efforts to connect them to overcome fragmentation (on Europe's R&I fragmentation, see chapter 6.2).

Public investment in research infrastructures serves as an engine for innovation, technological progress and talent development. The thematic scientific literature indicates that every euro invested in high-technology procurement can generate up to fifteen euro in additional industrial revenue (Gutleber and Charitos, 2021). Furthermore, the procurement process acts as a local multiplier via the supply chain for high-technology projects required to build frontier research infrastructures, supporting local innovation ecosystems (Crescenzi and Piazza, 2023). Finally, research infrastructures are knowledge hubs that promote talent development and circulation (Giffoni *et al.*, 2025), and improve citizen attitudes towards science (Barroeta *et al.*, 2017).

Technology infrastructures translate scientific knowledge into market-ready innovation, providing the critical facilities where breakthrough ideas are matured and de-risked. By offering 'single-entry points' to specialised technological expertise, technology infrastructures allow companies to simulate real-world conditions, shorten the time-to-market and ensure regulatory compliance. Technology infrastructures are often thematically focused to serve the needs of specific industries and sectors. The current landscape covers different domains, such as energy and environment, materials and manufacturing, digitalisation and automation, biotechnology and healthcare, and the circular economy (European Commission, 2025f).

Systemic investments in research and technology infrastructures are a strategic element for the European R&I system and the ERA. Despite the diversity of these organisations, characterised by different rationales, funding models and governance mechanisms, their importance is clear. A dedicated ERA structural policy for the 2025 to 2027 period aims to further enhance these investments.

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CHAPTER 3.3

OPEN, RESPONSIBLE AND FREE SCIENCE

Nicola Francesco Dotti

KEY QUESTIONS

- How is open science reshaping the European Research Area (ERA)?
- What are the main challenges and initiatives to improve assessment and incentives for scientific research?
- How does Europe engage with citizens science, Science for Policy (S4P) and the ecological impacts of research?
- What are scientific and academic freedoms, and how are these fundamental European values evolving?

HIGHLIGHTS

- Open science is accelerating the diffusion of knowledge, supported by numerous policy initiatives. Emerging geopolitical tensions call for enforcing European sovereignty and strategic autonomy, while reflecting on how to keep an 'open to the world' approach.
- Research assessment and incentive structures have shifted from qualitative, peer-review methods to quantitative, data-driven systems. This transition has led to a strong emphasis on output-oriented performance up to the extreme case of the 'publish or perish' mentality, which today is expected to evolve towards a more responsible system.
- Within the ERA and Horizon Europe, the EU promotes public engagement in research and innovation (R&I) through a dedicated structural policy. These efforts aim to foster the active participation and dialogue of citizens and enhance their trust in science.
- The majority of European countries rank very high in the Academic Freedom Index (AFI), despite a few falling significantly below the continental average. Europe is still a world champion for the freedom of conducting research in a context of generalised decline.

POLICY INSIGHTS

- The European model for open, responsible and free science provides strong, values-based leadership at the world level.
- Open science is now a consolidated trend reshaping European research, but this transition needs regular reflections: the emerging need for Europe's strategic autonomy calls for responsible and reciprocal sharing of research outputs, while the emergence of artificial intelligence (AI) pushes for increased data quality and security.
- Research assessment and incentives are evolving towards an integrated, balanced system that mobilises the whole research ecosystem, thanks to the Coalition for the Advancement of Research Assessment (CoARA), which has received extensive support across Europe.
- The European Citizens Science (ECS) platform, S4P actions and the Marie Skłodowska-Curie Actions (MSCA) Green Charter are concrete examples aiming to building trust in science, bridging the science-policy gap and promoting sustainable research practices.
- The current geopolitical tensions call Europe to lead by example in upholding the fundamental values of scientific and academic freedom, amid a global decline.

In Europe, science benefits from being grounded in the fundamental values of openness, responsibility and freedom. From open science to scientific and academic freedom, Europe is a global champion for researchers aiming to push the scientific frontier, improve knowledge and engage with societal challenges. Many initiatives are ongoing to improve the various elements of the European science system, with the European Commission engaged in the coordination of several institutional actors and stakeholders.

The European Research Area (ERA) represents 'the ambition to create a single, borderless market for research, innovation and technology across the EU' (Letta, 2024). Many policy initiatives are improving transnational scientific integration, from the flagship initiatives on open science and the Coalition for the Advancement of Research Assessment (CoARA) to the promotion of Science for Policy (S4P), citizens science, the greening of research and the protection of scholars at risk. These initiatives are related to the fundamental value of scientific freedom that, together with academic freedom and the freedom of speech, shape a value-driven science system for Europe. Promoting freedom is a fundamental value that has proven to lead to more innovations, better science and higher quality research.

A new momentum is rising with the 'Choose Europe for Science' initiative, which aims to attract and retain the best researchers in the European Union (see chapter 3.2). Launched in Paris on 5 May 2025, this strategy is not just about funding, but relies on open, responsible, fair and free approaches to science, whose conditions can no longer be taken for granted in many other parts of the world. These ambitious goals are pursued through a broad array of policy initiatives that acknowledge the challenges and needs inherent in upgrading the European science system.

1. The progress and challenges for open science

Open science represents a fundamental shift in how research is conducted, disseminated and assessed, moving towards a transparent, inclusive and globally accessible science ecosystem. The explicit objective is to accelerate research and drive greater societal benefits (David, 2003). Open science includes several different practices to make knowledge freely available, improve the efficiency of scientific processes and increase the societal impact of (publicly funded) research (Fecher and Friesike, 2014).

Opening science implies removing the 'traditional barriers' to facilitate access to research. The most common aspect is Open Access (OA) publications: if readers do not have to pay to access publications, then science can circulate more openly, facilitating exchanges and progress. Similarly, Open-Source Software (OSS) can be used, tailored and improved by other developers. Other open science practices are open research evaluation and open research methods, which will be discussed below in this chapter. A crucial aspect for open science is the adoption of the 'FAIR' principles to research data: i.e., Findable, Accessible, Interoperable, and Re-usable data (Wilkinson *et al.*, 2016; Klebel *et al.*, 2025). All these activities aim to improve the uptake of open science in scientific research and align with fundamental EU values promoted by like-minded organisations such as the United Nations Educational, Scientific and Cultural Organization (UNESCO) (2021) and the Organisation for Economic Co-operation and Development (OECD) (2015).

The primary justification for embracing open science is grounded in the theory of knowledge as a public good (e.g., see the contributions of 2025 Nobel Laureate Joel Mokyr). By reducing barriers to access and broadening the dissemination of (publicly funded) research outputs, open science is viewed as an essential mechanism for improving science and accelerating technological progress, thereby enhancing productivity, fostering innovation and generating long-run economic and societal benefits (Cole *et al.*, 2024; Tsipouri *et al.*, 2025). The traditional model of 'closed' science limits the returns of publicly funded research by limiting scientific flows. Openness is even more crucial following Mokyr's distinction between 'prescriptive' and 'propositional' knowledge, i.e., the 'why' something works and 'how' to make it work (Mokyr, 2005, 2010, 2011). Especially by opening the 'why' knowledge, technological progress advances much faster, reducing the barriers to its application. Nonetheless, scholars also argue that openness can become 'too much', turning into a detrimental approach: economic theory argues that a certain degree of 'closeness' enables a 'fair' return on investment (e.g., Schäper *et al.*, 2023).

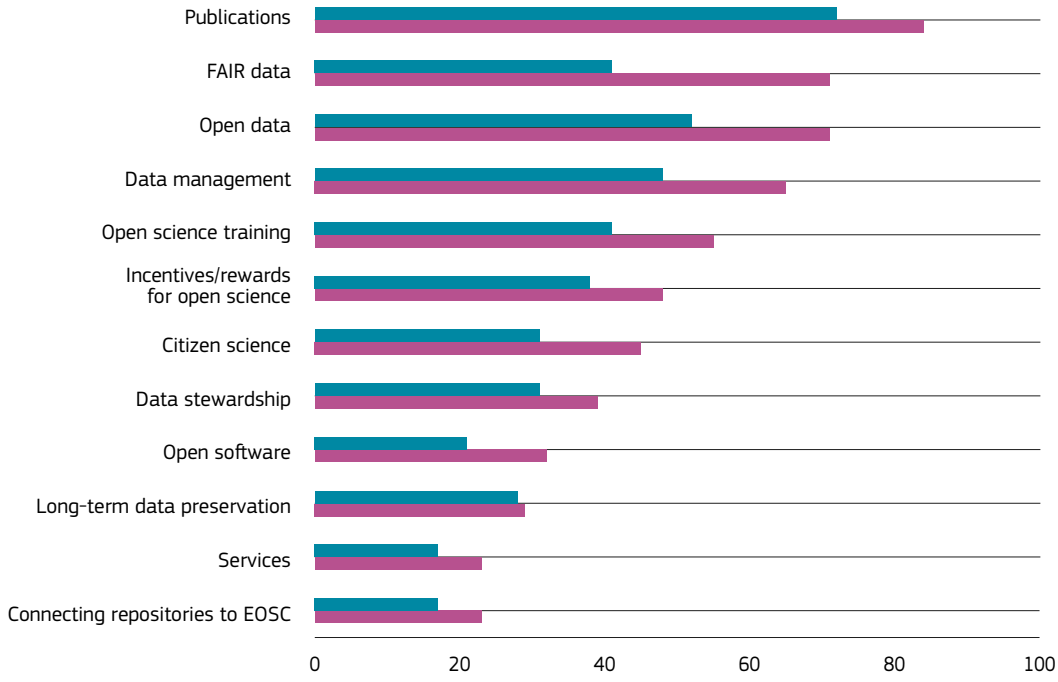
Making publicly funded research openly available is a strong political commitment. The requirements for OA to research publications and the dissemination of knowledge results are a concrete way to reduce barriers for knowledge advancement and optimise the use of public resources (David, 2004). By systematically reducing access barriers and ensuring widespread utilisation, open science practices are strategically positioned to accelerate the entire research life cycle, acting as a critical accelerator for European competitiveness, sustainability and resilience.

Open science necessitates a paradigm shift from merely publishing results to comprehensive sharing of knowledge across all stages of the research workflow (OECD, 2015; UNESCO, 2021). The evolution of open science is rooted in several foundational documents, among which the Budapest, Berlin, and Bethesda declarations are commonly cited as the main references (see Chan *et al.*, 2001, Max Planck Society, 2003, Brown *et al.*, 2003). The initial focus has grown from democratising knowledge access to include research transparency and reproducibility (Klebel *et al.*, 2025). Implementing the FAIR principles is today's main challenge to support 'open' research activities in a context of rapid technological changes, namely AI and its need for big data, and the increasing geopolitical competition.

The European Open Science Cloud (EOSC) is the EU flagship initiative for the Common European Data Spaces for R&I, providing a shared and trusted virtual environment viable to implement the FAIR principles across Europe. By developing such an infrastructure, the European Commission, together with the Member States, Horizon Europe Associated Countries and the research community aims to 'provide researchers and innovators in Europe with an open and trusted multi-disciplinary environment where they can publish, find and reuse data, tools and services for research and innovation' (European Commission, 2025c). EOSC is part of the EU's Framework Programmes that are promoting open science since the 2010s (Galsworthy and McKee, 2013; Robinson *et al.*, 2021).

The uptake of the open science policies and practices and their advantages are exemplified by the EOSC Open Science Observatory. Figure 3.3-1 shows that open science polices are emerging across all European countries and thematic areas. While publication and FAIR data-related policies are leading in terms of the number of actions, the increase covers all areas – a sign that the shift is underway, especially with a new generation of researchers supporting this change (Jamali *et al.*, 2020; Ferguson *et al.*, 2023).

Figure 3.3-1 National open science policies by areas, 2022 and 2024



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on EOSC (2025).

Empirical evidence confirms that open science generates significant economic returns through massive efficiency gains and accelerated innovation by facilitating knowledge sharing. A series of pioneering studies estimated that, since 2016, the European Bioinformatics Institute (EMBL-EBI) generates efficiency savings between GBP 2.6 and 11 billion per year (Beagrie and Houghton, 2016). These efficiency improvements came from removing the 'old science' barriers and facilitating exchanges. Similar results were found for other initiatives, like the Human Genome Project, where open science led to an increase of 20% to 30% in the time needed for product development (Williams, 2013). A recent cost-benefit analysis found positive impacts for both 'UniProt' (the world's leading, freely accessible resource of protein sequence and functional information) and RCAAP (Portugal's national repositories network), which are able to deliver substantial benefits for their respective communities (Catalano *et al.*, 2025). Beyond efficiency gains and enhancing innovation, empirical evidence at the macro level is less conclusive because of the methodological constraints (Tsipouri *et al.*, 2025).

The shift towards open science is not without problems, as many practices falsely claim to promote openness, without respecting the fundamental scientific and ethical values (UNESCO, 2023). For instance, open science played a crucial role in tackling the COVID-19 pandemic because many scholars shared openly the preprints of their research, facilitating the much-needed scientific exchanges to find suitable treatments. However, this openness also facili-

tated the diffusion of pseudo-scientific materials, creating confusion and leading to mistrust (Benson Marshall *et al.*, 2025). From a general perspective, serious concerns exist for the extreme facility to disseminate pseudo-scientific content and exploit the principles of open science for profit (Beall, 2012). Generative AI can easily produce content that looks 'scientific', that is then published in OA without rigorous scientific validation (Hanson *et al.*, 2024). While this can attract visibility and citations, it undermines the rigour of the scientific method (for a review, see also Bocanegra-Valle, 2023). Open science practices require high data quality and security standards, following the FAIR principles, for high quality scientific research (European Commission, 2025g, 2025h).

The rising geopolitical tensions are also questioning the open science paradigm, with Europe aiming to 'stay as open as possible and as closed as necessary' in a world with growing fragmentation. An emerging challenge exists between this open, inclusive approach and the risk posed by growing geopolitical tensions. In this context, the EOSC is considered an enabler of sovereignty, as it allows for open science that fosters global collaboration in a trusted, resilient and secure environment (European Commission, 2025b). Still, the case of dual-use research is a clear challenging example, because 'opening' science in militarily relevant technology fields can undermine the objective of promoting Europe's strategic autonomy and security (Huang and Soete, 2025). See more in chapter 4.4.

Open science is changing the role of science 'in and for' the society, leading to new forms of assessing, rewarding and incentivising research. While removing barriers facilitates exchanges, it also increases pressures to pursue research that can be shared more easily (Kaliuzhna *et al.*, 2025). Additionally, the transition to open science is costly, raising concerns regarding equity and increasing disparities across countries, and favouring those having the means to support this transition (UNESCO, 2021). In this perspective, the ERA Policy Agenda 2025-2027 includes an action on 'Applying Equity in Open Science', which aims to promote equitable participation in open science research.

2. Towards responsible research assessment and incentive systems

Promoting responsible research assessment and the 'right' incentives are two complementary elements, and Europe has engaged to promote more holistic, responsible approaches to enhance its science system. The way science is evaluated directly influences resource allocation, researcher careers, institutional strategies and, ultimately, the type of research conducted. Currently, the mainstream approaches rely heavily on quantitative indicators such as the Journal Impact Factor and the H-index. However, several criticisms have been raised because a narrow focus on quantifiable outputs tends to disregard qualitative elements (for a complete overview, see OECD, 2026). Many European science systems are already evolving to fairer research assessment approaches.

The fundamental objective of research assessment and incentives is to optimise the allocation of available, limited resources. These systems include all activities aiming to monitor, evaluate and review the scientific performance of individual researchers, their institutions or specific projects, programmes and initiatives. While research assessment systems

are formalised and codified, they interact with 'informal' factors of research cultures and other unwritten norms of scientific systems, such as peer recognition or disciplinary traditions. These systems aim to align political priorities with their implementation.

Research assessment and incentive structures are fundamental in shaping the expected outcome, and therefore enhance or constrain certain practices. As an example, a system mostly rewarding the number of scientific publications in certain (e.g., national or monodisciplinary) journals will lead to increasing the number of publications in those journals; while scholars will have to do less of other activities such as teaching, conference presentations, patenting, policy engagement, or outreach activities if those are not rewarded. This approach might lead to opportunistic behaviours, inflating the number of publications by lowering scientific standards or multiplying journals. This simple example shows the need to reflect on the responsible use of evaluation criteria to provide the right incentives to researchers.

Research assessment systems have historically evolved from purely qualitative, peer-review-based approaches to those relying more on quantitative indicators, to the current ongoing discussions towards a responsible, balanced and integrated system. While some incentives and rewards for academics and scholars can be dated back to the 17th century (Kronick, 1990; Biagioli, 2002; Fitzpatrick, 2011), the first modern generation of research assessment systems emerged in the 1970s and 1980s: decision-makers needed to rationalise the use of the limited resources vis-à-vis research programmes that were growing in size and complexity. In this perspective, systematic peer reviews were set-up to assess research activities. A second generation emerged as a reaction to subjective judgements and biases caused by peer evaluation. In the early 2000s, indicator-based systems entered and reshaped research assessment, thanks to the new availability of scientometric and bibliometric data and the popular success of rankings (Gingras, 2016; Florio, 2019). Nonetheless, this emphasis on quantifiable output caused much pressure to maximise efficiency and the return of (public) spending. Since the 2020s, an open discussion has developed to promote responsible research assessment integrating qualitative and quantitative approaches (Hicks *et al.*, 2015).

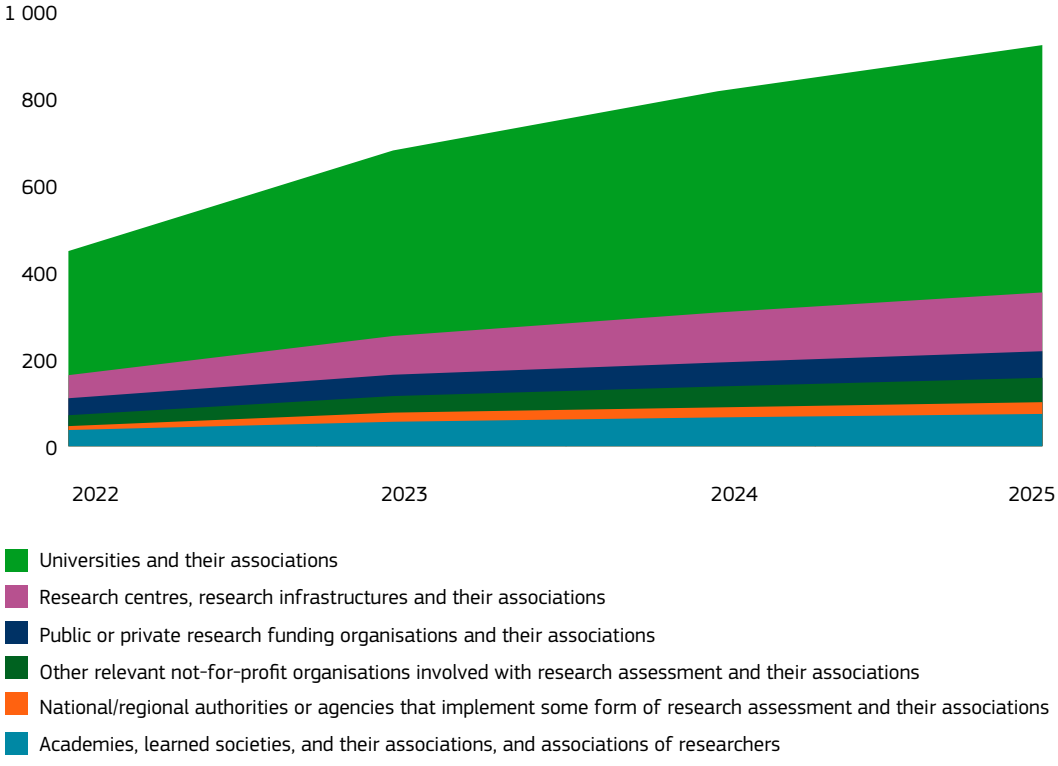
Today, research assessment and incentive mechanisms are called to evolve, combining data availability and new technologies, especially AI, with the need to ensure a better functioning of scientific systems. The overreliance on output indicators, like publication counts, citations and awarded grants, is causing the perverse system commonly referred to as 'publish or perish': researchers are pushed to prioritise output quantity instead of scientific quality. Duplication of publications (so-called 'salami publishing'), falsification of data and other unethical conduct are commonly reported as being caused by this publish or perish mentality (e.g., Miller *et al.*, 2011). An exaggerated emphasis on quantitative indicators caused a strong pressure to inflate publications (and citations), looking for visibility instead of scientific rigour (Chubb and Watermeyer, 2017; Hanson *et al.*, 2024). These problems have multiple causes and origins. The ecosystem of actors involved, from individual researchers and their institutions to policymakers, regulators, public and private funders, publishers and scientific societies, needs to work together toward a responsible and more sustainable system.

A critical and widely debated problem for research assessment is the role of rankings. Rankings, especially those comparing universities for prospective students, benefit from being easily communicated and spark interest to track the progress or decline of individual organisations. Furthermore, they can help policymakers and administrators monitor the effect of their leadership and policy. However, serious criticisms have been

raised because of the lack of methodological rigour and the profit-oriented approach of ranking companies (Enserink, 2007; Chirikov, 2023; Gadd, 2025). The risk is to reduce the complexity of research organisations and their evolution into a single, relative value interpreted as an absolute measure of their performance (see also chapter 3.2).

In Europe, a collective action to reform research assessment started in July 2022 with the signing of the Agreement on Reforming Research Assessment (ARRA) and culminated with the launch of CoARA in December 2022. The proposed reforms aim to overcome narrow definitions of scientific excellence that focus solely on output indicators and rankings, which have exacerbated pressure on researchers and research organisations. A closed, hyper-competitive environment ultimately undermines research quality, leading to unwanted effects. Although criticisms exist defending the quantitative model developed during the last decades (e.g., Abramo, 2024), the CoARA initiative immediately received strong support from a large set of actors from the research ecosystem, from universities and research institutes to research funding organisations, policymakers and learned societies, as shown in Figure 3.3-2. From 2023 to 2025, CoARA received the support from more than 920 member and signatory organisations from more than 60 different countries, including beyond Europe.

Figure 3.3-2 Evolution of CoARA members and signatory organisations, 2022–2025



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on CoARA (2026; as of 20 January).

Note: Data includes all organisations, both full members and signatories.

An initiative like CoARA gathers multiple actors in favour of reforming research assessment in a responsible way. Following similar initiatives like the Declaration on Research Assessment (DORA, 2012), the Leiden Manifesto (Hicks *et al.*, 2015), and the Hong Kong Principles for Assessing Researchers (Moher *et al.*, 2020), CoARA promotes qualitative judgements to assess research and the responsible use of research metrics (Arentoft *et al.*, 2022). This approach aims to promote the recognition of diverse research contributions, including teaching, mentoring, engaging with policy and open data sharing, rather than just traditional publications and citations. The commitments for responsible research assessment are currently being implemented with more than 260 institutional action plans adopted, and more under development.

Europe is also committed to ensure the highest standards in research ethics and research integrity as foundation for the ERA, the EU's Framework Programme (Horizon Europe), and the whole scientific system. The high levels of public trust in European science rely on the robust legal and organisational frameworks ensuring that research practices meet the highest scientific criteria, while instances of misconduct are formally investigated and met with institutional penalties. A key reference is the 'European Code of Conduct for Research Integrity' by ALLEA (2023), which grounds scientific practice to four core pillars: reliability, honesty, respect, and accountability. Evidence of this growing commitment is the increasing number of national research integrity bodies with a function of monitoring, oversight or investigation: the European Network of Research Integrity Offices (ENRIO) reports that 16 Member States and 5 Horizon Europe associated countries in Europe have such national bodies in 2026. This number has steadily grown over the last decades, and several countries are currently developing their systems. The 2025 Council Recommendation on the ERA agenda for 2025-2027 further links research integrity with the reform of research assessment and incentives, research ethics, research security, open science and AI in science (Council of the European Union, 2025). Together, these measures foster a research system dedicated to upholding the highest scientific standards, accountability, and trustworthiness.

Reforming research assessment and incentives is crucial to keep Europe's science system competitive, sustainable and innovative. A first challenge is that the coexistence of multiple research assessment and incentive systems causes overlaps and unintended consequences (for an overview of national research assessment, see Rushforth *et al.*, 2025). The complexity of today's systems calls for collective mobilisation, system thinking, a long-term perspective and a constant dialogue between experts, policymakers and stakeholders.

3. Doing science with and for people, better policy and our planet

Developing the ERA requires engaging with policy actions for systemic change, including specific challenges such as engaging with citizens science, bridging the science-policy gaps and ensuring the ecological sustainability of research activities. These policy areas aim to integrate other structural actions, as with those for open science and the reform of research assessment discussed in the previous sections. In this section, three of the most relevant areas are presented without aiming to be exhaustive. Public engagement in research and innovation (including

citizen science), S4P and the greening of research are chosen, as they refer to science for people, better policy and engaging with climate actions.

Citizen science aims to engage the broader public in science dialogues and scientific activities. Often associated with open science, the involvement of citizens offers an opportunity to bring together scholars, policymakers and civil society organisations at the EU, national or local level. This approach can be applied in many disciplines and different stages of the research process, such as co-creation, co-design, data collection and volunteer mapping up to more complex phases such as data interpretation, sense-making and results dissemination. The benefits are both epistemic and social, as public engagement helps enhance trust in science.

Europe has promoted citizen science and public engagement for decades via its Framework Programmes, Horizon Europe and its predecessors. This trend is supported by similar research funding programmes by Member States and beyond (European Commission, 2023b, 2023c, 2023d). For example, the European Citizen Science platform (ECS) provides a hub to gather initiatives across Europe, reporting more than 400 projects, 360 organisations and 5000 users in December 2025, and with a growing amount of resources to further improve these research practices (European Citizen Science, 2025). These efforts demonstrate the growing integration of citizens' input into Europe's research ecosystem, significantly contributing to improving trust in science.

Europe requires policies grounded in scientific evidence to address today's complex challenges, wicked problems and systemic changes during periods of instability and technological disruption. The European Commission, together with Member States and research stakeholders, is engaged in the so-called S4P activities, capitalising on the lessons learnt from the COVID-19 pandemic and the wave of disinformation and post-truth politics (for an overview, see OECD, 2020). In this context, S4P or evidence-informed policymaking refers to the use of the best available scientific evidence, knowledge and expertise to inform policymaking, aiming to achieve better public policies. The need for structured scientific support to policymaking at the EU, national and subnational levels has been underscored in several recent EU policy documents and initiatives. Most prominently, in the Council Conclusions adopted in December 2023, which call upon the European Commission to play a key role in coordinating actions in this domain, setting the stage for a European framework on S4P activities (Council of the European Union, 2023).

The European Union is committed to strengthening the S4P ecosystem, promoting the systematic use of scientific evidence for policymaking by developing institutional capacity, establishing enabling structures and processes, and integrating S4P approaches into policy frameworks. Several initiatives are developing to institutionalise S4P activities in different policy organisations, from governments to parliaments, from the European to the national and regional/local levels (Strand, 2022; Oliver *et al*., 2025). A trend of expanding S4P is observed, with forms varying according to the governance structures of each government tier. As an example, the Scientific Advice Mechanism (SAM) to the European Commission acts as a knowledge broker between the college of commissioners and the scientific community by reviewing existing scientific evidence and supporting evidence-based policy recommendations. Furthermore, a dedicated ERA action for S4P includes the establishment of a network of national correspondents, community-building initiatives and the creation of a repository of practices. These efforts are carried out in coordination with the Joint Research Centre (JRC), which provides in-house

S4P support for the European Commission itself. Finally, the European Commission make use of the so-called 'Feedback to Policy' (F2P) mechanism to promote the uptake of research findings into policymaking. The fundamental idea is to facilitate the uptake of EU-funded R&I projects and their results for designing, monitoring and reviewing policy.

Since science successfully identified and explained climate change as today's most pressing societal challenge, the research community is now working to lead the green transition by setting clear examples. Scientific research has fundamentally contributed to identifying the causes of climate change, biodiversity loss and pollution, and to developing new technologies and innovations to reduce carbon emissions, preserve natural ecosystems and cope with natural disasters. Nonetheless, research activities must also engage with reducing their carbon emissions from travel and facilities, promoting circular practices, reconceiving academic events, and reducing their ecological footprint for the so-called 'greening of research' (for a review of the challenges, see Dotti *et al.*, 2025; Farley, 2026).

The greening of research activities requires clear, concrete guidance to turn principles into actions. The MSCA Green Charter is a leading example for grant holders committed to the ecological sustainability of research activities. Based on extensive stakeholder engagement since 2021, the MSCA Green Charter, updated in 2025, provides non-binding guidelines and examples to mainstream sustainability in research activities. The sustainable use of resources, reduction of waste and harmful substances and emissions, and the respect of natural systems and biodiversity are some of the main areas of action. Specific attention is devoted to collaboration practices and use of digital technologies to reducing unneeded travels (European Commission, 2025d). These practices are spreading even beyond MSCA Green Charter grant holders (European Commission, 2023a), with several initiatives from Member States and grassroot initiatives working together for more sustainable research practices (European Commission, 2025e, 2025f).

4. The European Engagement for the Freedom of Scientific Research

The freedom of scientific research is a fundamental value for the European Union, making Europe a worldwide reference (cf. European Union, 2012). Despite widespread recognition that scientific freedom is crucial for high-quality research, many concerns arise because it is not always a reality in Europe and across the world (Maassen *et al.*, 2025). While most European countries have a leading position worldwide, scientific freedom requires constant attention and support as negative trends are observed in Europe, and in many parts of the world the situation is even more severe.

The Bonn Declaration (2020) states that the freedom of scientific research "encompasses the right to freely define research questions, choose and develop theories, gather empirical material and employ sound academic research methods, to question accepted wisdom and bring forward new ideas. It entails the right to share, disseminate and publish the results thereof openly, including through training and teaching. It is the freedom of researchers to express their opinion without being disadvantaged by the system in which they work or by governmental or institutional censorship

and discrimination. It is also the freedom to associate in professional or representative academic bodies. Freedom of scientific research needs opportunities for physical and virtual mobility in pursuit of one's research work, requires a culture of gender equality and the freedom to interact with students and colleagues. Freedom of scientific research is informed by the standards of academic disciplines. At the same time, it "enables researchers to challenge these standards when and if new research results begin to question their current validity" (Ministerial Conference on the European Research Area, 2020, p. 1).

Scientific freedom is strongly related to academic freedom and the freedom of speech for academics, which are all fundamental European values. Academic freedom is 'the freedom of academic staff and students to engage in research, teaching, learning and communication in and with society without interference nor fear of reprisal' (EHEA, 2020, p. 1). The freedom of speech is another fundamental, democratic value that should apply to every citizen, including academics and researchers who are particularly exposed for their role and engagement with societal challenges (see also European Commission, 2025a). The three inter-related concepts of scientific freedom, academic freedom and freedom of speech cover different dimensions from conducting research to teaching and learning, from the academic systems (universities, higher education institutes and academies) to other scientific organisations such as societies, scientific institutes and individuals.

Scientific freedom is a principle to be applied at three levels: individuals, organisations and country. This three-tier distinction aims to ensure that scientists can benefit from 'individual' scientific freedom within their organisations, while organisations shall have institutional autonomy to carry out scientific research within their countries. Again, these three levels are inter-connected, but not equivalent. For instance, scientists should be free to define their scientific agenda without fear of personal reprisal, censorship or professional sanctions. For scientific organisations, the external interference on their scientific agenda and governance are the main challenges, while governments should ensure adequate means and autonomy to scientific organisations.

The distinction between political and scientific spheres is crucial to guarantee scientific and academic freedoms. A clear and strong regulatory framework is needed to ensure that scientific freedom is not arbitrarily subjected to political pressure and contingencies or, even worse, external interferences. Constitutional guarantees for scientific freedom are often considered an important indicator. Scholars have shown that declines in academic and scientific freedom are often early predictors of democratic backsliding (Hellmeier *et al.*, 2021; Pelke, 2023).

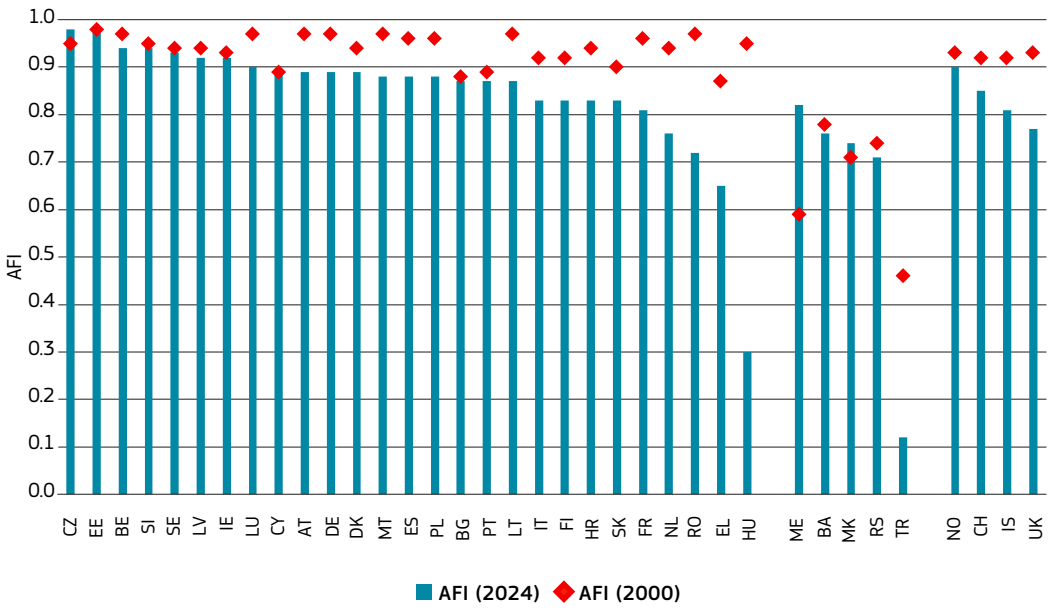
Europe has very high standards of academic and scientific freedom across its countries. The AFI provides yearly monitoring of the de facto levels of freedom along five fundamental dimensions: 1) freedom to research and teach; 2) freedom of academic exchange and dissemination; 3) institutional autonomy; 4) campus integrity; and 5) freedom of academic and cultural expression (see Spannagel and Kinzelbach, 2023). This monitoring activity provided by AFI plays an important role, showing that academic freedom improves with democratic values and declines when populist or authoritarian forces rise (European Parliament, 2024; Hernández-Huerta and Inclán, 2025).

Most European countries show high values on the AFI. Most Member States and Horizon Europe Associated Countries have an AFI value higher than 0.75 with 1.0 being the highest

possible value (Figure 3.3-3). The case of Hungary has attracted particularly high political concerns because of the very low level of academic freedom (0.30) for several years. In many member states, the trend is declining since 2000, mainly because of the reducing public budget for research, undermining the degree of freedom as reflected in the worsening of the AFI index. Among non-EU European countries, Montenegro stands out for having increased its freedom from an AFI value of 0.59 in 2000 up to 0.82 in 2025. On the contrary, Türkiye's AFI declined from 0.46 to 0.09, becoming one of the most concerning cases in the world.

Europe is globally the only leading knowledge region that ensures high levels of freedom for researchers. While Europe is a global leader in protecting academic and scientific freedom, the US reports a fast decline in the AFI from 0.91 in 2019 to 0.40 in 2025 (Figure 3.3-3). China, meanwhile, has constantly been reported under 0.10 since 2016, with a long-term process of decline since the early 2000s. In 2025, China is reported to have the tenth-lowest value in the world. Especially worrying is the fact that these declines co-occurred with changes in the political leadership in both countries (Kinzelbach *et al.*, 2023). On the contrary, Canada, South Korea and Japan report high values in the AFI with positive trends, especially in Japan.

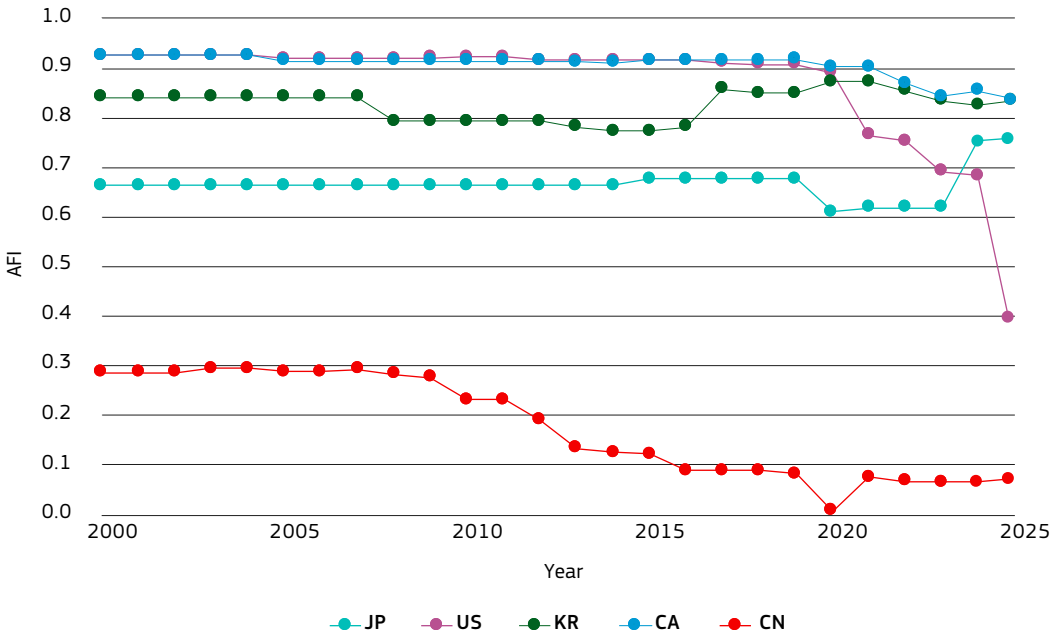
Figure 3.3-3 Evolution of the Academic Freedom Index (AFI) in Europe, 2000 and 2025



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Kinzelbach *et al.* (2026).

Figure 3.3-4 AFI index in selected non-European countries, 2000–2025



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Kinzelbach *et al.* (2026).

The AFI index also reports the de jure aspects, acknowledging that freedom cannot be measured exhaustively. Measuring the legal aspects, such as constitutional arrangements and fundamental laws ensuring academic or scientific freedom, does not automatically ensure that these principles are implemented (Maassen *et al.*, 2025). De jure protection is a necessary condition for freedom, but it also needs 'lived values' to take effect, as it is the application of the de jure framework that decides whether freedoms can be realised or not. For this reason, judicial cases and news monitoring are also relevant to understanding the extent of 'real' academic and scientific freedom. Box 3.3-1 below provides some concrete examples of these supporting actions. This tension between measurable legal dimensions and qualitative cases exists and must always be combined for a comprehensive assessment, especially considering trends, rather than static perspectives. Specific analysis shows that these de jure and de facto situations do not always correlate (Bjørnskov, 2024).

Scientific and academic freedom encompasses formal, legal aspects, as represented by existing indices, as well as concrete cases promoting and implementing this fundamental European value. While the AFI has become the main reference within and beyond the European context because of its methodological rigour and global reach, tracking individual cases of endangered scholars or investigating deeper, specific national situations are also crucial for promoting a culture of freedom (Maassen *et al.*, 2025). Box 3.3-1 presents a concrete case of support for researchers at risk (for an in-depth analysis of these challenges, see European Commission, 2025a).

Box 3.3-1 Europe supports researchers at risk

Marija Mitic (European Commission, DG Education, Youth, Sport and Culture)

Since 1999, the international association 'Scholars at Risk' aims to 'protect scholars and the freedom of think, question and share ideas' (Scholars at Risk, 2025). The actions to protect scholars at risk have multiple forms, from advocacy to raising awareness and guaranteeing legal protection to scholars threatened across the world. From the first actions in the US, more initiatives are emerging across the world, and the network of multiple European organisations are committed to protecting scholars and the principles of academic and scientific freedom is growing.

Between 2019 and 2025, the European Commission provided support for capacity building, knowledge exchange and networking at the European level through the Inspireurope and Inspireurope+ projects, funded under the MSCA. The projects have in addition trained researchers and potential host organisations and provided a set of materials and resources for the policymakers and practitioners in the field (Scholars at Risk - Europe, 2021).

Another key resource developed in this period is the Marie Skłodowska-Curie Actions (MSCA): *Guidelines for inclusion of researchers at risk* (2021), which will be updated in 2026. While the MSCA grants are open to all researchers, these specific guidelines are devoted to the case of scholars who are at risk because of their scientific interests, activity, status, or because they come from countries at war. The guidelines provide practical information on involving and supporting at-risk researchers in EU projects, and concrete examples of good practices for their inclusion in MSCA projects. Other, similar initiatives are also promoted by Member States and Associated Countries in a collective effort to promote academic and scientific freedom in Europe.

Since 2022, MSCA has supported 175 researchers forced to flee Ukraine, including doctoral candidates and postdoctoral researchers, to continue their work on research projects at host institutions based in the EU and Horizon Europe Associated Countries. The initiative has provided EUR 35 million for the employment of the researchers and included support for research, training and networking, allowing fellows to continue their research in safety.

Promoting a culture of freedom requires a strong framework for engaging in science diplomacy. For this reason, the 'European framework for science diplomacy', published in February 2025, provides useful recommendations to coordinate all actors involved to address existing vulnerabilities and to proactively engage with a rapidly changing geopolitical context (Gjedsso *et al.*, 2025). This framework follows the Staff Working Document *Tackling R&I foreign interference*, published in 2022, which provides guidelines on how to respond to external pressure undermining core European principles such as academic and scientific freedom (European Commission, 2022).

The high standards of scientific and academic freedom in Europe are a value-based choice with strong benefits on competitiveness, innovation and quality of research. Recent analysis shows a positive impact of academic freedom on research, especially in the fields of science, technology, engineering and mathematics (Fernandez *et al.*, 2024). These positive effects are also observed for innovation output, assuming a century-long perspective (Audretsch *et al.*, 2024). Therefore, being a leading region for research freedom provides relevant and strategic framework conditions for world-leading research in Europe.

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CHAPTER 4

TECHNOLOGIES AND GLOBAL CHALLENGES

CHAPTER 4.1

TECHNOLOGY LEADERSHIP AND SUPPLY CHAIN DEPENDENCIES

Valentina Di Girolamo, Florence Benoit

KEY QUESTIONS

- How is the EU positioned in the development of key strategic technologies?
- What are the primary risks associated with strategic dependencies in critical supply chains?
- What major initiatives has the EU launched to safeguard economic security and strengthen strategic autonomy?

HIGHLIGHTS

- Between 2000 and 2022, the EU's share of Patent Corporation Treaty (PCT) patent applications fell from about 30% to around 16%, while China rose from 3% to nearly 33%, signalling a redistribution of global innovation capacity.
- Europe performs relatively well in areas such as advanced materials and manufacturing, but lags in digital technologies such as artificial intelligence (AI) and photonics.
- The EU remains strong in several technologies supporting the green transition such as wind energy, hydrogen, electricity grids, carbon capture and biofuels. However, compared with the US and China, the EU has fewer strengths in complex digital areas such as AI, advanced semiconductors and cloud computing.
- Weaker technological positions often coincide with reliance on foreign suppliers. In areas where Europe lags technologically, it is also more likely to depend on production and inputs from outside the EU.

POLICY INSIGHTS

- The EU's *Competitiveness Compass* puts the need to close the innovation gap in strategic technologies between the EU and its main international peers at centre stage, calling for ambitious effort to strengthen competitiveness and technological sovereignty.
- Ensuring technological sovereignty and strategic autonomy has important implications for economic security, calling for the development of a more cohesive and impactful approach to respond to new geopolitical and technological realities.
- The EU is deploying several initiatives to strengthen resilience, while preserving its commitment to open international trade. This includes actions aimed at prioritising resource efficiency and sustainable management practices, reducing dependencies in critical supply chain and enabling technologies, as well as in transitioning energy- and resource-intensive value chains toward circularity, thereby enhancing industrial competitiveness and long-term sustainability that underline industrial competitiveness.

Over the past two years, the global economy and political dynamics have continued to evolve towards greater strategic competition. Intensifying geopolitical rivalries, wide economic uncertainties and renewed trade disruptions are shaping the international environment in which the EU operates. The deepening technological race between the US and China, characterised by export controls, retaliatory measures, and restrictions in critical technologies and raw materials has heightened uncertainty across global value chains. At the same time, the reintroduction of tariffs and the use of industrial policy tools to secure strategic advantages have amplified tensions in the global trading system.

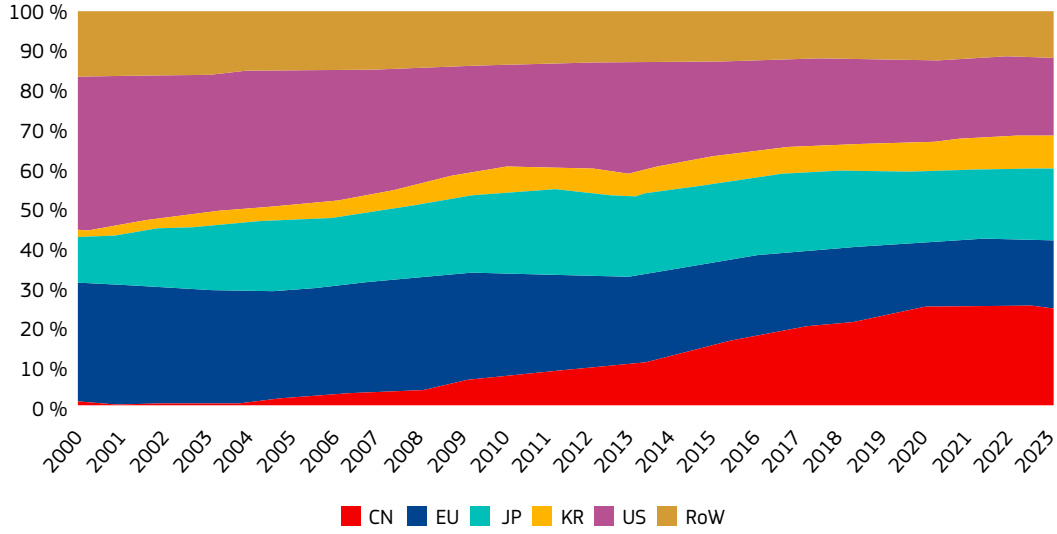
For the EU, these developments have reinforced the urgency of redefining its economic model around resilience, competitiveness and strategic autonomy. The policy debate has increasingly centred on how to 'de-risk' strategic dependencies while preserving the benefits of open markets and cross-border collaboration. Strengthening technological sovereignty has become essential to address vulnerabilities in key supply chains, secure access to critical technologies and safeguard Europe's long-term capacity for innovation and strategic autonomy.

1. The EU's technological position

Technologies are widely recognised as a key driver of both economic success and geopolitical power. In today's interconnected economy, advancements in critical strategic technologies are reshaping global competitiveness. Countries that lead in developing and deploying these technologies not only gain economic advantages through innovation, high-value job creation and market dominance, but also acquire strategic leverage in global value chains, supply networks and standards setting. Consequently, technological leadership has become a central pillar of power, determining the capacity to project influence, secure autonomy and advance interests on the international stage.

Over the last two decades, there has been a significant redistribution of global patenting activity, with the EU maintaining a strong but declining presence relative to rising competitors. Between 2000 and 2023, the EU's share of PCT patent applications has gradually declined from nearly 30 % to around 17 % in 2023. Similarly, the US witnessed a steady decrease from close to 40 % in 2000 to 20 % in 2023. This contrasts sharply with China, whose share has increased from just 2 % in 2000 to nearly 26 % in 2023, reflecting a rapid increase in innovation output. South Korea also steadily increased its share in patenting activity, rising from under 2 % to 8 % (Figure 4.1-1). These trends in patenting activity, reflecting broader patterns of technological strength and innovative effort, highlight a shifting global landscape.

Figure 4.1-1 World share of patent applications filed under PCT, 2000–2023



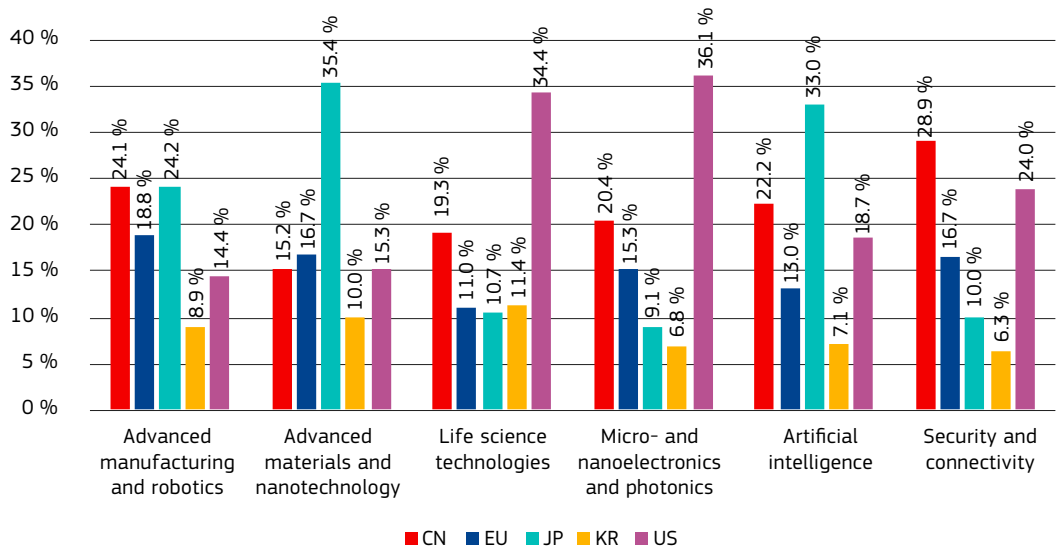
Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Fraunhofer ISI, using PATSTAT.

Note: PCT patents, fractional counting method, inventor's country of residence and priority date used.

The EU remains competitive across several key enabling technologies (KETs), but persistent gaps with other global innovators remain. In 2023, the EU reported a relatively good performance in terms of share in the world's patent applications in advanced materials and nanotechnology (approximately 17%), and advanced manufacturing and robotics (18.8%). However, this performance still fell well below that of Japan (which dominated both fields with shares of 35.4% and 24.2%, respectively) and China, reporting 24.1% in advanced manufacturing (Figure 4.1-2). Furthermore, the EU ranked third in areas related to security and connectivity (around 17%) and life sciences (15.3%), after both the US (24.0% and 36.1%, respectively) and China (29.0% and 20.3%, respectively). The EU's lowest performance is reported for micro- and nanoelectronics and photonics, where its share is only about 13.1%, significantly behind Japan (33.0%), China (22.3%) and the US (18.7%). The EU also remains weak in AI, with a share of 11.0% against the 34.4% and 19.3% of the US and China, respectively (see chapter 7).

Figure 4.1-2 World share of patent applications filed under PCT, by key enabling technologies, 2023



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Fraunhofer ISI, using PATSTAT.

Note: PCT patents, fractional counting method, inventor's country of residence and priority date used.

Nevertheless, the EU's performance remains good in high-value patent filings[1] in renewables and energy efficiency fields. The EU remains in the lead for renewables (29%), and ranks second behind Japan in sustainable transport. The EU's performance remains good also in energy efficiency where it remains on par with China (20%) and slightly behind Japan (24%). On the contrary, China dominates in the area of smart systems, with a share of 32%, while the US ranks first in carbon capture, utilisation and storage (CCUS) technologies, followed by the EU and Japan (Figure 4.1-3). The US and China are also leading in the field of nuclear safety with 25% and 19% respectively, while the EU reports a share of 15% .

Furthermore, the EU continues to be strong in technologies such as wind, hydrogen, smart grids and ocean energy. The EU shows a significant strong position in wind energy, with a share close to 60%, clearly distancing other major global innovators, which remain below 15% (Figure 4.1-4). The EU remains in the lead also in hydropower (28%) ranking slightly ahead of China (26%), and in hydrogen (32%) where it faces close competition from Japan (30%). The EU ranks first also in ocean energy with a share of 25%, but remains behind the US and China in areas related to batteries and geothermal energy (European Commission, 2025a). Specifically, the US performance is particularly strong in the field of geothermal energy (25%), whereas battery technologies are clearly dominated by Asian economies, with Japan leading (32%), followed by South Korea (around 22%) and China (around 17%). On the contrary, the EU and the US show comparatively weaker positions, reporting a share of 12% and 11%, respectively (figure 4.1-4).

1 High-value patents are measured as the top 10% by forward citations.

Figure 4.1-3 EU positioning in high-value patents in the energy union R&I priorities, total over 2017–2021



Science, Research and Innovation Performance of the EU 2026

Source: JRC SETIS (March 2026), based on PATSTAT.

Figure 4.1-4 EU positioning in high-value patents in selected green technologies, total over 2017–2021



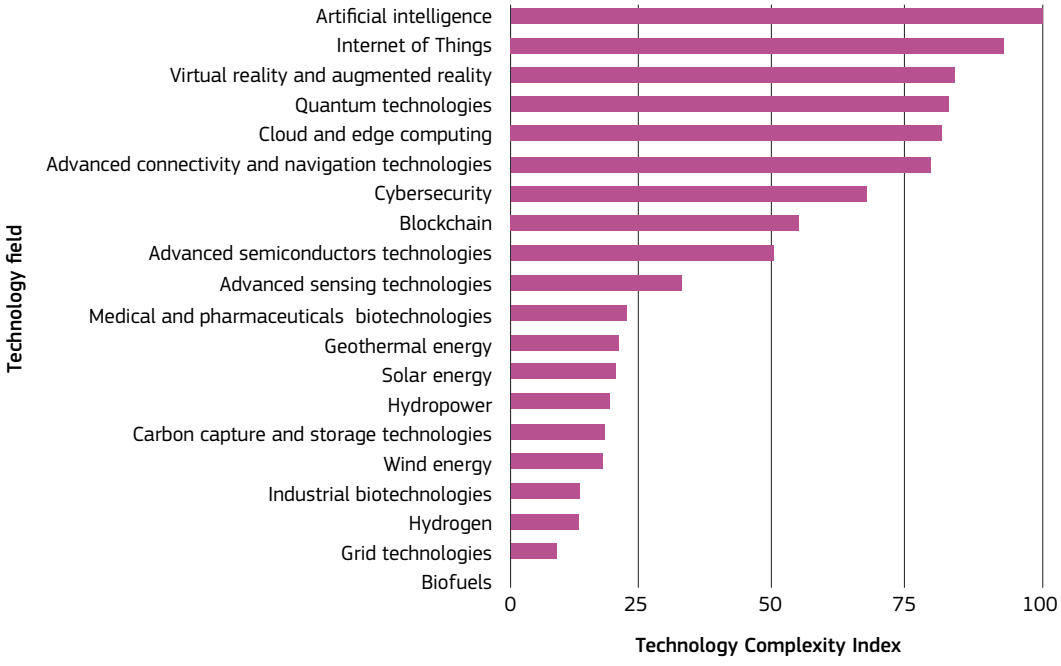
Science, Research and Innovation Performance of the EU 2026

Source: JRC SETIS (March 2026), based on PATSTAT.

As global dynamics evolve, strengthening the EU's technological capabilities in key sectors remains important to support long-term resilience, competitiveness and economic well-being. The current geopolitical backdrop has led to a shift in policy priorities, from efficiency to resilience, strategic autonomy and economic security (European Commission, 2024). At the same time, profound technological changes add to the intensity of the increasing global competition, bringing to the fore those technologies with the greatest potential to transform production systems, markets and value chains.

Within this context, complex technologies are set to play a prominent role in determining both economic competitiveness and geopolitical strength. These technologies rely on advanced scientific knowledge, significant capital investment, and highly interconnected ecosystems of skills, infrastructure and supply chains. They can deliver substantial productivity gains and influence economic competitiveness and geopolitical standing (see box 4.1-1 for more information on the use of complexity indicators in research and innovation (R&I) policy). This is particularly relevant for digital technologies, including AI, cloud and edge computing, cybersecurity, quantum technologies, blockchain and advanced semiconductors, which stand out as highly complex technology areas (Figure 4.1-5) and, as such, are characterised by the highest growth potential (WIPO, 2026). Being able to secure leadership in these technology fields is key to enhance competitiveness and foster growth, enabling countries to gain a competitive edge on their competitors and secure their position in critical global supply chains.

Figure 4.1-5 The complexity of selected critical technologies, 2019–2023



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on PATSTAT (2025; as of December).

Note: On the y-axis, technologies are ranked by Technology Complexity Index (TCI), which measures complexity at the technology level, normalised between 0 and 100.

Box 4.1-1 Complexity metrics for R&I policy

Benoit, F., Di Girolamo, V., Diodato, D., Canton, E. and Ravet, J. (2025). 'Enhancing EU Policy Through Complexity Metrics: A new lens for research and innovation', *fteval Journal for Research and Technology Policy Evaluation*, (57), e10.

R&I policy has shifted from a broad, sector-wide focus to a more targeted, challenge-driven approach. This shift requires some reflection on the indicators used to inform policy-decisions. Traditional innovation indicators often entail the use of simple output indicators due to the ease of understanding, monitoring and communication. However, they often treat outputs as equal and are unable to capture differences in quality or technological sophistication. The new shift in policy focus calls for more nuanced metrics that can better reflect the context of innovation.

To address these limitations, policymakers are increasingly combining traditional metrics with quality-focused and context-sensitive indicators. Complexity metrics can add another layer to these efforts by examining not only what an economy produces, but how innovations are embedded within broader technological and capability networks. Rather than counting outputs, complexity metrics identify the structure of relationships across technologies, assess how well-equipped regions are to absorb new knowledge and highlight development pathways that build on existing strengths. This allows policymakers to distinguish between more and less feasible options based on where existing capabilities offer clear advantages and stronger prospects for successful innovation allowing for better resource allocation.

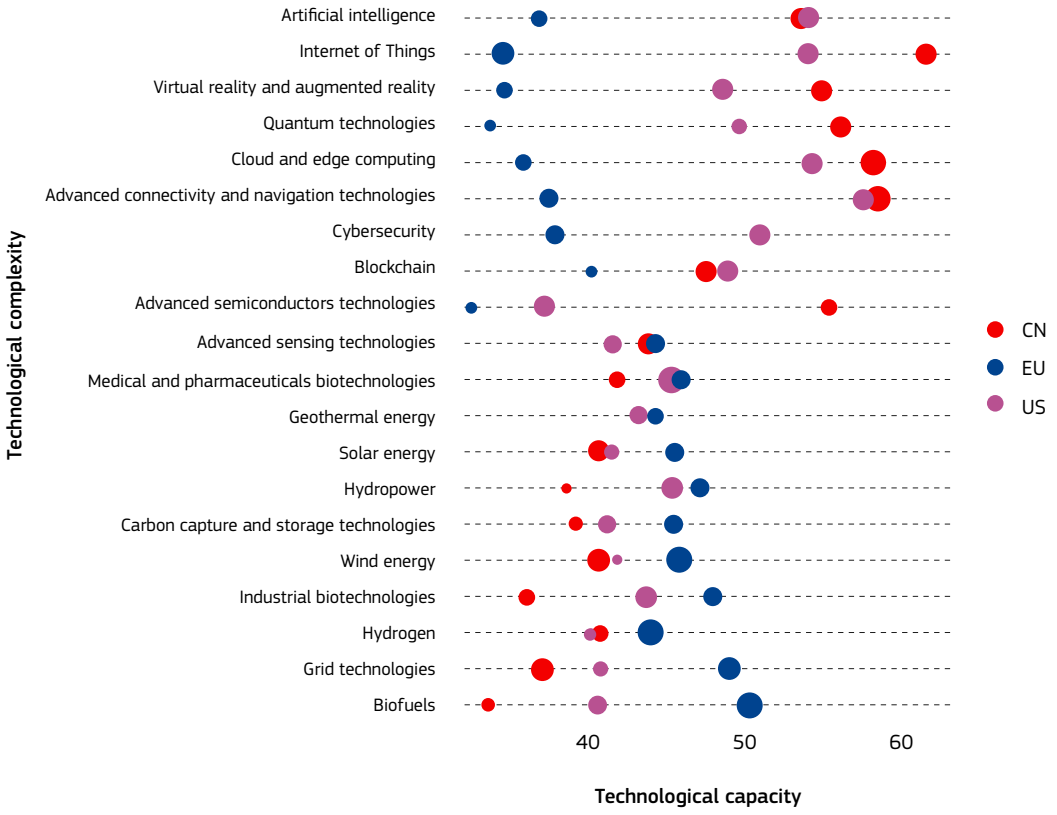
Beyond identifying promising opportunities, complexity metrics provide a forward-looking perspective that can help policymakers understand how innovation systems evolve over time. By mapping how technologies and capabilities are interconnected, they highlight which transitions into new or emerging technological areas are most realistic based on existing strengths. This is particularly valuable for long-term strategic planning, as it supports the design of interventions that align with regional capabilities, guide investment in skills and infrastructure, and encourage collaborations needed to develop or adopt new technologies. Complexity tools also enable continuous monitoring, allowing strategies to adjust as technological landscapes and economic conditions change.

The technological gap between the EU and other global innovators remains significant in many strategic sectors. In particular, the US currently leads both the EU and China across major critical and emerging technology sectors, such as AI, biotechnologies and quantum computing. This is mostly due to the US's uniquely decentralised innovation ecosystem, significant economic resources and diverse research talent, which enable the rapid scaling and deployment of ideas and breakthrough innovations (Rosenbach *et al.*, 2025). Nevertheless, competition from China is increasing, whereas the EU keeps reporting a lower degree of specialisation in the most complex digital areas (Figure 4.1-6).

The EU lags behind both the US and China not only in terms of current specialisation, but also when looking at future diversification potential in these strategic fields. The EU's ability to acquire specialisation in highly sophisticated digital technologies, including AI, Internet of Things (IoT), cloud and edge computing, and advanced semiconductors technologies, remains low (Figure 4.1-6). This signals that the EU's ability to build up capacity in more sophisticated technologies (see chapter 10 for more details on how to assess technological potential) vis-à-vis its main competitors remains weaker in critical digital fields.

Nevertheless, the EU retains some strengths in net-zero technologies. The EU shows comparatively strong technological capabilities in areas related to wind energy, solar and grid technologies, hydrogen, carbon capture and storage technologies, and biofuels

Figure 4.1-6 The EU positioning in selected critical technologies vs the US and China, 2019–2023



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on PATSTAT (2025; as of December).

Note: The x-axis indicates the relatedness density in any of the technology fields considered. On the y-axis, technologies are ranked by complexity levels as captured by the Technology Complexity Index (TCI), normalised between 0 and 100. The size of the bubble captures the degree of specialisation that each country reports in a given technology field, as measured by the revealed comparative advantage (RCA). Relatedness density for the EU is calculated as the population-weighted average of the EU Member States.

(Figure 4.1-6). These are fields where the EU shows both high patent activities and future technological potential for sustained competitiveness. Other areas in which the EU shows potential for technological development include industrial biotechnologies, geothermal energy and hydropower.

Furthermore, the EU also shows technological potential in nuclear energy technologies but faces more structural capability gaps in battery technologies. The EU reports a relatively strong technological potential also for technologies related to nuclear energy, indicating that, despite relatively lower current patenting activities in this area, the EU is well positioned to be able to strengthen its innovation performance with targeted support. Nevertheless, Europe lags significantly behind other global leaders in battery energy storage systems (BESS), both in terms of current specialisation and technological potential for future diversification (Albora *et al.*, 2025). This raises concerns about the sustainability of Europe's competitive position in the field.

To strengthen the EU's global competitiveness and achieve technological sovereignty and strategic autonomy, it is critical to prioritise investments in strategic areas. To do so, policy actions need to simultaneously select the right technologies and the right places where to redirect financing resources. In this regard, understanding how critical technologies connect and relate to one another remains key to identifying technology areas that build on similar knowledge, thereby providing important insights into how easy it would be for a country or region to leverage its existing innovation capabilities to move and diversify into new technology fields (box 4.1-2; European Commission, 2022).

Understanding the extent to which a country can influence[2] and shape subsequent innovation elsewhere is also critical to technological sovereignty, as it allows for gathering insights into the ability to steer technological development in other geographical regions. In this regard, the US remains the world's technological superpower, exerting significant influence in shaping innovation trajectories in other regions. On the contrary, despite the remarkable improvements in its innovation performance over time, China remains less influential internationally, as its technologies are cited less frequently by foreign actors (relative to established leaders). As regards other key global innovators, Japan shows a gradual decline in influence over time, while South Korea maintains a stable and relatively strong position despite a smaller patent portfolio (Mueller and Boeing, 2024).

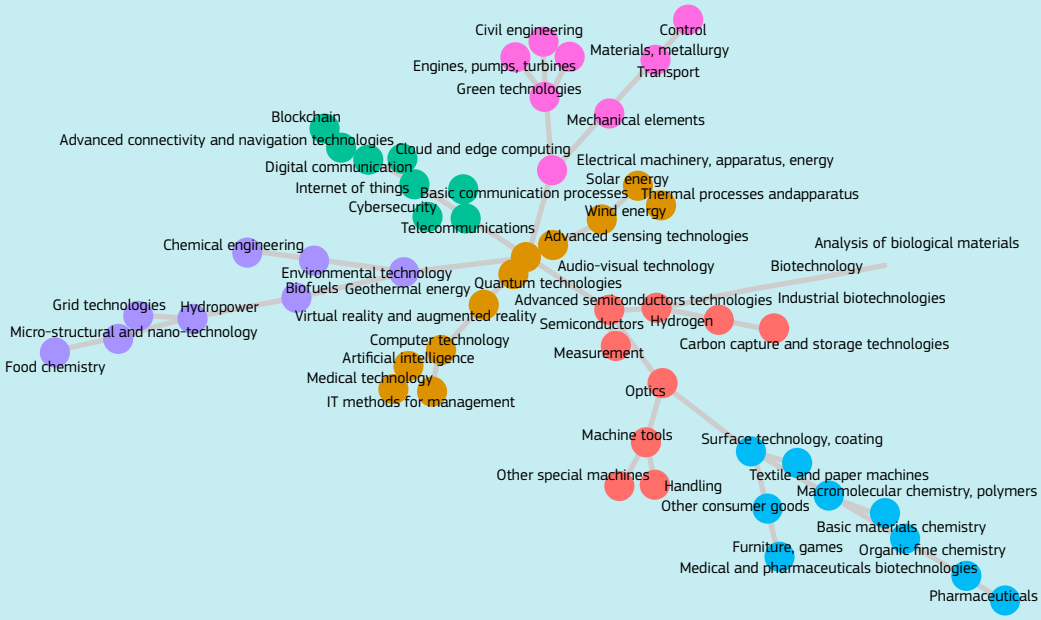
Europe also exerts significant international influence, but trails behind the US. A substantial two-way citation flow exists between Europe and US patents, suggesting a strong and reciprocal integration between the two systems. Nevertheless, Europe also shows bilateral dependence on other big innovators, such as Japan and South Korea. In contrast, Europe's influence on Chinese inventions remains strong in terms of forward patent citations (Mueller and Boeing, 2024).

2 In this context, technological influence reflects who controls and owns the knowledge that shapes subsequent innovation.

Box 4.1-2 The technological space of selected critical technologies

Technologies are not developed in a vacuum, but rather require a specific set of skills, resources and infrastructure. For these reasons, technologies tend to cluster into groups that rely on similar underlying capabilities. As an example, digital technologies such as AI, cloud computing, cybersecurity and the IoT form a closely interconnected cluster, suggesting strong synergies and opportunities for joint development (Figure 4.1-7). Energy-related technologies such as geothermal energy and grid technologies form another cluster within the broader category of environmental technologies. Advanced semiconductors occupy a bridging position in the technology space. This reflects their critical role as enabling technologies across digital, energy and manufacturing areas, further confirming their strategic importance for technological sovereignty and competitiveness, as progress in this field can support innovation across a wide range of other priority sectors.

Figure 4.1-7 The technological space of selected critical technologies



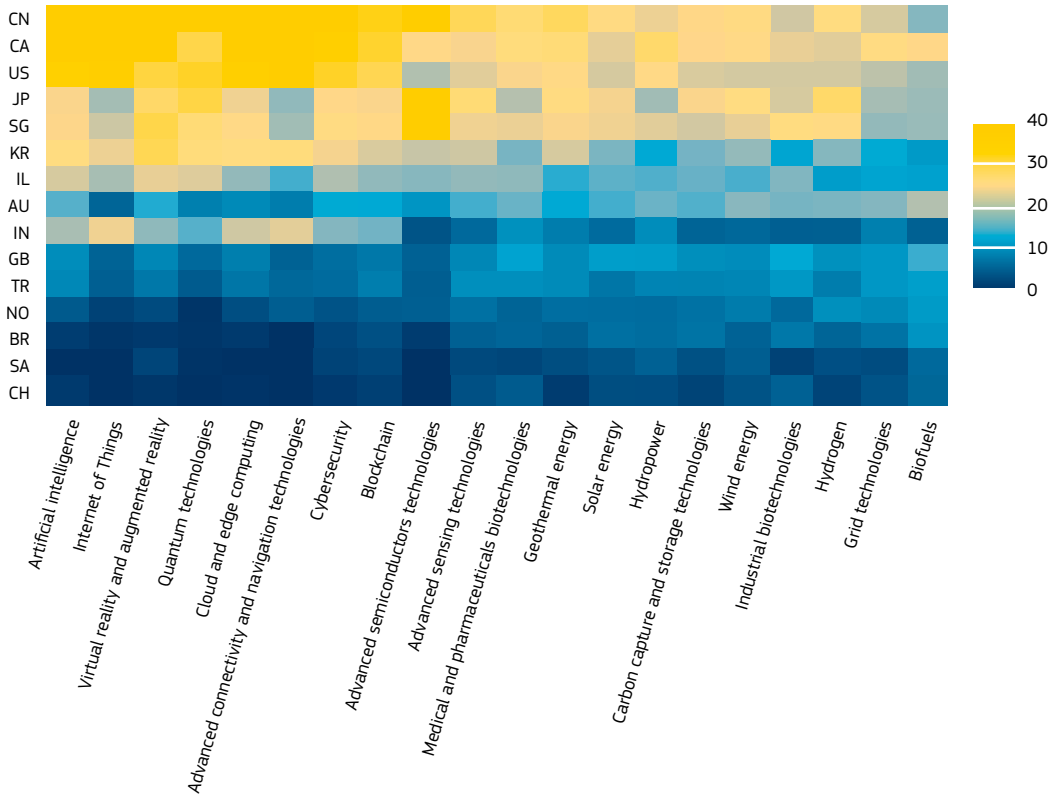
Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on PATSTAT (2025; as of December).

Note: The network is based on a technological proximity matrix derived from the co-occurrence of technologies. Technologies that frequently appear together in the same location are considered closely related, reflecting shared knowledge bases and innovation capabilities. For visual clarity, the network is displayed using a maximum spanning tree, which preserves the strongest connections between technologies while reducing visual complexity. Technology clusters are identified using the Louvain community detection algorithm, highlighting groups of technologies that are more closely interconnected.

The risk for the EU to remain technologically dependent on other global players needs to be balanced against its long-standing commitment to openness and international cooperation in R&I. While the EU has long prioritised openness and international collaboration in science and technology, a natural tension exists between the priority of safeguarding the EU's technological sovereignty and fostering international R&I cooperation (European Commission, 2024). Figure 4.1-8 maps the EU's technological complementarities (i.e. to what extent non-EU countries can complement the EU's technological deficiencies in different technology fields) for a selected set of strategic technological areas. Countries such as China, the US, Japan and South Korea show high complementarity with the EU across the most complex digital fields, e.g., AI, cloud and edge computing, advanced semiconductors and cybersecurity. Interestingly, other countries such as Canada, Singapore and India also show significant complementarities with the EU across these critical technologies, indicating a wider scope for diversification of international partnerships in these domains. The EU's technological complementarities with

Figure 4.1-8 The EU's technological complementarities in selected critical technologies, 2019–2023



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on PATSTAT (2025; as of December).

Note: On the x-axis, technologies are ordered according to the degree of technology complexity (TCI index). The y-axis reports the top 15 countries by total number of PCT patent applications filed and geolocalised based on the inventors' addresses. Countries are ranked according to the average relatedness density added, here used to capture technological complementarities based on Balland and Boschma (2021).

other global innovators are lower for medical and pharmaceutical biotechnologies and industrial biotechnologies. Complementarities with the US and China also remain strong in some energy-related fields such as grid technologies, hydrogen, carbon capture and storage, but appear uneven and relatively lower in other areas (Figure 4.1-8).

2. Supply chain dependencies and their implications for the EU's technological sovereignty

Technological leadership and sovereignty in the modern economy

Today, technological leadership depends not only on knowledge creation but also on the ability to control production capacities and critical supply chains. The ability to develop, produce and deploy advanced technologies is essential for economic and social prosperity and for maintaining global influence. Having the ability to produce this type of technology in-house limits sovereignty risks, while reliance on external partners can create vulnerabilities, both through supply restrictions and slower access to innovation (Aghion *et al.*, 2023). These concerns have brought industrial policy back to the centre of the policy debate as a tool to better align technological capabilities with domestic production (European Commission, 2024).

Technological sovereignty reflects the capacity of economies to shape the development and strategic use of critical technologies. Technology-gap trade models show that international trade patterns reflect differences in technological knowledge embedded in production, with large gaps giving leading economies significant advantages. As a result, comparative advantages in strategic technologies are increasingly tied with the ability to produce critical tradable goods (Aghion *et al.*, 2023). This is particularly relevant in sectors such as raw materials and key decarbonisation technologies, where limited substitutability and high market concentration increase the risk of structural dependencies. These dependencies can carry long-term implications for Europe's innovation capacity, as reliance on external providers for strategic technologies could limit the EU's ability to shape technological trajectories and develop embedded know-how, potentially locking the EU into an 'adopter' role rather than a developer of core technologies.

Geopolitical tensions amplify these risks, raising the likelihood that export restrictions, tariffs and supply disruptions will directly affect technological deployment and industrial competitiveness. International cooperation in areas such as trade, technology and research has become more challenging. This challenge is further compounded by the need to address pressing issues such as climate change, the transition towards more carbon-neutral economies and heightened defence priorities (see chapter 4.3). Achieving these policy objectives requires balancing openness with the risks associated with structural trade and technological dependencies (Guarascio *et al.*, 2025).

In this regard, Europe's growing technological dependence has emerged as a structural vulnerability that mirrors the firm-level exposure in increasingly complex supply chains. As supply chains have become more complex, risks increasingly extend beyond the physical movement of goods to questions of who controls, owns and governs the critical technologies on which the EU economy depends. As production becomes more

technology-intensive, a concentrated supply of key technologies can quickly turn into strategic risks. In this context, technological sovereignty no longer implies full autonomy, but rather maintaining sufficient control over essential technologies or limiting dependence on non-reliable partners (Edler *et al.*, 2020; European Parliament, 2022). Against these considerations, the EU now faces the complex policy challenge of balancing safeguarding technological leadership and supply chain security while maintaining openness to trade.

Integration, trade and supply chain vulnerabilities

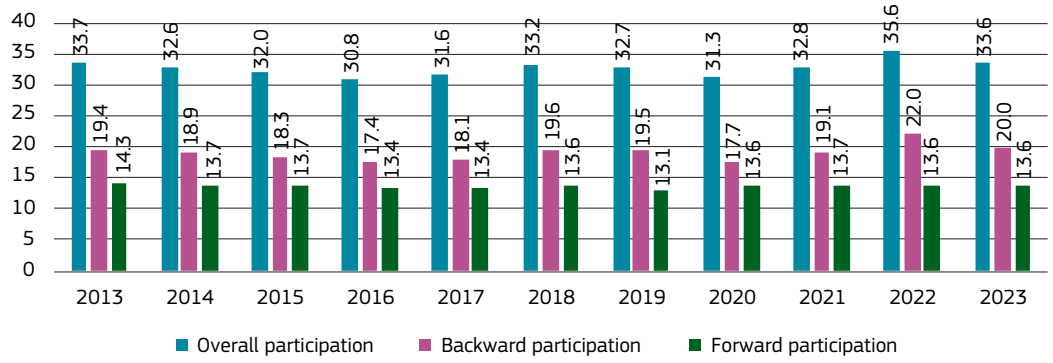
The EU remains a fundamentally open economy driven by open trade policies and strong global partnerships. Total external trade in the EU accounted for 45% of its GDP in 2024, which is considerably higher than the 25% and 37% reported for the US and China, respectively (EIB, 2025). On average, a firm within Europe is directly connected to 30 to 50 suppliers and customers (Bacilieri, 2023), depending on its size. This openness reflects the EU's long-standing integration into global value chains (GVCs), which has allowed firms to specialise, source inputs efficiently and produce components across multiple locations (Alfaro and Chor, 2023).

Nevertheless, the COVID-19 pandemic, the Russian invasion of Ukraine, the energy crisis and rising geopolitical tensions have highlighted existing structural vulnerabilities in EU supply chains and challenged assumptions around global trade governance (European Commission, 2024). The EU economy's structure, anchored in advanced manufacturing and high-value services, makes it particularly sensitive to shifts in global trade conditions.[3] EU firms have been found to be widely exposed to trade tensions, even to the extent that companies not engaging in import activities report being affected by limited access to raw materials or disruptions in logistics (EIB, 2025), thereby illustrating how interconnected and interdependent EU production networks have become.

The EU's integration in GVCs has remained stable, yet its dependence on foreign inputs has gradually increased over time. Over the past decade, overall GVC participation by the EU, captured by its involvement in cross-border production, has consistently hovered around one-third of its exports, confirming that the EU continues to rely heavily on cross-border production links (Figure 4.1-9). However, over time, the EU has become more reliant on foreign inputs (backward participation), whereas other countries' reliance on EU inputs (forward participation) has remained roughly the same.

3 Typically, these activities are tightly integrated into cross-border value chains and depend heavily on imported intermediates as well as on foreign demand. Disruptions to cross-border trade (e.g. from tariffs or supply chain bottlenecks) can therefore rapidly affect output, costs and export performance in these industries.

Figure 4.1-9 Global value chain participation as a % of EU gross exports



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Eurostat (DOI link: https://doi.org/10.2908/NAIO_10_FGGVCE).

Note: Backward participation is calculated as a share of foreign (non-EU) value added in EU exports, i.e., how much of EU exports comes from inputs produced outside the EU. Forward participation is calculated as the domestic value added generated in the EU by non-EU economies' exports, measured as a share of EU exports.

The EU is dependent[4] on imports from foreign suppliers for a wide range of critical products. The EU currently faces foreign dependencies in critical sectors like green transition, health and pharmaceuticals and digital technologies, for 204 products. China is the main import source for 64 products, the US for 38 and Russia for 15. Among the range of dependent products, nearly 20% are at high risk of being subject to Single Points of Failure (SPOFs), i.e., products where global production is concentrated in only a few countries central to global trade networks (Arjona *et al.*, 2023).

Overall, the EU remains more vulnerable to external trade shocks compared to China and less vulnerable than the US across strategically important industrial products, but exposure varies across sectors. The mapping of four strategic supply chains (Table 4.1-1) shows that the EU's exposure is highest in raw materials, followed by semiconductors and net-zero technologies. Across all three of these strategic supply chains, the EU is more exposed than China. In semiconductors, the EU is also more exposed than the US. Encouragingly, vulnerability levels have remained broadly stable, with some improvement for raw materials (Connell-Garcia and Ho, 2025).

Sectoral dependencies and strategic implications

In particular, the EU suffers from important dependencies in the semiconductors industry but retains some strengths in the semiconductor equipment segment. Semiconductor manufacturing is characterised by very strong economies of scale, requiring significant capital injection, specialised knowledge and talent. As such, the manufacturing capacity of this industry appears to be highly concentrated. Europe consumes around 20% of global microchips but produces only about 10%, and remains highly dependent on external suppliers for both advanced chips and critical inputs, including rare earths and materials such as gallium and germanium, most of which are refined in China. The EU also relies heavily on Asian firms, particularly Taiwan's TSMC, which alone accounts for over

4 A product is considered foreign-dependent when three conditions are met: most extra-EU imports originate in fewer than three foreign countries, extra-EU imports represent at least half of intra-EU imports, and extra-EU imports exceed total EU exports (Arjona *et al.*, 2023).

Table 4.1-1 External Vulnerability Index (EXVI) across four strategic supply chains for the EU, US and China

	Strategically important industrial products	Semiconductors	Net-zero technologies	Raw materials
EU	0.20	0.23	0.17	0.30
US	0.28	0.20	0.29	0.31
China	0.11	0.18	0.09	0.22

Science, Research and Innovation Performance of the EU 2026.

Source: DG GROW, Chief Economist Team based on BACI (202601 version).

Note: EXVI scores: the index assesses vulnerability on a scale from 0 (low risk) to 1 (high risk), considering trade dependencies, competitive positions and sensitivity to external shocks. Strategically important industrial products broadly include semiconductors, net-zero technologies, raw materials, basic metals, chemicals, machinery and motor vehicles.

50% of global semiconductor production and nearly 90% of the most advanced chips (European Commission, 2024). Despite these vulnerabilities, Europe retains important strengths in semiconductor equipment, accounting for around 25% of the global market, led by firms such as ASML, whose extreme ultraviolet (EUV) lithography machines are essential for advanced chip manufacturing (CEPS, 2025).

As concerns clean technologies, the EU's strong innovation capabilities are not matched by a similar manufacturing capacity. The supply of clean technologies remains highly concentrated. As an example, around 90% of the manufacturing capacity of solar PV wafers and batteries is located in the Asia-Pacific (APAC) region (Draghi, 2024). Among the critical technologies targeted by the EU's policy agenda, batteries and electric vehicles (EVs) play an important role, accounting for two-thirds of the global clean technology market in 2023 (Jugé *et al.*, 2025). Europe's manufacturing capacity in these segments has significantly improved over the past few years, but it remains structurally dependent on non-EU producers, especially in the battery industry. Specifically, the EU's battery manufacturing capacity strongly relies on foreign direct investment, especially from South Korea, home of LG Energy, SK Innovation and Samsung SDI, which account for four-fifths of operational battery cell manufacturing capacity in Europe (Jugé *et al.*, 2025).

Digital technologies and infrastructures represent another area of deep dependency, with around 80% of digital infrastructure and technologies imported from abroad, raising operational, security and legal concerns. One of the most visible examples of this dependence is the heavy reliance of EU consumers, businesses and even governments on US-developed software, social media platforms and data centres (CEPS, 2025). In particular, the US dominates the cloud computing landscape, with Amazon, Microsoft and Google accounting for more than 60% of the European market, whereas Europe's largest cloud operator holds only 2% (Draghi, 2024). Additionally, most data from Western Europe is stored in US-owned infrastructure. This creates operational dependence and legal exposure, as US extraterritorial laws allow access to data handled by US companies, even when stored in Europe (European Parliament, 2025).

The observed digital dependence stems from deep structural factors rooted in its post-war development path and the fragmented nature of its innovation ecosystem. While Europe focused on rebuilding

traditional industries (see chapter 2.1), the US and later China invested heavily in the research, scale and strategic direction needed to drive technological revolutions. Europe's diversity of languages, regulations and national policies made it much more difficult for emerging tech firms to grow beyond their home countries (see chapter 6.2). Paired with an innovation culture that often favours incremental progress over high-risk, disruptive advances, these systemic frictions have constrained the EU's capacity to build globally competitive digital technology companies.

The EU also suffers from severe dependency on international peers in AI technologies. The risk for Europe to remain fully dependent on AI models designed and developed in third countries remains very high for both general-purpose AI and vertical uses dedicated to crucial EU sectors, such as automotive, banking, telecoms, health, mobility and retail industries (Draghi, 2024). The EU's competitive position in this technology is hindered by several factors, including significantly lower levels of private investment available to European companies and the massive brain drain of AI talent, which favours Europe's main competitors, mostly the US (see chapter 7).

This weak position in developing AI will likely have important implications for the EU's competitiveness in several adjacent sectors. Given the pervasive nature of AI technologies, the EU risks seeing its competitive advantage weakened in several industrial sectors that are significantly impacted by the digital transition, such as the automotive industry, robotics and advanced manufacturing. As an example, European performance in the robotic industry has been particularly strong in the last decade, allowing the EU to position itself as second largest market in 2021, after China. The introduction of AI-controlled capabilities is set to further expand the EU's service robot market, with an expected company annual growth rate (CAGR) of 14% by 2026. Nevertheless, the persistence of a weak AI ecosystem vis-à-vis that of its main competitors represents a key challenge for Europe to address in order to reap the full benefit from the digitalisation process and reduce the risk of losing its current leadership in key industrial segments, such as advanced manufacturing (Draghi, 2024).

Export dependencies represent another key dimension of the EU's external vulnerabilities. Both China and the US have at times used trade measures to exert economic pressure (e.g., McCaffrey and Poitiers, 2024). China, for example, has threatened to limit imports of Spanish pork and French cognac[5] in response to EU countervailing duties on Chinese electric vehicles[6]. While these actions are not macroeconomically significant, they show how trade restrictions can serve as political leverage. Similarly, the US has imposed tariffs on EU steel, aluminium and aircraft products, demonstrating that even major trading partners can reshape trade flows and affect competitiveness. The potential for expanded US tariffs remains a significant concern, given that the US is the EU's largest export destination.

In addition to building domestic capacities, maintaining reliable trade relations and diversified supply chains is central to the EU's economic strategy. Firms across the EU have adapted by shifting imports away from countries with which the EU has no trade agreements and toward EU partners or other reliable suppliers (Arjona *et al.*, 2024). Companies are also investing in digital tools to monitor supply chains, increasing inventories of key inputs, and sharing risks with partners. These steps help them detect emerging problems earlier and respond faster (EIB, 2024).

5 https://www.reuters.com/world/asia-pacific/china-cuts-eu-pork-tariffs-final-ruling-2025-12-16/
6 EU Implementing Regulation 2024/2754

3. The EU is deploying several policy initiatives to close strategic technological gaps

The EU's Competitiveness Compass identifies clear policy objectives that aim to contribute to closing the gap in strategic technologies between the EU and its main international peers. The EU's weaker performance in critical technologies has profound implications in terms of economic growth. The latter is typically the result of the combination of the benefits of disruptive innovations brought about by a dynamic entrepreneurial ecosystem (see chapter 5.2) and the efficiency gains from the application of these technologies in more mature industrial sectors (Draghi, 2024). These two forces have been relatively weak in Europe in the last decade, leading to sluggish productivity growth (see chapter 5.1).

Therefore, creating the right conditions to be at the forefront of innovation in critical technology sectors remains essential for both competitiveness and technological sovereignty. In this regard, the European Commission has laid down an ambitious roadmap, with important measures to be deployed across several important technology areas (see chapter 4.3). The sector-specific actions are complemented by a clear agenda to improve the framework conditions for innovation: simplifying the European articulated regulatory system, making the EU more attractive to talent (see chapter 5.3) and improving the functioning of the EU's capital markets (European Commission, 2025b).

In a world where geopolitics and technology are increasingly intertwined, ensuring technological sovereignty and strategic autonomy also has important implications for economic security. Technological capacity has become central to determining a state's ability to exercise economic and strategic power, calling for increasing efforts to integrate security and open strategic autonomy considerations more tightly into economic policies (European Commission, 2025b). These considerations were reflected in the first-ever *Economic Security Strategy* launched by the European Commission in 2023, which emphasised the need to develop a more cohesive and impactful approach to respond to new geopolitical and technological realities (European Commission, 2023b).

After decades centred on horizontal policies, the EU has shifted back towards a more interventionist economic stance. The shocks of recent years have revealed how an economy deeply integrated into GVCs can be vulnerable to external disruptions. Guided by the principle of being 'as open as possible, as closed as necessary', the EU's concept of open strategic autonomy seeks to balance openness to global trade with the strengthening of domestic capacities in key sectors and technologies (European Commission, 2021). This approach underscores that competitiveness and economic security now rely not only on open markets, but also on the strategic capacity to shape and sustain Europe's industrial strengths in a rapidly changing global economy.

In this regard, the EU is deploying concrete initiatives to strengthen resilience in the face of growing external economic threats, while preserving its commitment to open international trade. In December 2025, the European Commission launched its new *Economic Security Strategy*, aiming to reduce the EU's exposure to strategic dependencies and vulnerabilities, prevent the weaponisation of economic interdependence, and strengthen resilience across critical supply chains, technologies and infrastructures (European Commission, 2025c).

This new Communication was accompanied by the launch of the *RESourceEU Action Plan*, which builds on the *Critical Raw Materials Act* and is intended to accelerate and amplify the efforts to secure the EU's supply of critical raw materials for key industrial sectors, thereby protecting EU value chains from supply disruptions (European Commission, 2025d).

The EU is also remaining active through initiatives that target the EU's dependence on critical enabling technologies. On 3 June 2026, the European Commission proposed its new *European Technological Sovereignty Package*, which marks a change in Europe's approach to its tech ecosystems and it aims to bolster the EU's digital autonomy. The package puts forward a comprehensive strategy to achieve (digital) technological sovereignty, revolving around interconnected and mutually reinforcing policy initiatives that target each stage of the value chain, from chips, to infrastructure, to software, cloud and AI, and in synergy with past and ongoing initiatives such as AI Factories and AI Gigafactories[7]. As an example, the *European Chips Act 2.0*[8] is central to this effort, addressing vulnerabilities in highly concentrated global semiconductor value chains through coordinated investment, innovation support and enhanced crisis-preparedness mechanisms. These actions are complemented by wider efforts to strengthen digital capacities, including support for key technologies such as advanced computing and AI infrastructure (see chapter 7).

A second cluster of initiatives focuses on reducing dependencies in energy- and resource-intensive value chains that underline industrial competitiveness. The *Clean Industrial Deal*, launched in February 2025, aims to scale up clean technologies, support energy-intensive industries and embed circularity across industrial ecosystems (European Commission, 2025e). *The Net Zero Industry Act* creates conditions supporting an increase of the EU's clean technologies manufacturing capacities. The proposed *Industrial Accelerator Act* aims to boost demand and investment in areas energy-intensive industries, the automotive value chain and cleantech. Complementing these efforts, the EU has also introduced strategies on advanced materials, including the upcoming *Advanced Materials Act*, which will target innovation in high-performance materials for semiconductors, batteries and aerospace through dedicated R&I funding and public-private partnerships (European Commission, 2025b). In addition, the Commission also launched the *European Chemicals Industry Action Plan* to strengthen the competitiveness and resilience of the sector, by addressing key challenges (like high energy costs, unfair global competition, and weak demand) and promoting investment in innovation and sustainability.

A third set of initiatives addresses structural and future dependencies by strengthening Europe's capabilities in advanced and emerging technologies. This approach is embodied in strategies such as the *EU Quantum Strategy*, which seeks to build domestic capacity in quantum research, infrastructure, skills and pilot manufacturing, reducing the risk of future technological lock-ins (European Commission, 2025f).

7 https://digital-strategy.ec.europa.eu/en/library/communication-european-tech-sovereignty-accompanied-eu-open-source-strategy

8 Regulation (EU) 2023/1781.

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CHAPTER 4.2

KNOWLEDGE VALORISATION AND TECH DEPLOYMENT

Haya Al-Ajlani, Bianca Cavicchi

KEY QUESTIONS

- What progress has the EU made in translating innovation into economic benefits?
- What are the key factors constraining knowledge valorisation in the EU?
- To what extent does Europe's upstream innovation strength translate to deployment?

HIGHLIGHTS

- Over the past decade, the EU's innovation output has increased by close to 10 %, yet this progress has not been sufficient to close the gap with leading innovation systems.
- Universities account for a relatively larger share of patented innovation in central and eastern Europe.
- Patenting activity is concentrated in a limited number of universities, particularly in France and Germany, reflecting the presence of research-intensive institutions with substantial patent portfolios.
- The generation of academic patents is closely linked to the strength of regional innovation ecosystems, including the presence of industrial partners and technology transfer infrastructures.
- Collaboration between industry and research organisations remains predominantly national, with cross-border linkages comparatively limited.
- EU deployment signals remain uneven, with the clearest overlap between firm growth and economic weight in medium-high-tech manufacturing.
- The final-demand profile of EU production is broader, combining knowledge-intensive services with selected manufacturing strengths, including pharmaceuticals, machinery, automotive and food.

POLICY INSIGHTS

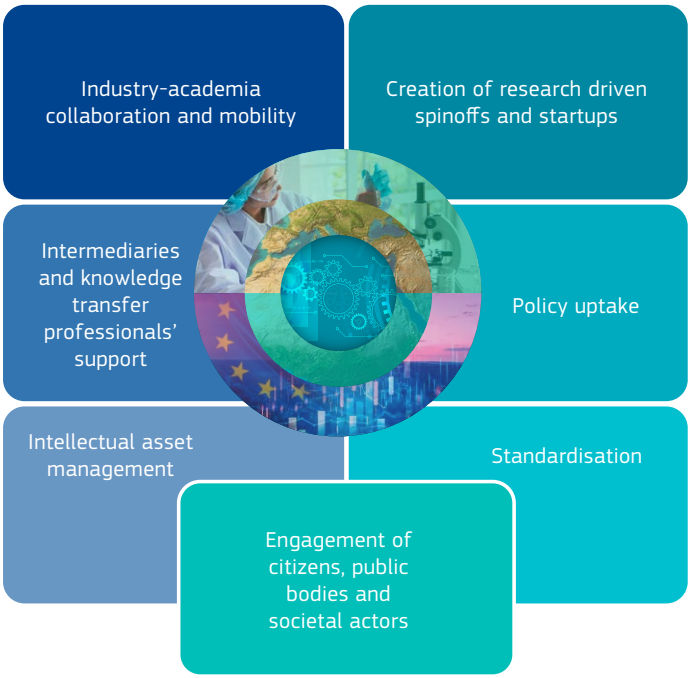
- The EU's competitiveness agenda puts stronger emphasis on closing the innovation gap by improving the translation of research results into market uptake and wider deployment, alongside maintaining scientific excellence.
- The European single market dimension remains important for knowledge valorisation, as cross-border industry–science collaboration is still limited and may constrain the scaleup of solutions across Europe.
- The EU's knowledge valorisation framework provides a basis for action across the research and innovation (R&I) system, as uneven valorisation outcomes across countries, institutions and sectors continue to shape overall performance.
- Strengthening Europe's deployment capacity has become central to competitiveness and strategic autonomy, as bottlenecks at the transition from research to scaleup and from scaleup to industrial uptake can delay the impact of R&I investments.

Strengthening Europe's competitiveness and resilience requires coupling excellent science with the translation of knowledge into deployable technologies, creating economic and social benefits to society. Knowledge valorisation (the process of creating social and economic value from knowledge) and technology deployment are therefore two closely interconnected priorities for the EU (European Commission, 2022).

A strong knowledge valorisation process is a requisite for fostering technology deployment. Knowledge valorisation entails connecting different areas and sectors to transform data, know-how and research results into sustainable products, services, solutions and knowledge-based policies that benefit society (European Commission, 2022).

Effective knowledge valorisation requires coordinated engagement of different actors across various channels. This includes the creation of spinoffs and startups, the mobilisation of intermediaries and knowledge transfer professionals, efficient management of intellectual assets, standardisation, the involvement of citizens and local communities, and knowledge dissemination and policy uptake mechanisms (Figure 4.2-1).

Figure 4.2-1 Channels for knowledge valorisation



Science, Research and Innovation Performance of the EU 2026

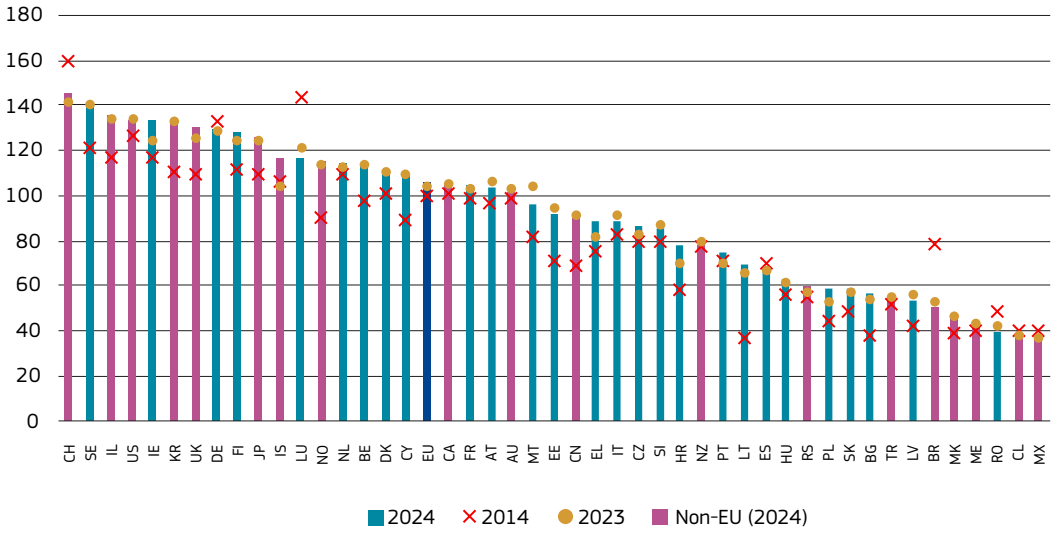
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Council of the European Union (2022).

Monitoring the process of knowledge valorisation is inherently complex. By construction, knowledge valorisation is a multi-channel, multi-actor and multi-outcome process, meaning that no single dataset or linear sequence of events can fully capture its dynamics (European Commission, 2026). This complexity is further compounded by data limitations, which constrain the ability to comprehensively track valorisation processes. Nevertheless, a set of existing indicators outlined in a new European Commission expert study (2026b) can help assess knowledge valorisation by capturing key dimensions, including the innovation activities of universities and the interactions between academia and industry.

1. Despite progress, the EU continues to lag in translating innovation into economic outcomes

The ability to translate research innovation into economic value is integral to knowledge valorisation, and the EU has strengthened this capacity over the past decade. The EU showed an improvement in innovation output performance, as measured by the Innovation Output Indicator (IOI)[1], of about 9.6% compared to 2014 values (Figure 4.2-2). An improvement in the IOI suggests greater effectiveness in how innovative ideas reach the market, generate knowledge-intensive jobs, and enhance technological capabilities (Bello *et al.*, 2026). The EU's growth level is similar to that of Japan and the UK, and larger than that of the US. On the other hand, South Korea and China depict larger growth rates.

Figure 4.2-2 **Innovation Output Indicator in the EU and selected third countries, 2014, 2023 and 2024**



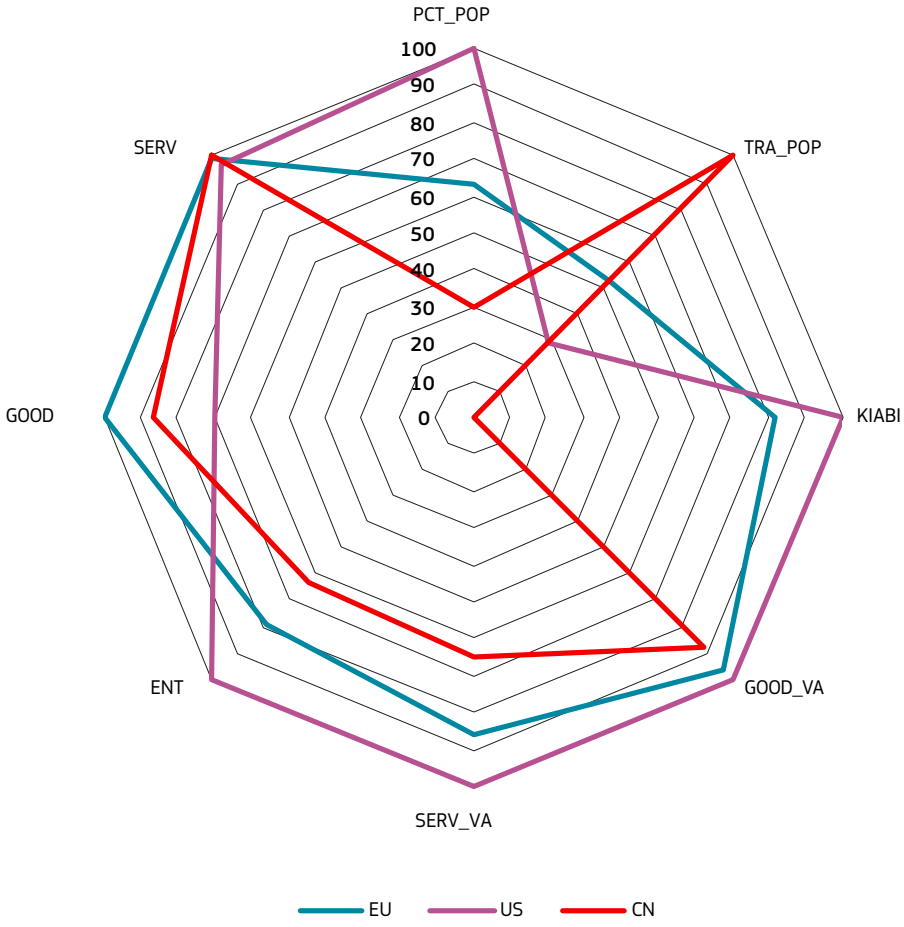
Science, Research and Innovation Performance of the EU 2026

Source: Bello *et al.* (2026).
Note: Scores normalised to the EU-27 score in 2014.

1 The IOI includes a total of six indicators aggregated into four components, including intellectual property (IP), knowledge-intensive activities in business industries (KIABI), domestic technology capacity (TECH_CAP), and innovative-active enterprises (ENT).

Despite this progress in innovation output achieved over the past decade, the EU's performance remains below that of leading global competitors. Switzerland ranks first in the 2024 IOI and has consistently maintained this position in 2014 as well as 2023 (Figure 4.2-2). It leads a group of top-performing innovation systems, including Israel, the US, South Korea, the UK and Japan. The EU ranks below this leading cluster but ahead of a second group comprising Norway, Australia, Canada, China and New Zealand, with relatively small score differences vis-à-vis Canada and Australia. A further set of

Figure 4.2-3 Innovation output components in the EU, US and China, 2024



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Bello *et al.* (2026).
Note: PCT_POP denotes PCT patent application per million population; TRA_POP is trademark classes in total trademark resident applications in direct and Madrid system by origin (equivalent count) per million population; KIABI is the share of employment in knowledge-intensive activities in business industries [%]); GOOD_VA is domestic value added content of medium-high and high-tech manufacturing exports as a share of total manufacturing exports; SERV_VA is domestic value added content of knowledge-intensive service exports as a share of service exports; ENT is innovation-active enterprises as a share of total enterprises (ENT includes product and/or process innovative enterprises, as well as enterprises with only innovation activities); GOOD is the share of medium- and high-tech products in total product exports; and SERV is knowledge-intensive services exports as share of total service exports.

emerging economies, namely, Serbia, North Macedonia, Türkiye, Brazil, Mexico and Chile record lower performance levels.

The EU demonstrates a balanced innovation output profile, with relative strength in knowledge-intensive service exports and medium and high-tech export products. Across the eight indicators of the IOI, none of the three major economies (the EU, the US and China) dominates across all innovation dimensions. The US leads on the more firm-level dimensions such as patent activity, the share of ENT, and knowledge-intensive employment. China's relative performance is strongest in terms of trademark and knowledge-intensive service export share (Figure 4.2-3).

2. Academic patenting is concentrated in specific sectors and in a limited number of countries

Universities and public research organisations (PROs) are a key source of knowledge for industry, generating scientific outputs that can be commercialised. They therefore play an important role in shaping Europe's innovation ecosystems, valorising knowledge and creating value for society.

Universities account for a relatively larger share of patented innovation in central and eastern Europe. Between 2000 and 2020, the total share of academic patents in total European patents filed by domestic applicants is highest in Romania, Hungary, Bulgaria and Estonia, where academic patents account for more than one-third of domestic patenting activity (European Patent Office, 2024).

Patenting universities are clustered in France and Germany, denoting the presence of research-intensive universities with substantial patent portfolios. Considering the total number of universities with a European Patent Office (EPO) application, France and Germany's share exceeds 15 % (European Patent Office, 2024). In Germany, the share of academic patents significantly exceeds the share of patenting universities, pointing to a high concentration of patenting activity in a limited number of institutions. In France, by contrast, the two shares are closely aligned, suggesting a more even distribution of patenting across universities (European Patent Office, 2025).

The generation of academic patents is closely linked with the strength of the regional innovation ecosystems. Universities located in the more industrialised regions of Europe tend to produce more patents, reflecting stronger collaboration opportunities and more developed technology transfer linkages with industry (European Patent Office, 2024). Proximity to industrial partners, access to applied research funding and established commercialisation infrastructures appear to facilitate the translation of scientific outputs into patent applications.

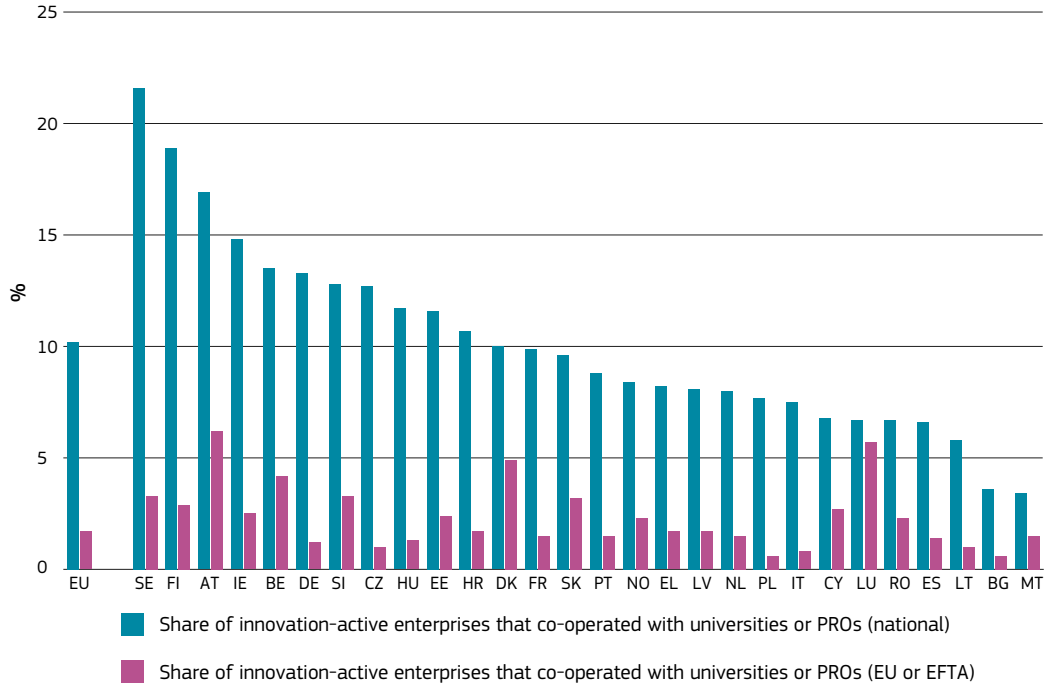
Dedicated policy interventions can help universities and research organisations commercialise their R&I results. Evidence from a 2020 survey conducted by the EPO indicates that failure to progress beyond the development stage is the most frequently cited barrier to exploitation for patented inventions, affecting 71 % of inventions with existing exploitation plans and 46 % of those without (European Patent Office, 2020). Limited commercial opportunities represent the second most common constraint, reported in 55 % of

cases overall, and are particularly prevalent among inventions with exploitation plans (66%, compared with 31 % for those without). Difficulties in identifying suitable partners are also significant, cited by 38 % of respondents, while one quarter mentions resource constraints. Therefore, policy interventions that speed up development pipelines and improve technology transfer matchmaking based on the EC Codes of practice on industry-academia co-creation, intellectual asset management and standardisation would address these types of problems[2].

3. Industry-science linkage remains predominantly concentrated across national borders in the EU

Effective industry-academia collaboration is critical to accelerating the uptake of innovative solutions and to developing new technologies, products and services that address pressing societal challenges, including the green and digital transitions. Strengthening structured cooperation with industry is therefore essential to translate scientific discoveries into market-ready applications and maximise their economic and societal impact.

Figure 4.2-4 Collaboration between industries and academia/research institutions, 2022 or latest available



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Eurostat (DOI links: https://doi.org/10.2908/INN_CIS13_COOP and https://doi.org/10.2908/INN_CIS12_COOP).
Note: Values are ordered by the share of ENT that cooperate with universities or PROs on a national level.

2 http://data.europa.eu/eli/reco/2023/498/oj

Collaboration between industry and research organisations remains predominantly national rather than cross-border in scope. The share of ENT cooperating with universities or PROs within their own country ranges from below 5 % in Malta and Bulgaria to around 20 % in Sweden and Finland, with an EU average of approximately 10 % (Figure 4.2-4). The strongest integration between firms and domestic research institutions is witnessed in Sweden, Finland and Austria exceeding 15 %. Finland, among other Member States, has also launched notable initiatives supporting the link between research and industry (box 4.2-1). By contrast, cross-border cooperation is limited as in most Member States, fewer than 5 % of ENT collaborate with universities or PROs located in other countries, and the EU average stands at around 2 % (Figure 4.2-4). Even in countries with relatively stronger national research–industry linkages such as Finland and Sweden, cross-border collaboration rates remain comparatively low. This gap suggests structural barriers within the European innovation ecosystem that continue to hinder deeper integration (see chapter 6.2).

Universities and PROs primarily collaborate in the context of patenting activities. Universities and PROs exhibit very similar co-application patterns. Around 30 % of universities and PROs direct academic patents involve co-applications with each other (PROs: 30 %; universities: 30.3 %). In addition, both universities and PROs appear as co-applicants with large firms in around 10 % of EP applications (PROs: 9.7 %; universities: 10.5 %) and with small and medium enterprises (SMEs) in 6.1 % and 7.8 % of cases, respectively (European Patent Office, 2025).

Box 4.2-1 Best knowledge valorisation practices

Several initiatives across Europe support knowledge valorisation by strengthening collaboration between research organisations and industry. Notable examples include the Open Discovery Innovation Network (ODIN)[3], a collaboration platform where Danish universities, together with international pharma and biotech companies, co-create open research projects relevant for drug discovery and diagnostics, embedding valorisation from the outset.

In Finland, VTT Launchpad[4] is an in-house business incubator for research-based spin-offs. It focuses on achieving global impact by supporting the creation of investor-ready companies and is built on technologies developed by researchers working at VTT Technical Research Centre of Finland.

Another example of a good knowledge valorisation practice is the Collaborative Laboratories (CoLAB) Network[5], a national initiative in Portugal that institutionalises co-creation between universities, research, organisations, companies, the public sector and social partners. CoLABs foster the development of new local focal points for transdisciplinary R&D activities aimed at creating innovation-oriented jobs and generating economic and social value.

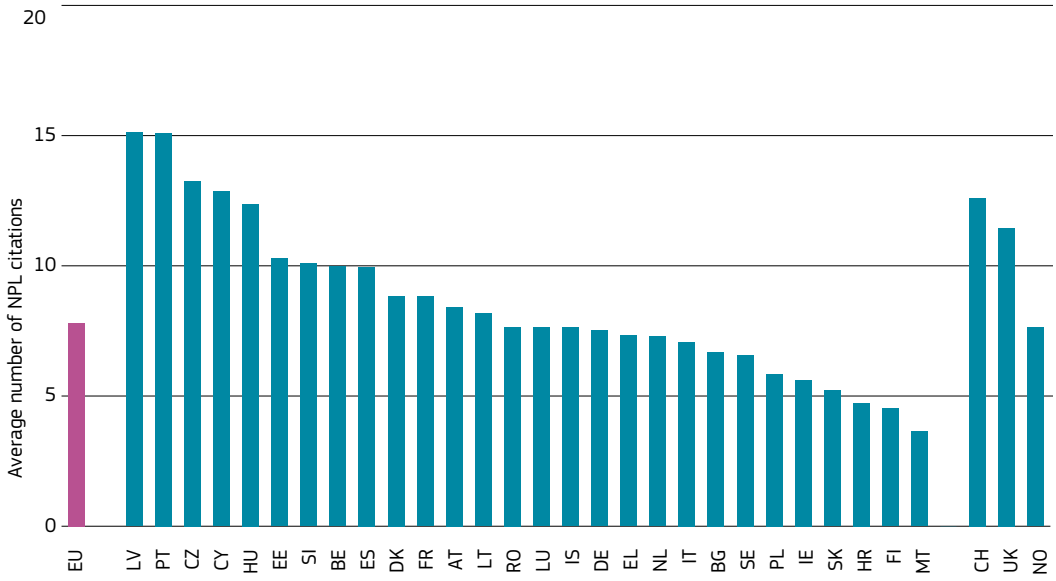
3 https://projects.au.dk/open-odin/

4 https://www.vttresearch.com/en/vtt-launchpad

5 https://ani.pt/en/colab-network/

The integration of scientific knowledge into patented innovation appears to be more pronounced in certain technology fields. In 2020, the average number of non-patent literature citations (NPL) in patent documents at the EPO ranged from 5 to 15 (Figure 4.2-5). The EU average stands at 8 NPL citations, with notable countries above this average being Latvia, Portugal, Czechia, Cyprus, Hungary and the UK. These comparatively higher values are consistent with the technological profile of their patent portfolios. A larger share of their patents is concentrated in science-based fields such as organic fine chemistry, mechanical engineering, biotechnology and pharmaceuticals, where reliance on scientific literature is typically higher. Sectorial concentration of patenting activities is also witnessed across EU enterprises (box 4.2-2).

Figure 4.2-5 Average number of NPL citations for EPO applications, 2020



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

Note: EPO applications based on inventor data.

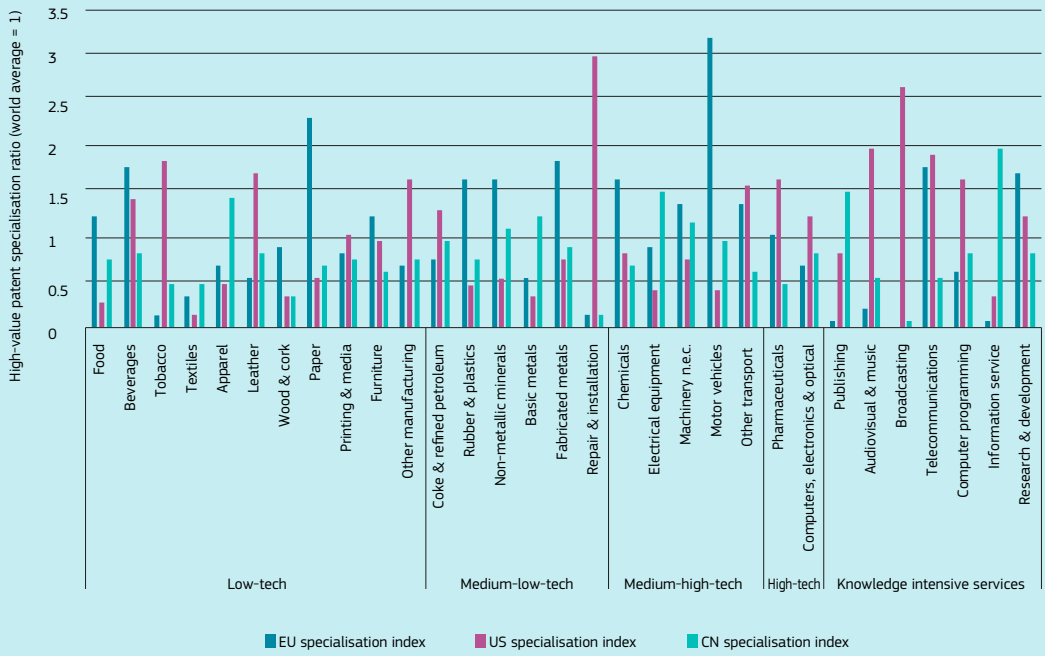
Spinoffs and academic startups can play an important role in the knowledge valorisation ecosystem by providing a pathway for the development of research results into market-oriented applications. They can also contribute to innovation diffusion, regional development and the creation of high-value jobs (European Commission, 2020).

Yet, less than a quarter of European startups have been founded by a PhD holder. Around 16 % of startups in the EU have at least one founder with a PhD, compared with 12 % in the US (Figure 4.2-7). Only a small fraction of these startups combines doctoral-level human capital with patenting activity in both continents, around 6 % or fewer of startups have

Box 4.2-2 Patenting activities across EU sectors

Europe's high-value patenting profile remains more manufacturing-led than that of the US. The EU's stronger relative specialisation is concentrated mainly in medium-high-tech manufacturing and in selected medium-low-tech manufacturing activities, including motor vehicles, machinery, chemicals, other transport equipment, fabricated metals, non-metallic minerals, and rubber and plastics. The US shows a stronger tilt towards knowledge-intensive services and selected high-tech activities, with relatively stronger positions in audiovisual, broadcasting, telecommunications, information services and pharmaceuticals. China shows a broader mixed profile, combining relative specialisation in several manufacturing activities with stronger positions in selected publishing- and information-related services. Overall, the picture suggests a more manufacturing-based specialisation profile in the EU, a more service-oriented profile in the US, and a broader mix in China.

Figure 4.2-6 Relative specialisation in high-value patenting by sector, EU, US and China, cumulative, 2000–2023



Science, Research and Innovation Performance of the EU 2026

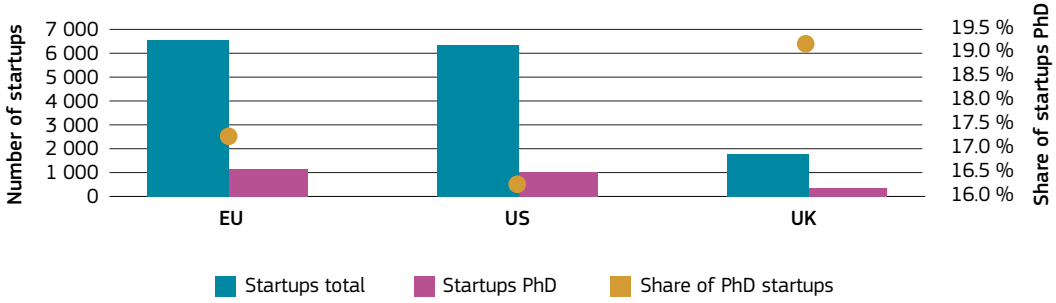
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on PATSTAT.

Note: Sector groupings follow Eurostat technology-intensity and knowledge-intensive services classifications (NACE Rev.2). The specialisation ratio is calculated as the share of a sector in a region's total high-value patents divided by the share of that sector in total world high-value patents. Values above 1 indicate relative specialisation in that sector compared with the world average; values below 1 indicate below-average specialisation.

both at least one PhD founder and at least one patent. This suggests that the translation of advanced scientific skills into patent-protected entrepreneurial outcomes remains constrained.

The integration between academic research and startup patenting also remains limited. Among all identified startups that have filed at least one European patent application, only 27.2 % (around 2 800 firms) have inventors linked to European research institutions, including universities, PROs and research hospitals. France (550), the UK (414) and Germany (398) account for the largest numbers of such patenting startups (European Patent Office, 2025).

Figure 4.2-7 Share of startups with at least one founder holding a PhD, EU, US and UK, 2017–2025



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Dealroom.

Note: Startups are defined, to the extent permitted by the data, in line with Commission Recommendation C(2026) 1800 final (European Commission, 2026a). In this context, a startup is a company employing fewer than 100 people and operating for less than 10 years. The share is calculated as the number of startups founded since 2017 with at least one founder holding a PhD, divided by the total number of startups founded since 2017 with founders from all educational backgrounds. Startups for which information on founders' educational background was unavailable were excluded.

Entrepreneurial activity among researchers is supported by intermediary actors that strengthen linkages between academia and industry. Intermediary entities such as knowledge transfer offices (KTOs) and, technology transfer offices (TTOs) facilitate the commercialisation of research results by supporting the development of solutions, products and services. They act as primary contact points for researchers and firms seeking collaboration opportunities and provide complementary services such as networking, mentoring, coaching and the exchange of best practices to enhance innovation capacity (European Commission, 2024).

Box 4.2-3 Academic entrepreneurship and European research spinouts

Academic entrepreneurship plays an important role in fostering innovation and growth. Scientific discovery is an important driver for long-term economic growth, and universities and PROs are key players in the generation and dissemination of new ideas.

However, translating scientific discoveries into market viable solutions is not an easy task. For scientific research and knowledge to deliver economic impact, it needs to translate into innovations deployable on the market, including product, services, processes or business models that can create societal value (Berger *et al.*, 2026). In this regard, academic entrepreneurship represents an important mechanism for R&I valorisation and deployment.

Academic spinouts[6] have become a central driver of Europe's deep tech and life science innovation economy. They account for 40% of all new deep tech and life sciences startups created in Europe since 2019, reporting an 80% increase compared to the period of 2010 to 2018. Academic spinouts in Europe are mostly concentrated in frontier fields such as quantum, photonics, semiconductors, medical devices, nuclear energy, and AI-driven deep tech. These companies have been very effective in generating economic impact, representing about USD 400 billion in enterprise value, and have contributed to the creation of over 160 000 jobs across more than 7 000 startups (Dealroom, 2025).

The funding ecosystem of European academic spinouts is also improving. Compared to pre-pandemic levels, the funding allocated to European university spinouts in deep tech and life sciences has doubled. As of November 2025, these companies have raised USD 7.9 billion in venture capital (VC) funding, with the largest VC rounds showing a strong focus on AI and autonomy, quantum, space, medical devices and life sciences and nuclear energy (Dealroom, 2025).

Despite the improvements in the academic spinouts' funding ecosystem, challenges persist. Due to their long development cycles and distinct academic imprint, this type of company often appears less appealing to private investors and are more likely than non-academic startups to revert to alternative funding instruments, such as grants and debts (Berger *et al.*, 2026).

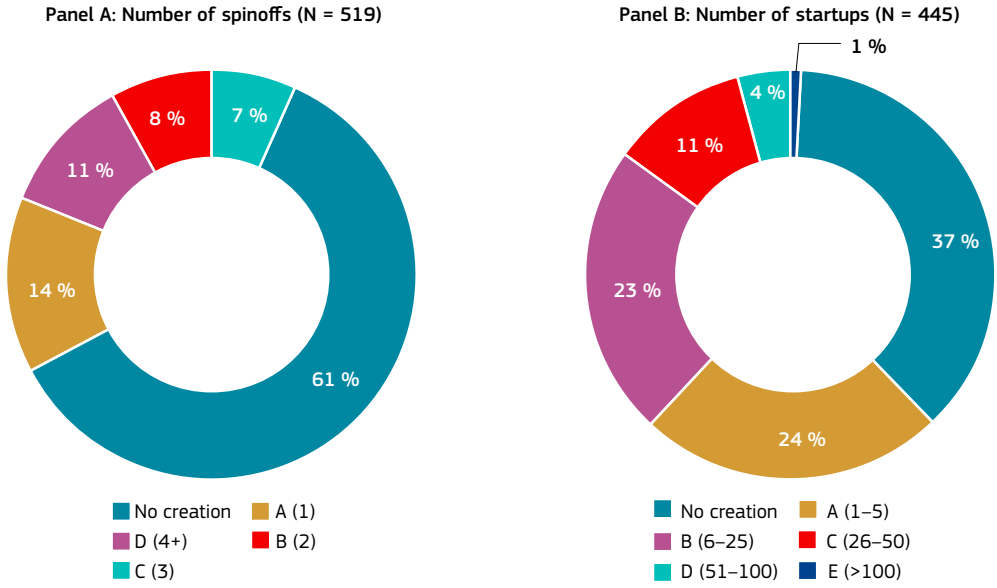
Furthermore, initial funding choices play a key role in shaping the long-term financing trajectories of this type of companies. Recent evidence suggests that academic startups that begin their development journey with grant funding face difficulties transitioning to equity investment or other type of funding instruments at a later stage. This tendency is likely to be due to the unique nature of this type of companies, which typically pursue objectives that prioritise research over immediate commercialisation (Berger *et al.*, 2026).

Creating a diverse and supportive funding environment for academic startups thus remains critical. Ensuring that academic and research spinouts have access to appropriate funding and support instruments throughout their entire development cycle is pivotal if academics are to commercialise their research and overcome the barriers typically faced in transitioning from lab to market, particularly in high-impact sectors.

6 According to Dealroom, spinouts are companies created directly out of universities. Spinouts and spinoffs are synonymous in this chapter.

KTOs across the EU have helped create startups and spinoffs. As key intermediaries in the knowledge valorisation process, KTOs play a central role in translating academic research into knowledge that can be absorbed by industry and society (Conti and Grimaldi, 2024). Recent data show that 39 % of KTOs managed to create spin-offs[7] compared to 63 % of KTOs managed to help create startups[8] (Figure 4.2-8). Around 24 % of KTOs helped create between 1 and 5 startups, 23 % created between 6 and 25 startups, and less than 5 % created over 50 startups (Figure 4.2-8, Panel B). Regarding spinoffs, 11 % of KTOs helped create at least 4 spinoffs (Figure 4.2-8, panel A). These results suggest that many KTOs are not being used to their full potential, as they often lack the organisational capabilities, staffing and resources needed to engage in broader forms of valorisation or to contribute meaningfully to transformative innovation. Evidence from recent studies points to persistent gaps in skills, institutional coordination and strategic positioning, all of which limit the extent to which KTOs can translate research outputs into societal or economic value (Borrás *et al.*, 2024; Compagnucci and Spigarelli, 2024). Putting into place incentive and reward programmes for researchers and support professionals alike can help the knowledge valorisation process (WIPO, 2024).

Figure 4.2-8 Number of spinoffs and startups created by KTOs, 2022



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Association of Science and Technology Professionals (ASTP).

Note: The A to G labels are category groupings that classify KTOs according to how many startups/spinoffs they created. The numbers in brackets denote the number of startups/spinoffs. N refers to the number of responses based on TTOs from Austria, Belgium, Czechia, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Luxembourg, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain and Sweden.

7 This dataset defines a spinoff as a company established specifically to develop or exploit IP generated by a PRO, and that maintains a formal contractual relationship with that organisation. This includes, but is not limited to, companies founded by PRO staff. It excludes firms that have no formal agreement to commercially develop IP or know-how originating from the institution.

8 In this dataset, a startup is defined as a newly registered company founded by students or employees of a PRO that is not directly engaged in exploiting IP generated within that organisation.

4. The EU continues to face weaknesses in deployment capacity

Bringing innovation to market is a core part of knowledge valorisation and central to closing Europe's innovation gap (Draghi, 2024). This depends not only on invention, but also on firms' ability to mobilise tangible assets, technical capabilities, commercialisation channels and later-stage finance, especially in activities where scaling requires production capacity and product market access (Teece, 1986; Gans and Stern, 2003; Quas *et al.*, 2022). Yet many EU firms still face practical and structural obstacles, including fragmentation in the European single market, limited scale-up finance, and difficulties in building production and operational capacity (European Commission, 2026). It follows that innovation strength does not automatically translate into firm growth, industrial build-out or downstream value capture in the same sectors (Teece, 1986; Arora *et al.*, 2023). These barriers are often most visible at transition points, when scientific and technological advances should translate into commercial and scalable solutions, but too many projects still struggle to progress (European Commission, 2026).

Among the EU's largest corporate research and development (R&D) investors, some deployment strength remains visible in sectors where innovation effort is paired with capital expenditure and profitability, notably automotive, hardware- and equipment-related activities, and health-related manufacturing (European Commission, 2025). But the sector mix behind these large corporate profit pools differs across major economies. In the US, downstream strength is more strongly centred on software and computer services, while China combines a very large software segment with a broader manufacturing profile, including hardware- and equipment-related activities (European Commission, 2025). This suggests that Europe's large-firm profile is structurally different rather than simply weaker. At the same time, this large-corporate picture is only partial. It does not show whether similar sector strengths carry through into the wider firm population, broader sector structures or the absorption of value in final demand. As such, the question is not whether Europe innovates, but whether innovation strength carries over into firm scaling and deployment more broadly. Deployment is read here through a set of complementary signals covering firm growth, sector economic weight and market absorption, since these dimensions do not necessarily move together across sectors and firm profiles (Moncada-Paternò-Castello, 2022; García-Manjón and Romero-Merino, 2012).

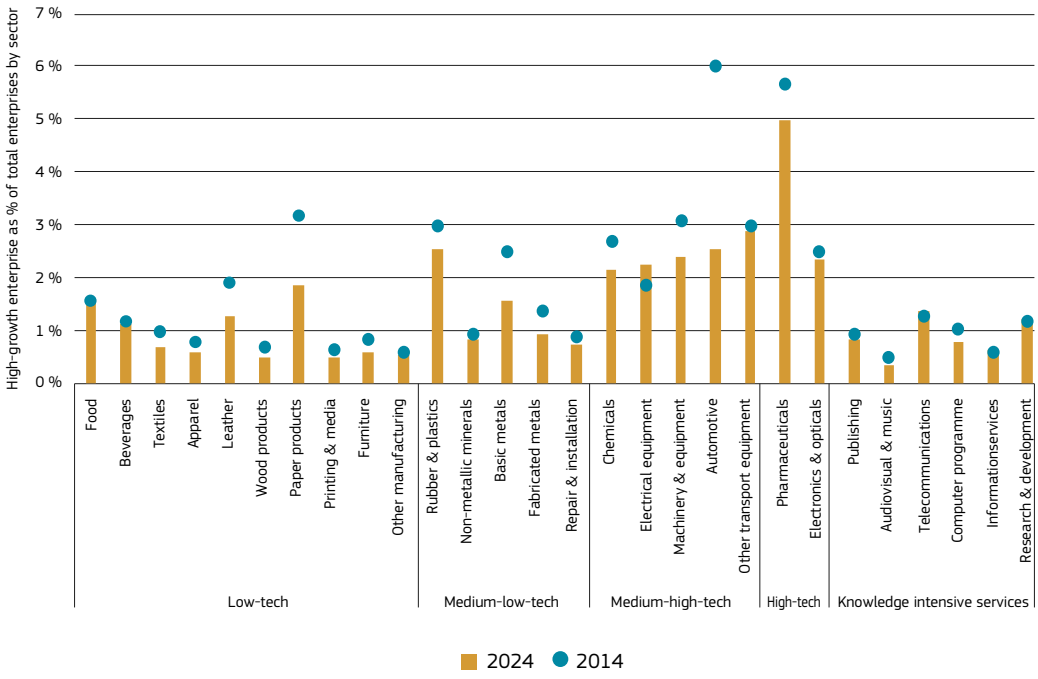
5. Europe shows uneven deployment signals across sectors and technologies

Beyond the largest corporate R&D investors, the EU high-growth enterprises[9] (European Commission, 2026c) **pattern appears weaker than a decade ago. Compared with 2014, the share of high growth enterprises over the total firms population is lower in 2024 in most sectors.** The weakening is visible across much of the distribution, including low-tech and medium-low-tech manufacturing, but also in several medium-high-tech and high-tech activities. A few sectors still show comparatively stronger fast-growth intensity in 2024, notably pharmaceuticals, transport equipment, machinery, electrical equipment, electronics, chemicals, and rubber and plastics, alongside selected knowledge-intensive services such as telecommunications and R&D (Figure 4.2-9).

High growth is also not evenly aligned with sector size in the EU economy (Figure 4.2-10). High-growth firms are not confined to a narrow set of sectors, but their distribution should be read against differences in economic weight (OECD, 2000; 2021). Many low-tech and medium-low-tech activities account for relatively small shares of EU gross value added and show relatively low shares of high-growth firms. Food, beverages and tobacco are the main exceptions. Medium-high-tech manufacturing shows the broadest overlap between the two dimensions, with sectors such as machinery and equipment, automotive, chemicals and electrical equipment combining some fast-growth dynamism with a visible economic footprint. High-tech manufacturing is more uneven: pharmaceuticals show very high fast-growth intensity despite a more limited share of gross value added, while electronics and optical products are more moderate on both measures. Knowledge-intensive services are also uneven, with IT and information services standing out more for economic weight than for fast-growth intensity.

9 Definition of high growth enterprises: 'an enterprise with an average annualised growth in employees that is greater than 10% over a 3-year period, whereby the enterprise must have at least 10 employees at the beginning of said growth period.'

Figure 4.2-9 High-growth enterprises by sector and technology group in the EU, 2014 and 2024

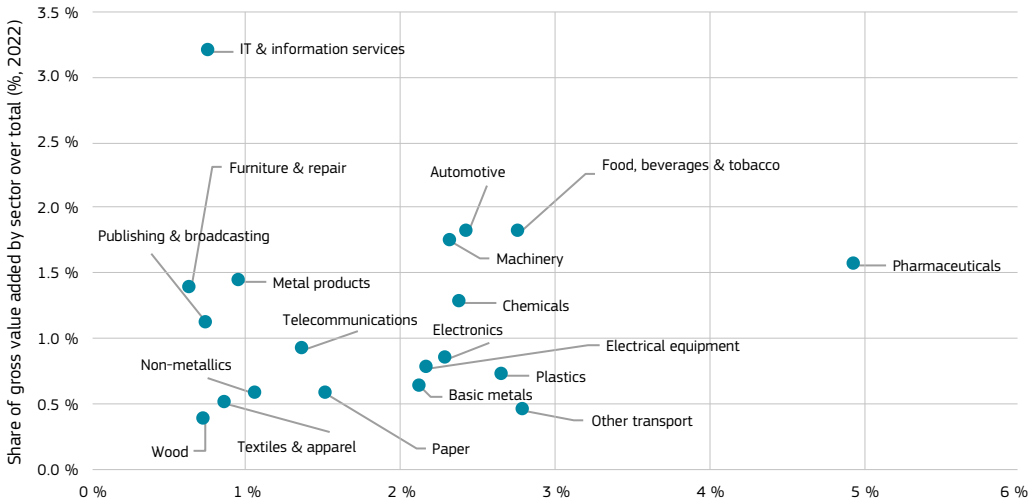


Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Eurostat (DOI links: https://doi.org/10.2908/BD_HG, https://doi.org/10.2908/SBS_NA_IND_R2, https://doi.org/10.2908/SBS_NA_1A_SE_R2 and https://doi.org/10.2908/SBS_SC_OVW).

Note: Sector groupings follow Eurostat technology-intensity and knowledge-intensive services classifications (NACE Rev.2). The indicator is calculated as high-growth enterprises as a share of total enterprises in each sector. Dots show baseline values, mostly for 2014, and bars show the latest available values, mostly for 2024. Where 2014 or 2024 data were unavailable, the nearest available year was used instead. Some sectors (i.e., tobacco and petroleum) were excluded due to data unavailability.

Figure 4.2-10 High-growth enterprises and sector weight in the EU economy, 2022



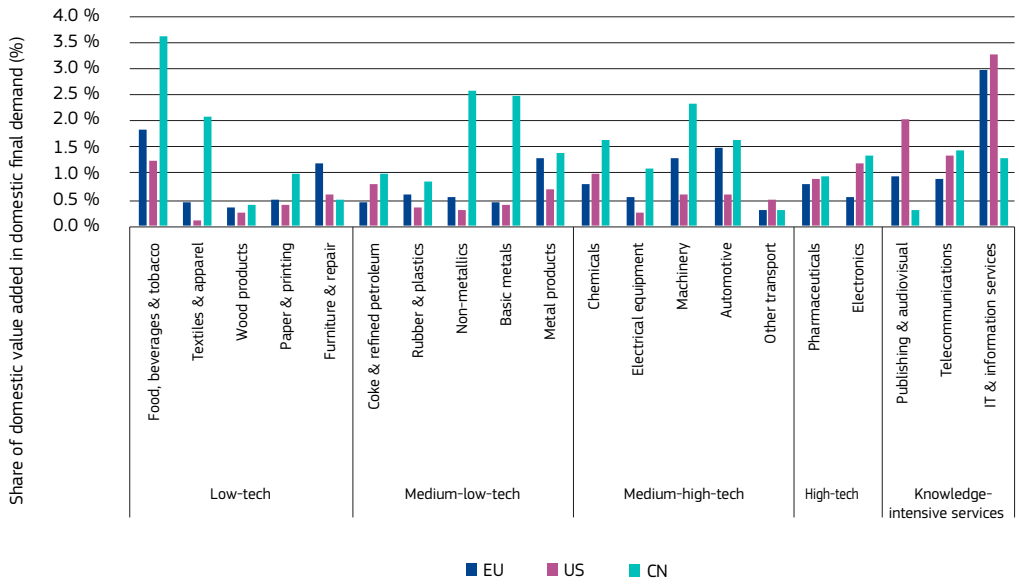
Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Eurostat (DOI links: https://doi.org/10.2908/BD_HG, https://doi.org/10.2908/SBS_NA_IND_R2 and https://doi.org/10.2908/SBS_NA_1A_SE_R2) and OECD Trade in Value Added (TiVA, 2022).

Note: The x-axis shows high-growth enterprises as a share of total enterprises by sector in 2022 due to data availability in TiVA. The y-axis shows each sector's share of total EU gross value added in 2022. Data is missing for high-growth enterprises concerning tobacco and petroleum.

Market absorption highlights a partly different set of sector strengths from those visible in firm growth or corporate investment. TiVA indicators trace where domestic production is ultimately absorbed and where sectors capture value in domestic and foreign final demand (Johnson and Noguera, 2012; Koopman *et al.*, 2014; OECD, 2025). In the EU, home-market absorption is concentrated in knowledge-intensive services, especially information and communication (ICT)-related services, in line with their economic weight in Figure 4.2-11. Some manufacturing sectors, notably automotive and food, also remain visible, consistent with earlier evidence, but less prominently than ICT-related services. The US shows a similar pattern, whereas China has a more manufacturing-weighted home market, with broader domestic value absorption across manufacturing and intermediate industries (Figure 4.2-11).

Figure 4.2-11 Home absorption of domestically produced value added, by sector, 2022



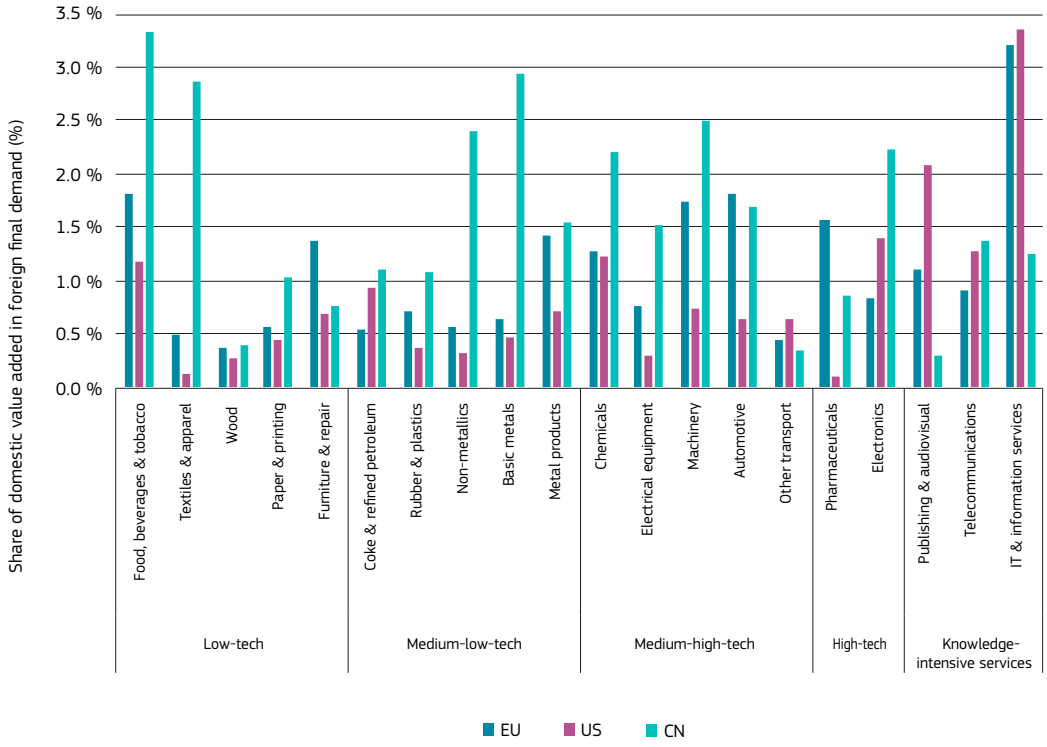
Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on OECD Trade in Value Added (TiVA, 2022).

Note: Sector groupings follow Eurostat technology-intensity and knowledge-intensive services classifications (NACE Rev.2). Bars show, for each economy, the share of total domestically produced value added absorbed by domestic final demand generated in each sector in 2022. The indicator is calculated as sectoral domestically produced value added absorbed by domestic final demand, divided by total domestically produced value added absorbed by domestic final demand in the economy.

Abroad, the EU's external market reach is strongest in machinery, automotive and pharmaceuticals, alongside ICT services (Figure 4.2-12). The US stands out for the particularly strong role of ICT and other content-related services in external demand, while China's external reach is more strongly spread across manufacturing and intermediate industries, including electronics, food, textiles and basic metals.

Figure 4.2-12 Foreign absorption of domestically produced value added, by sector, 2022



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on OECD Trade in Value Added (TiVA, 2022).

Note: Sector groupings follow Eurostat technology-intensity and knowledge-intensive services classifications (NACE Rev.2). Bars show, for each economy, each sector's share of domestically produced value added absorbed by foreign final demand in 2022, calculated as sectoral foreign-absorbed value added divided by total domestically produced value added absorbed by foreign final demand in the economy.

6. The EU's commitment to an interconnected innovation ecosystem that supports the flow of knowledge

In addition to the Guiding Principles for Knowledge Valorisation, aiming to align national, regional and local policy measures to maximise the impact of research and innovation investments, the Commission has put forward a set of Codes of Practice. These codes were implemented between 2023 and 2024 and are concerned with intellectual assets management[10], standardisation[11], industry-academia co-creation[12] and citizen engagement[13] to support implementation and provide practical guidance to R&I actors.

To promote industry-academia cooperation and mobility, the EU has put in place targeted instruments such as Marie

10 https://eur-lex.europa.eu/eli/reco/2023/499/oj

11 http://data.europa.eu/eli/reco/2023/498/oj

12 http://data.europa.eu/eli/reco/2024/774/oj

13 http://data.europa.eu/eli/reco/2024/736/oj

Skłodowska-Curie Actions and collaborative research grants. The Marie Skłodowska-Curie Actions provide funding for excellent R&I and help researchers acquire new knowledge and skills, through mobility across borders and exposure to different sectors and disciplines.

The EU support research entrepreneurship through initiatives such as the European Innovation Council (EIC), ERC Proof of Concept funding (ERC-POC) and the European Institute of Innovation and Technology (EIT). These initiatives aim to foster entrepreneurship and early-stage commercialisation. For instance, the EIC identifies breakthrough technologies and game changing innovations from Europe's research base and accelerates their scaleup and market deployment. The ERC-POC funding supports research activities at the very early stage of turning research outputs into a commercial or socially valuable proposition. The EIT fosters excellent technical as well as entrepreneurial skills in its education programmes and powers innovative ventures through its network of Knowledge and Innovation Communities (KICs).

Intermediaries and knowledge transfer professionals also receive tailored support to highlight success stories of EU funded projects and valorise their output. Examples of such support include the Horizon Results Booster and the Horizon Results Platform. The Commission also offers expertise in technology transfer in the context of capacity building, financing and innovation ecosystems through the Competence Centre on Technology Transfer.

Commercialisation of R&I results is also supported under the Startup and Scaleup Strategy[14] adopted in 2025. Under this strategy, the *Lab to Unicorn* initiative, launched in 2026, aims to enhance university-based innovation ecosystems via European Startup and Scaleup Hubs; a blueprint for licensing, royalty and revenue sharing; and equity investment and state aid guidance for startups established in academic institutions. Similarly, as part of this strategy, in July 2026, the European Commission has adopted a Communication on the Charter of access for industrial users to research and technology infrastructures, aimed at strengthening collaboration between industry and infrastructures, improving access conditions and facilitating innovation across the EU.[15] By endorsing the charter, research and technology infrastructure hosts will make it easier for companies to access their services and thus speed up the journey of innovative products and technologies to market.

The planned adoption of a European Research Area (ERA) Act in 2026, as set out in the Competitiveness Compass for the EU[16], will further support these knowledge valorisation efforts. By addressing persistent fragmentation in regulatory frameworks, disparities in R&D investment and barriers to knowledge circulation, the *ERA Act* aims to establish more coherent framework conditions for the effective exploitation and deployment of research results. Building on the renewed ERA and the implementation of successive *ERA Policy Agendas*[17] since 2021, the initiative seeks to enhance policy coordination, reduce structural asymmetries across Member States and facilitate cross-border knowledge flows.

14 https://research-and-innovation.ec.europa.eu/strategy/strategy-research-and-innovation/jobs-and-economy/eu-startup-and-scaleup-strategy_en

15 https://research-and-innovation.ec.europa.eu/strategy/strategy-research-and-innovation/our-digital-future/charter-access-industrial-users-research-and-technology-infrastructures_en

16 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52025DC0030

17 https://european-research-area.ec.europa.eu/era-policy-agenda-2025-2027

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CHAPTER 4.3

DEEP-DIVE INTO R&I ACTIVITIES – FROM R&D TO DEPLOYMENT

Bianca Cavicchi

KEY QUESTIONS

- How well does the EU turn strong Research and Innovation (R&I) performance into deployment, scale-up and value creation in Europe?
- Where are the main bottlenecks along the path from Research and Development (R&D) to deployment in strategic sectors?

HIGHLIGHTS

- Across life sciences, clean technologies and digital, the EU has a substantial R&I base, but its strengths are uneven across technologies, sectors and Member States.
- Deployment is where the innovation gap becomes most visible: EU strengths in R&I translate unevenly into clinical development, bioeconomy scale-up, clean tech manufacturing and advanced digital uptake.
- The main bottlenecks differ by activity cluster. Life sciences face late-stage finance, regulatory pathway and market access issues; clean technologies depend more on manufacturing scale, infrastructure and bankable projects; digital depends on diffusion, compute, connectivity and skills.
- The EU often retains strengths in selected upstream R&I or enabling activities, while competitors are stronger in downstream scale, production capacity and control over critical parts of value chains.

POLICY INSIGHTS

- The proposed European Competitiveness Fund reflects a shift towards supporting strategic technologies along the entire R&I-to-deployment pathway, including applied research, scale-up, manufacturing and market uptake.
- In life sciences, the policy focus is moving towards faster translation from science to real-world solutions, including clinical development, biotechnology scale-up, market access, innovation procurement and clearer regulatory pathways.
- In clean technologies and decarbonisation, EU policy links climate objectives more directly with industrial competitiveness, with closer attention paid to manufacturing capacity, energy costs, circularity, clean product demand and supply chain dependencies.
- In digital, EU policy connects technological development with faster diffusion across firms and public services, stronger connectivity, higher compute capacity, increased digital skills and lower dependence in critical infrastructures and services.
- Other policy instruments to boost and direct private R&I investments are for instance the EU Missions, launched under Horizon Europe (2021-2027), and the EU partnerships which are instrumental in focusing investments and bringing solutions while also addressing societal and global challenges.

The EU's competitiveness agenda is increasingly framed around three linked priorities: closing the innovation gap, decarbonising the economy, and reducing strategic dependencies. This policy shift, set out in the Draghi report and carried forward in the *Competitiveness Compass* (European Commission, 2025a), is now being translated into a stronger focus on strategic technologies and on the conditions needed to bring them to scale in Europe. The proposed European Competitiveness Fund (European Commission, 2025g) reflects this direction by treating life sciences, clean technologies and digital as strategic policy windows and by aiming to support them throughout the entire innovation-to-investment journey: from applied research to scale-up, deployment and manufacturing.

This broader policy context is directly relevant to the three areas examined in this chapter. In life sciences, the focus is increasingly on turning scientific strength into real-world solutions. In clean technologies and decarbonisation, the focus is on linking decarbonisation more closely with industrial competitiveness, manufacturing and infrastructure. In digital, the focus is on combining technology development with faster diffusion, stronger connectivity, higher compute capacity and lower strategic dependence in critical parts of the stack. Against this background, the chapter examines how the EU performs in these three areas in terms of both R&I strength and deployment capacity (Draghi, 2024).

1. Life sciences: health, biotechnology, food and bioeconomy

Life sciences are a major part of the EU's economy and matter for both competitiveness and resilience. This policy area brings together activities that address core societal needs in health, food and environmental sustainability, while also creating industrial opportunities across pharmaceuticals, medical technologies, biotechnology, food systems and bio-based industries. These activities also depend on resilient ecosystems. Degraded natural systems can affect water availability, soil quality, pollination, carbon sequestration and climate resilience, turning biodiversity loss into a competitiveness and resilience risk for food, bioeconomy and bio-based value chains. The recently adopted IPBES Business and Biodiversity Assessment reinforces this point, showing that business practices, finance and governance frameworks need to account more systematically for nature-related dependencies, impacts and risks (IPBES, 2026).

The EU has a broad research and innovation (R&I) base in these areas, supported by strong scientific capabilities, established industrial activities and a large economic footprint. However, the picture is uneven across the policy area. The EU's strengths are more visible in some parts of the bioeconomy: food, chemicals and manufacturing base, while global competition is stronger in frontier health technologies, biotechnology and scale-up-intensive activities. The key question is whether this broad R&I base translates into deployment. Across the area, the main pressure points are not only in invention but also in clinical and technological development, scale-up finance, regulatory pathways, industrial production capacity and market uptake. These issues are visible in different ways: in health and biotech through clinical development, regulation and late-stage finance; in medical technologies through market access and regulatory complexity; and in food and bioeconomy through demonstration, first commercial production and demand creation.

R&I strengths are broad but uneven

Upstream evidence points to a broad but uneven EU profile across these activities (Grassano and M'Barek, 2025). Pharmaceuticals and medical technologies accounted for 12.6 % of all IP5[1] (Intellectual Property) patent families worldwide in 2010-2020, and patenting in these technologies grew by 4.6 % per year, almost double the rate for other technologies (Grassano and M'Barek, 2025). The EU remained a major patenting region, accounting for 17.2 % of pharmaceutical and medical technology patent families, second only to the US at 25.1 % (Grassano and M'Barek, 2025).

The EU's position is nevertheless under pressure. The gap to the US has widened over time, as EU patenting in these technologies has grown only slightly while US patenting has expanded at a faster rate, reducing the EU's level from 80.1 % of that of the US in 2010 to 60.4 % in 2020 (Grassano and M'Barek, 2025). The EU's patent intensity in the field has remained broadly in line with the world average, while the US shows clear specialisation (Grassano and M'Barek, 2025). China's patent intensity remains much lower in absolute terms, at 3.2 % of the US level, but it recorded the fastest growth from 2010 to 2020 (Grassano and M'Barek, 2025).

The EU's profile is also concentrated within specific parts of Europe. Germany accounts for 36 % of EU pharmaceutical and medical technology patent families, and the top five Member States for 76.6 %. Within this field, medical technologies account for much larger patent volumes than pharmaceuticals, with prominent EU examples including diagnostic and surgical devices, devices that introduce media into or onto the body and implants and prostheses (Grassano and M'Barek, 2025). In 2024, medical technology, biotechnology and pharmaceuticals together accounted for around 16 800 European Patent Office (EPO) patent applications, while medical technology alone generated more than 15 700 applications (EuropaBio, 2025; MedTech Europe, 2025; European Commission, 2025h).

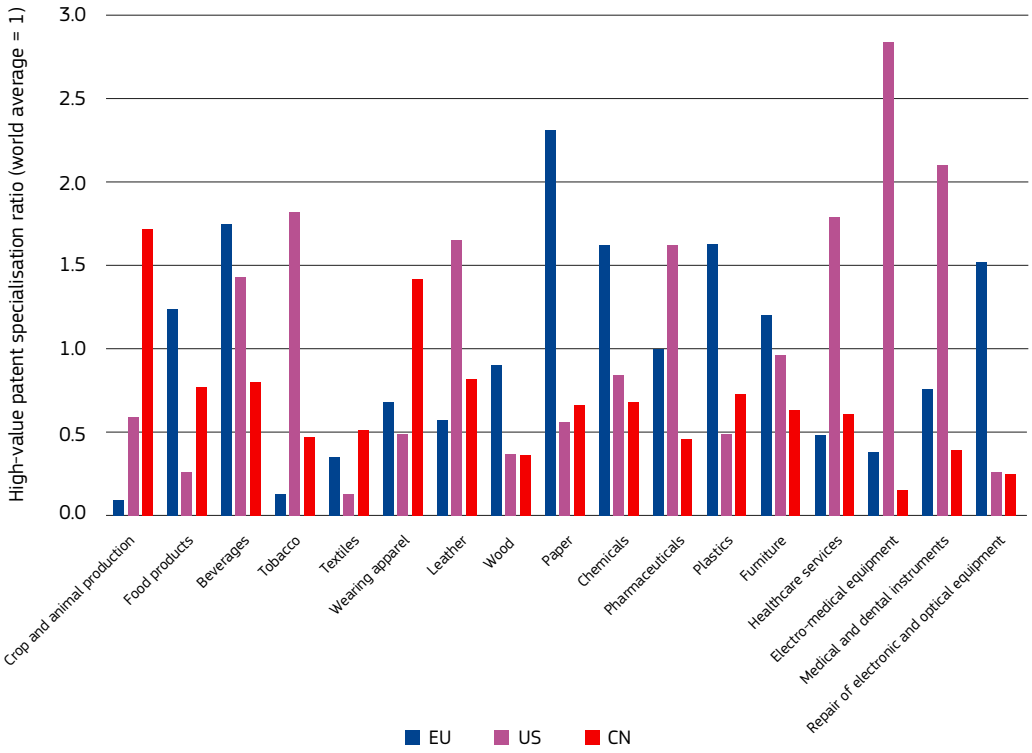
Beyond the core health domain, the broader bioeconomy also shows a substantial upstream base (Grassano *et al.*, 2024; European Commission, 2025b; 2025d). Bioeconomy-related sectors accounted for EUR 23.2 billion in research and development (R&D) investment in 2023, equivalent to 9 % of total R&D investment, and patents in these fields accounted for 5 % of all EU patents between 2008 and 2020 (European Commission, 2025b). In biotechnology patenting, the EU remains a major player but not the leader: it is behind the US and is rapidly being caught by China (Grassano *et al.*, 2024; European Commission, 2025d). Most biotechnology patenting is concentrated in industrial and medical applications, and EU activity is itself concentrated in a few Member States, notably Germany and France (Grassano *et al.*, 2024). For food systems, the available evidence is less a direct measure of frontier leadership than of enabling capabilities, pointing above all to the importance of technology, digitalisation and knowledge transfer across the food chain (Tóth *et al.*, 2024).

In terms of high-value patents, the EU remains present across a broad range of life science-related activities, including health, agrifood and bio-based manufacturing, even though, in many cases, it does not hold the largest global share (Figure 4.3-1). The US is more prominent in several core health-related activities, while China holds larger shares in several agrifood and bio-based manufacturing activities. Even so, the EU's positions of strength are more visible in numerous areas of the wider bioeconomy and manufacturing base, including chemicals, plastics, beverages, food products and paper and paper products.

1 The term IP5 means a single invention is protected in five major areas: the US, Europe, Japan, South Korea and China. Since this of protection is significantly more expensive, these patents show high-value global inventions.

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Figure 4.3-1 Relative specialisation in high-value patenting by life science-related sector, EU, US and China, 2000–2023 [2]



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on the DG Research and Innovation internal RDI database developed by Idea Consult, drawing on PATSTAT and Technote data.

Note: Values above 1 indicate relative specialisation in that activity. Only distinct patent families are counted. Years are based on patent priority dates.

CHAPTER 4

Deployment is more limited than R&I

The main pressure point lies beyond science and invention. Life science activities in the EU employed around 29 million people in 2022 and generated EUR 1.5 trillion in value added, corresponding to 13.6 % of overall employment and 9.4 % of EU gross domestic product (European Commission, 2025d). This gives the EU a large base on which to build. However, turning research results into commercially viable products, scaling them up and securing market uptake remain more difficult. The bottlenecks are visible in finance, regulation and demand conditions. Access to scale-up capital remains more limited than in other major regions, while time-to-market, regulatory complexity and fragmented uptake across the single market continue to slow progress from development to market, including for biotechnology, bio-based solutions and medical technologies (European Commission, 2025c; 2025e; 2025f).

2 Statistical classification of economic activities (NACE) codes selected based on JRC dashboard 'Socioeconomic indicators for the Life Sciences sectors' (Lasarte Lopez *et al.*, 2025).

These pressures are particularly visible in health biotechnology, where capital needs rise sharply as firms move towards clinical development and commercialisation (European Commission, 2025f). Between 2015 and June 2025, US biopharma startups received around nine times more late-stage funding than their EU counterparts, with around EUR 219 billion of venture capital focused on health biotechnology invested in the US compared to EUR 25 billion in the EU. EU public equity markets for biotechnology remain comparatively underdeveloped, with stock exchanges still largely fragmented across Member States. As a result, many EU scaleups choose to list abroad: over the last six years, 66 out of 67 EU biotechnology companies that went public chose to list on non-EU exchanges (European Commission, 2025f). The clinical development pathway points in the same direction. The global share of commercially sponsored clinical trials in the European Economic Area (EEA) declined from 22 % in 2013 to 12 % in 2023. Most comparator regions issue decisions on validated clinical trial applications within 60 days, whereas in the EU it takes on average 113 days for multinational trials. This matters because clinical trials are a late-stage development indicator: they show whether upstream R&I activity is progressing towards validation, regulatory approval and eventual market entry.

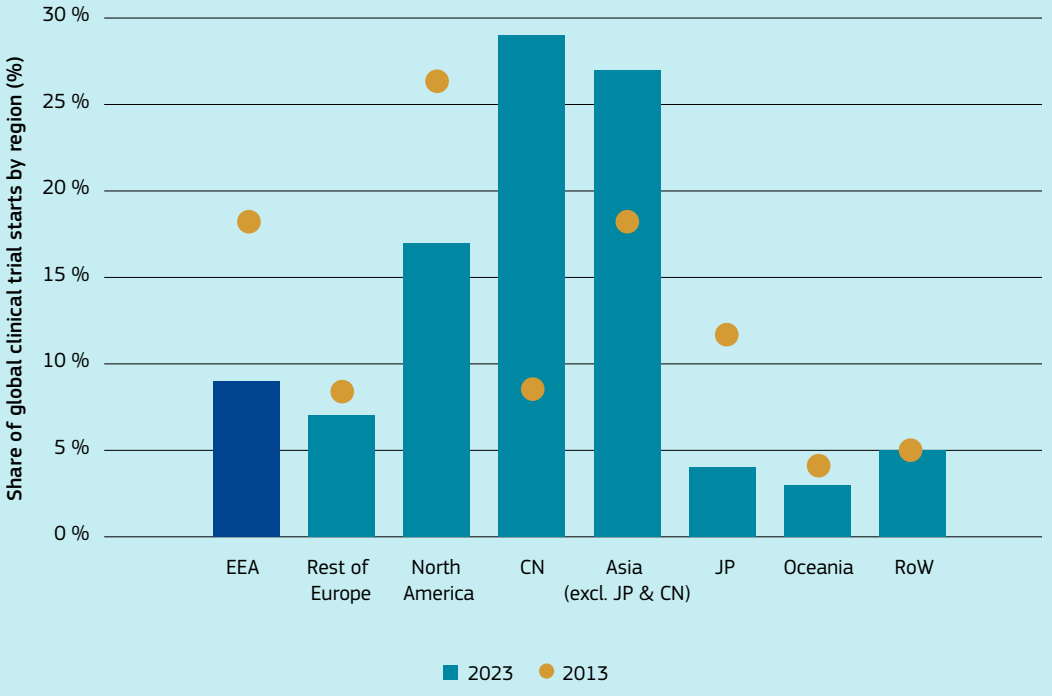
In bioeconomy, the bottlenecks are concentrated around the move from research and demonstration to first commercial production and industrial scale-up. The bioeconomy is already a major economic base and a route to decarbonisation, including through advanced biofuels, waste-based processes and the replacement of fossil-based materials (European Commission, 2025b; Lasarte-López *et al.*, 2025b). Biomass production and conversion activities employed 17.1 million people in 2023 and generated EUR 863 billion in value added (European Commission, 2025b). However, firms face financing gaps, limited scale-up infrastructure and uncertainty around long-term demand, especially in biomanufacturing, advanced bio-based materials and circular bioeconomy infrastructure. Stakeholders also point to slow and uncertain regulatory approval processes, regulatory complexity, fragmentation across the EU and market barriers linked to demand, pricing and the classification of novel bio-based products. These pressures make it harder to move bio-based innovations beyond the lab and through the two 'valleys of death' towards industrial scale and market uptake (European Commission, 2025b; 2025n).

In medical technologies, the challenge is not lack of market relevance but market access. The European medical device market is large, estimated at around EUR 170 billion in 2024, and the second largest in the world after that of the US. But regulatory complexity, uncertainty and uneven application across Member States have constrained innovation and competitiveness, particularly for SMEs. This has resulted in longer timelines and limited device availability, notably affecting niche and orphan devices, where limited profitability and high compliance burdens have led to portfolio reductions and market withdrawals (European Commission, 2025d; 2025f).

Box 4.3-1 Clinical trials as a late-stage development indicator in life sciences

The EU's clinical trial activity has remained broadly stable, but its share of global clinical trial starts has declined as other jurisdictions have increased activity, with Asia gaining ground over time. In Europe and the US, clinical trials are almost evenly split between commercial and non-commercial sponsors, while in China most trials have a non-commercial sponsor (IQVIA, EFPIA and Vaccines Europe, 2024). Within Europe, sponsor structure also has geographical implications: while most commercial trials in the EU/EEA are multi-country trials (71 %), non-commercial trials remain mainly single-country affairs (86 %). Clinical trial activity is also unevenly distributed across the EU/EEA. Five countries – Germany, Spain, France, Italy and Poland – account for 51.8 % of authorised clinical trials, while trial intensity per inhabitant is highest in Belgium, Denmark and the Netherlands (ACT EU, 2025). Together, these indicators point to persistent frictions in running clinical development efficiently across borders, which can contribute to longer time to market and weaker progression towards market entry (European Commission, 2025c).

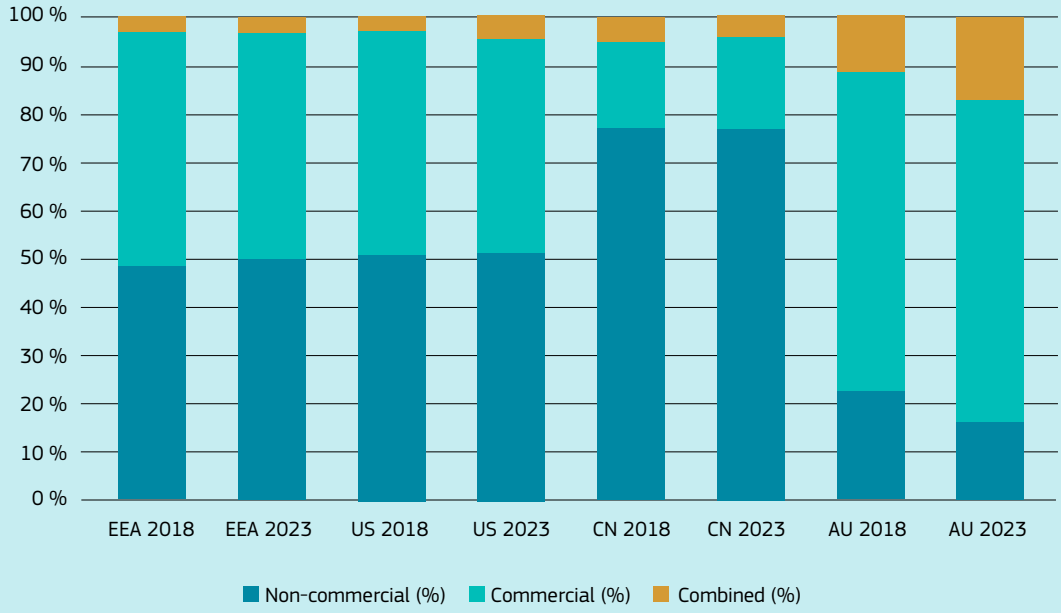
Figure 4.3-2 Global clinical trial starts by region and sponsor type, 2013 and 2023



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on ACT EU (2025).
Note: Shares are calculated as regional clinical trial starts over the global total. The total number of trial starts increased from 13 255 in 2013 to 22 041 in 2023.

Figure 4.3-3 Sponsor composition of clinical trials by region, 2018 and 2023

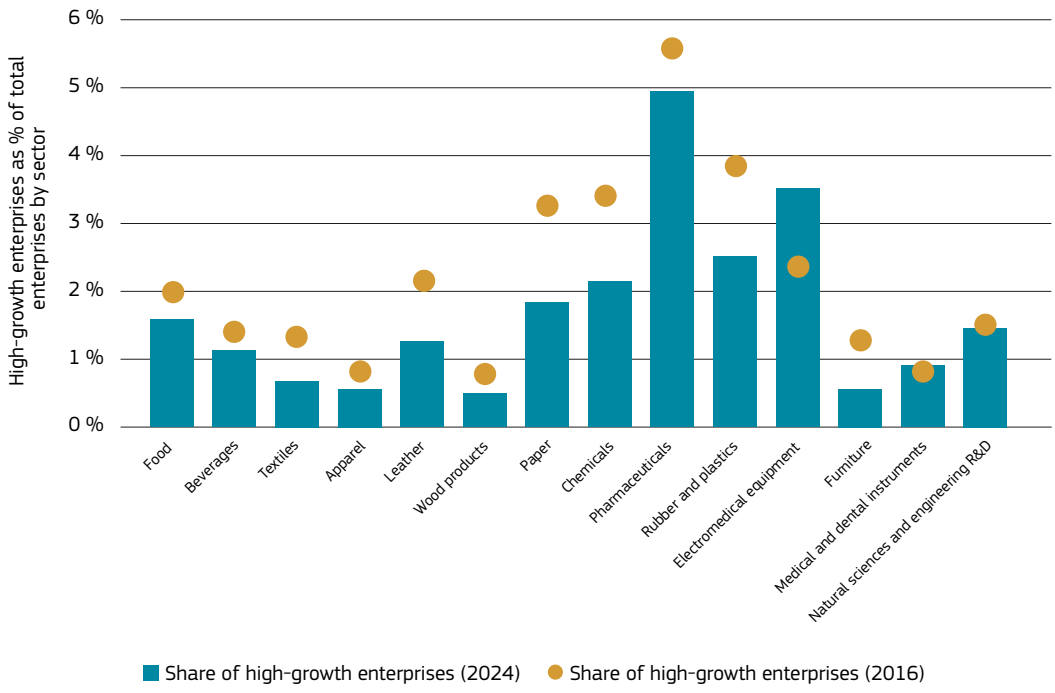


Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on ACT EU (2025).
Note: Shares are calculated as the number of clinical trial starts by sponsor type over the total number of clinical trial starts in each region and year. 'Combined' refers to trials with more than one sponsor type, including non-commercial actors, emerging biopharma companies, mid-sized pharma and big pharma. Medical device trials and terminated or suspended trials are excluded.

Firm growth patterns within the EU also point to uneven deployment dynamics across activities. High-growth enterprises are most prevalent in pharmaceuticals, which stands out clearly from the other sectors shown (Figure 4.3-4). Relatively high shares are also visible in chemicals, rubber & plastics, paper and food. By contrast, high-growth enterprises are less common in textiles, apparel, wood products, furniture and medical and dental instruments, while natural sciences and engineering R&D remains in an intermediate position rather than among the strongest growth activities. Compared with the baseline, the share of high-growth enterprises is lower in most sectors, suggesting that growth dynamics have weakened since the mid-2010s, even in activities where firm growth remains relatively visible.

Figure 4.3-4 High-growth enterprises[3] by sector in the EU, 2016 and 2024[4]



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Eurostat (DOI links: https://doi.org/10.2908/BD_HG, https://doi.org/10.2908/SBS_NA_IND_R2, https://doi.org/10.2908/SBS_NA_1A_SE_R2 and https://doi.org/10.2908/SBS_SC_OVW).

Note: The indicator is calculated as high-growth enterprises as a share of total enterprises in each sector. Dots show baseline values, mostly for 2016, and bars show latest available values, mostly for 2024. Where 2016 or 2024 data were not available, the nearest available year was used instead. Sector groupings follow the Eurostat/OECD technology- and knowledge-intensity classification.

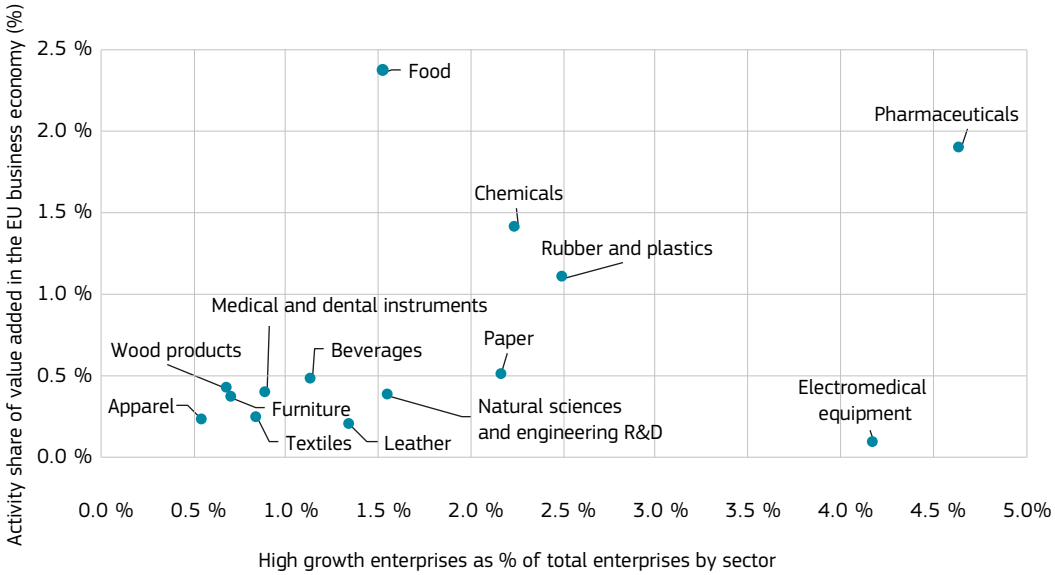
The EU's positions of strength become more concentrated when firm growth is considered together with value added, which brings production more clearly into view (Figure 4.3-5). In this selection of NACE activities, pharmaceuticals stand out most clearly, while chemicals and rubber and plastics also combine relatively strong growth with a more visible value-added base.

Food products carry more weight in value added terms but are less dynamic. More narrowly defined activities, such as electromedical equipment and medical and dental instruments, remain smaller in value added terms, even where growth is more visible.

3 According to Regulation (EU) 2020/1197, 'a high-growth enterprise is an enterprise with an average annualised growth in employees that is greater than 10 % over a 3-year period, whereby the enterprise must have at least 10 employees at the beginning of said growth period'.

4 NACE codes selected based on Statistical classification of economic activities (NACE) codes selected based on JRC dashboard 'Socioeconomic indicators for the Life Sciences sectors' (Lasarte-Lopez *et al.*, 2025).

Figure 4.3-5 High-growth enterprises and economic weight of selected NACE activities in the EU, 2023[5]



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Eurostat (DOI links: https://doi.org/10.2908/BD_HG, https://doi.org/10.2908/SBS_NA_IND_R2 and https://doi.org/10.2908/SBS_NA_1A_SE_R2).

Note: The x-axis shows high-growth enterprises as a share of total enterprises by activity in 2023. The y-axis shows each selected activity's share of total EU business economy value added in 2023, calculated as activity value added divided by total value added in the EU business economy. To preserve activity-specific signals, some broader NACE divisions are replaced by more detailed groups or classes where these are more meaningful for the analysis. Parent and child activities are not shown together.

EU policy toolbox

The EU policy mix in this area spans R&D, deployment and market uptake. Horizon Europe is the main R&I instrument, notably through Cluster 1 'Health' and clusters 4 and 6 for enabling technologies, biomanufacturing, bioeconomy and food and bio-based solutions. It is complemented by European partnerships, including the Innovative Health Initiative, Global Health EDCTP3 and the Circular Bio-based Europe Joint Undertaking, as well as co-funded partnerships on personalised medicine, One Health antimicrobial resistance and food systems, including FutureFoodS. It is also complemented by *EU Missions* in Horizon Europe, namely the mission 'Restore our Ocean and Waters'. Longer-term direction is provided by the *Strategy for European Life Sciences*, the *Bioeconomy Strategy*, the *Pharmaceutical Strategy* and the *R&I Framework Food 2030*, with *Food 2040* under preparation. For pharmaceuticals, this includes the aim of supporting innovation, improving access to affordable medicines, addressing unmet needs and strengthening the resilience of supply chains (European Commission, 2025b; 2025d; 2025f). A second set of instruments shapes deployment conditions. EU4Health supports health system capacity, cross-border cooperation and procurement, while the planned *Critical Medicines Act* and the revision of pharmaceutical legislation aim to strengthen supply security, improve access and support more predictable regulatory pathways. Across health technologies, the *Health Technology Assessment*

5 NACE codes selected based on Statistical classification of economic activities (NACE) codes selected based on JRC dashboard 'Socioeconomic indicators for the Life Sciences sectors' (Lasarte Lopez *et al.*, 2025).

Regulation supports common EU-level clinical assessments for medicinal products, certain medical devices and in vitro diagnostics. In medical technology specifically, the *Medical Devices* and *In Vitro Diagnostic Medical Devices* regulations establish framework conditions, while the *European Health Data Space* shapes the wider data environment for health innovation (European Parliament and the Council of the European Union, 2021c; 2025; European Commission, 2025h).

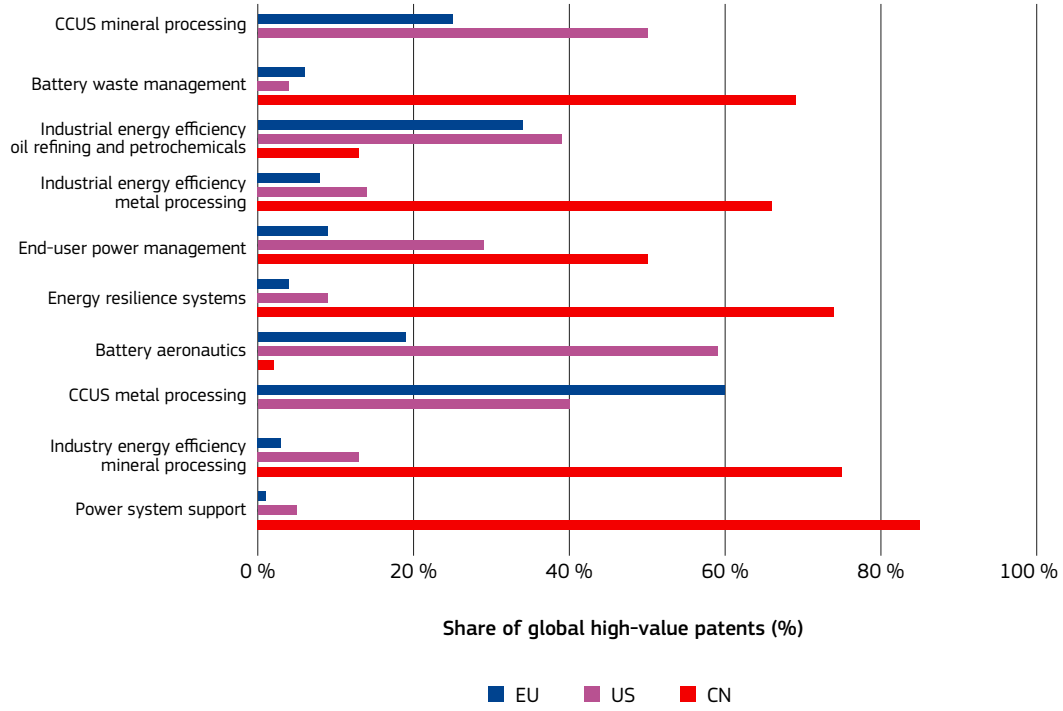
Financing instruments such as the European Innovation Council, InvestEU, HERA Invest, the European Circular Bioeconomy Fund and European Investment Bank (EIB) Group tools support higher-risk projects, including in life sciences, biotech and biomanufacturing (European Commission, 2025a; EIB, 2026). Much of the investment, however, remains national or regional, especially in health infrastructure, clinical research, agriculture, food systems and bioeconomy R&I and biomanufacturing facilities. Delivery therefore depends not only on EU instruments but also on how well they align with national strategies, budgets and regulatory reforms (European Commission, 2025f; EIB, 2026).

2. Clean transition and industrial decarbonisation

Clean energy and industrial decarbonisation technologies sit at the intersection of energy security, industrial competitiveness, strategic autonomy and the transition to a climate-neutral economy. This technological area is broad. It includes renewable and low-carbon energy technologies, energy storage and batteries, renewable hydrogen, carbon capture, utilisation and storage (CCUS), and the system integration needed across buildings, grids, industry and transport (Georgakaki *et al.*, 2025). This makes the clean transition different from many other technological areas. It combines technologies already being deployed at scale, such as solar photovoltaics (PV), wind, batteries and heat pumps, with technologies still moving towards broader commercialisation, such as renewable hydrogen and CCUS. It also depends heavily on manufacturing capacity, infrastructure, grids, skilled labour, permitting, raw materials and the ability to turn R&I into bankable projects and industrial production. This is particularly relevant for energy-intensive industries, where recent INCITE evidence shows an active pipeline of industrial decarbonisation demonstrators in iron and steel, chemicals, and cement, lime and magnesia, including renewable hydrogen use, electrification, CCUS, circularity and energy-efficiency solutions (Aries *et al.*, 2026).

The EU has a strong clean-tech R&I base, but its position is more uneven when moving from research to manufacturing and scale-up. It remains comparatively well placed in wind, heat pumps and some grid technologies, while in solar PV and batteries, it is more exposed to global competition and faces issues linked to manufacturing scale and supply-chain dependencies. This makes the central question for these technologies not only whether the EU can sustain clean-tech innovation, but whether it can turn selected strength into manufacturing capacity, deployment and value capture (Georgakaki *et al.*, 2025; European Commission, 2025k).

Figure 4.3-6 Selected EU clean tech and decarbonisation technologies by share of global high-value patents



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on the DG Research and Innovation internal RDI database developed by Idea Consult, drawing on PATSTAT and Technote data.

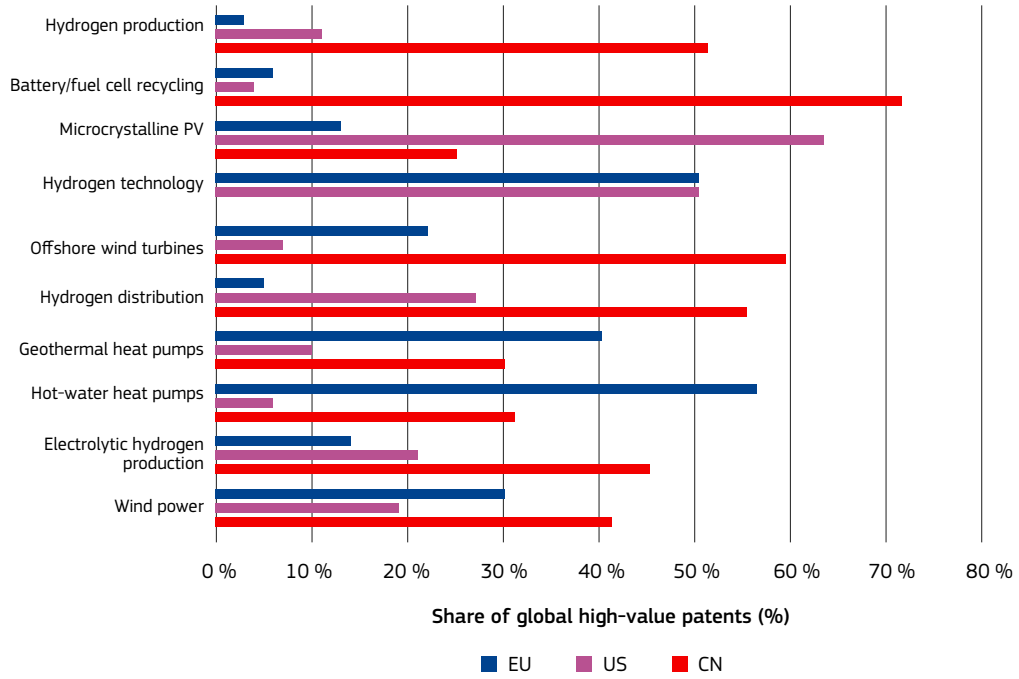
Note: Technologies are selected based on the EU share of patents that are of high value. US and China shares are shown for the same technologies only.

Upstream technological strength

The EU's upstream clean tech output is substantial but variable. Public R&I efforts in clean energy remain significant, and the EU maintains sizeable innovation outputs in areas such as renewables and energy efficiency. At the same time, the EU profile differs sharply across technologies. It remains strong in wind, selected grid-related technologies, heat pumps and some industrial decarbonisation technologies, while it is weaker in PV and more exposed in batteries, where east Asian competition is stronger across both innovation and production (Bielewski *et al.*, 2024; Georgakaki *et al.*, 2025; European Commission, 2025k).

Early-stage evidence points in the same direction. The EU is relatively specialised in CCUS, district heating and wind but less focused on batteries, energy storage and smart grids (Eulaerts *et al.*, 2024). This reinforces the picture of a strong but selective upstream base: EU strengths are concentrated in a limited number of industrial and decarbonisation niches rather than spread broadly across technologies. The high-value patent evidence confirms this pattern. Among the selected technologies, the EU's clearest leading position is in CCUS metal processing. It also has considerable shares of high-value patents in CCUS mineral processing, industrial energy efficiency technologies related to oil refining and petrochemicals and battery aeronautics,

Figure 4.3-7 Selected EU clean and renewable technologies by share of global high-value patents



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on the DG Research and Innovation internal RDI database developed by Idea Consult, drawing on PATSTAT and Technote data.

Note: Technologies are selected based on the EU share of patents that are of high value. US and China shares are shown for the same technologies only. Percentages show each region's share of global high-value patents in those same technologies.

although it is not in the lead in these areas. In most of the other technologies shown, China or the US account for significantly larger shares of global high-value patents. China stands out in battery waste management, energy resilience systems, power system support and industrial energy efficiency technologies related to metal and mineral processing, while the US is stronger in CCUS mineral processing and battery aeronautics (Figure 4.3-6).

When going into more technological detail, a similarly selective pattern can be seen. Within clean and renewable technologies, the EU's high-value patent profile is strong for hot-water heat pumps, wind power and electrolytic hydrogen production. However, its strengths do not always translate into global leadership. In several technologies in this area, China or the US account for larger shares of global high-value patents, especially in battery and fuel cell recycling, offshore wind turbines, hydrogen production and hydrogen distribution. This suggests that the EU is very strong in some areas but that the overall picture is mixed (Figure 4.3-7).

Deployment is more limited than innovation

The EU's deployment and manufacturing position is more uneven than its innovation base. It remains well placed in clean tech R&I, but production and market deployment evidence gives a more mixed picture. The EU net-zero industry continues to face

difficulties in maintaining global market shares, while China dominates production in key sectors. At the same time, EU renewable energy turnover and gross value added have grown, but manufacturing performance remains mixed: production has expanded in batteries, heat pumps and fuel cells but has declined in areas such as bioenergy and PV. Trade deficits remain especially visible in solar PV and batteries, while trade in wind and district heating is in a stronger position. This confirms that clean tech competitiveness depends not only on R&I strength but also on manufacturing scale, value chains, investment and market conditions (Georgakaki *et al.*, 2025; Bianchini *et al.*, 2025; Dahlström, 2025; European Commission, 2025k).

The gap between deployment and manufacturing is particularly visible in scale-intensive hardware segments. In solar PV, the EU remains a major deployment market, but manufacturing is highly exposed to Chinese dominance, with 91 % of commissioned manufacturing facilities located in China. In batteries, China accounts for more than 85 % of global commissioned manufacturing capacity, compared with about 7 % for the EU. The stationary storage market shows a similar imbalance: China accounted for around 60 % of new global battery energy storage installations in 2023, compared with 12 % for the EU. These are fast-growing markets, but they are also markets where cost competition, manufacturing depth and supply chain control have a strong influence on global positioning (Bielewski *et al.*, 2024; European Commission, 2025k).

The EU's position is stronger, but still under threat, in several system and enabling technologies. Wind remains one of the main areas of EU industrial strength, although its global market share is under pressure from lower-cost competitors. The situation is similar for heat pumps, with EU manufacturers leading in high-end domestic and industrial solutions and final assembly capacity broadly aligned with 2030 deployment needs. However, the sector still depends on imported components, including compressors, and European heat-pump sales have recently fallen. Grid technologies are another area where the EU has long-standing market and technology leaders, but manufacturing depends on materials such as copper, aluminium and grain-oriented electrical steel, and international competition is expected to intensify (European Commission, 2025k; Georgakaki *et al.*, 2025; Volt *et al.*, 2025).

For emerging decarbonisation technologies, the bottleneck is less about mass manufacturing alone and more about creating complete value chains and bankable projects. In fuel cells, installed capacity in Europe was around 0.6 gigawatts in 2023, or 7.7 % of the global total, while Asia remained the main deployment centre. In CCUS, the global project pipeline is expanding, and EU public support is significant, but the sector is not yet operating at scale and still lacks specialised value chains. Deployment depends on infrastructure, business models and market formation, including CO_2 transport and storage hubs, clearer demand for storage and stronger coordination across capture, transport, utilisation and storage (Weidner *et al.*, 2025; Martinez Castilla *et al.*, 2025; European Commission, 2025a). In energy-intensive industries there is already an active pipeline of industrial decarbonisation demonstrators, especially in iron and steel, chemicals, and cement, lime and magnesia. The main routes include renewable hydrogen use, electrification, CCUS, circularity and energy efficiency, but deployment remains constrained by permitting, infrastructure and financing risks for first-of-a-kind plants.

Energy infrastructure is becoming a deployment bottleneck in its own right. As electrification accelerates, clean tech deployment depends increasingly on grids, interconnectors, flexibility, storage and digitalised grid management. Batteries and solar PV remain exposed because they combine rapid deployment with strong manufacturing scale effects and supply chain concentration. Heat pumps are less affected but still require component supply, installation capacity and stable demand. Hydrogen and CCUS require infrastructure, offtake arrangements and clearer market frameworks. The issue is therefore not only whether the EU can develop clean technologies but whether it can scale them under tightening manufacturing, supply chain and infrastructure conditions (Georgakaki *et al.*, 2025; Bielewski *et al.*, 2024; Martinez Castilla *et al.*, 2025; European Commission, 2025k).

Market formation reinforces this picture. Making the business case for many innovative clean energy and industrial decarbonisation technologies remains difficult because they are more costly, more infrastructure dependent or less mature than incumbent solutions. The EU's 2040 and 2050 climate targets, together with sectoral regulation and instruments such as the *Net-Zero Industry Act*, provide an important demand signal. However, targets alone do not create bankable projects. Scaling also depends on credible markets, permitting, offtake arrangements, grids, CO_2 transport and storage infrastructure, hydrogen networks and the ability to reduce investment risks. The deployment challenge is increasingly a market-and-infrastructure challenge: the EU needs to turn long-term policy direction into bankable projects and industrial capacity (Bielewski *et al.*, 2024; European Commission, 2025k; Georgakaki *et al.*, 2025; Martinez Castilla *et al.*, 2025; Weidner *et al.*, 2025).

EU policy toolbox

The EU policy mix in this area is increasingly about connecting R&I strengths with markets, industrial capacity and infrastructure. The policy challenge is not only to develop better technologies but to make them attractive to investors. Current instruments include, Horizon Europe, notably Cluster 5 'Climate, Energy and Mobility', which supports clean energy R&I from research to demonstration and first industrial application, alongside public-private partnerships such as the Clean Hydrogen Partnership and BATT4EU. *The Strategic Energy Technology Plan* and the European Institute of Innovation and Technology communities help coordinate priorities and support uptake (European Commission, 2024b; 2025j). On deployment and manufacturing, the *Net-Zero Industry Act* and the *Renewable Energy Directive* provide key frameworks for scaling EU production and uptake of net-zero technologies. The Innovation Fund, including Hydrogen Bank auctions; the Modernisation Fund; and Important Projects of Common European Interest (IPCEIs) in batteries and hydrogen support first-of-a-kind projects, clean tech manufacturing and value chain development. The Innovation Fund is financed through revenues from the EU Emissions Trading System (ETS). Innovation and green public procurement are also increasingly recognised as tools to help create lead markets, although their use remains uneven (European Parliament and the Council of the European Union, 2023a; 2024d; European Commission, 2023a; 2024c).

On finance and framework conditions, InvestEU, EIB Group instruments and the European Innovation Council help mobilise investment for deep tech and net-zero scale-up. Public finance is not a substitute for market demand, but it can help crowd in private investment where upfront costs are high, demand is uncertain or infrastructure risks are still significant. The EIB Group plays an important role through venture debt, venture capital and other risk-sharing instruments, while the Innovation Fund supports the transition from demonstration to industrial deployment. By the end of 2023, the Innovation Fund had committed around EUR 6.5 billion in grants and had 104 projects under implementation. The Strategic Technologies for Europe Platform (STEP) and the proposed European Competitiveness Fund aim to strengthen support for critical technologies, including clean tech. Regulatory experimentation, including sandboxes for smart grids, flexibility markets and storage, is also being used to test solutions before wider roll-out (European Parliament and the Council of the European Union, 2021a; European Commission, 2021; 2023d; 2024a; 2025g; EIB, 2026).

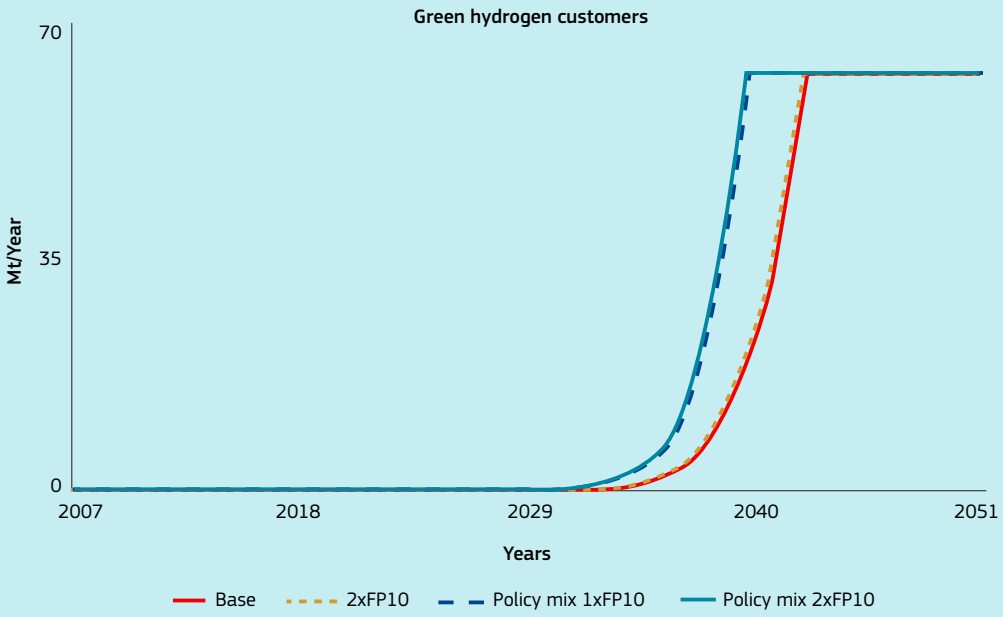
Box 4.3-2 Green hydrogen: from research to market

The case of green hydrogen shows why clean tech deployment cannot rely on R&I funding alone. Research support can improve core technologies such as electrolysis and on-site storage, but deployment depends on whether projects have a credible business case. This requires demand, offtake, infrastructure, lower financing risks and a narrower cost gap to incumbent fossil-based solutions.

The EU policy mix has therefore moved beyond upstream R&I. The 2030 targets for renewable hydrogen production and imports, demand-side provisions under the *Renewable Energy Directive* and instruments such as the European Hydrogen Bank are all designed to create market pull and reduce early-stage risks for projects (European Commission, 2022; 2023a).

Scenario simulations reinforce this point. Doubling Framework Programme (FP) R&I support alone produces limited deployment gains compared with a broader policy package. Stronger results come when R&I support is combined with measures that improve firm uptake of research results, reduce financing costs and support deployment conditions. The main message is therefore not that R&I is unimportant, but that R&I needs a market to land in. For green hydrogen, demand creation and investment conditions are decisive for turning technological progress into projects, production and use (Czermainski de Oliveira and Cavicchi, 2025).

Figure 4.3-8 Green hydrogen adoption under alternative EU policy mixes



Science, Research and Innovation Performance of the EU 2026

Source: Czermainski de Oliveira and Cavicchi (2025).
Note: Model simulation results for EU green hydrogen adoption under alternative EU policy mixes. Adoption is expressed in million tonnes (Mt)/year.

3. Digital transition

Digital technologies and infrastructures are major enablers of productivity and innovation and are therefore foundations of European competitiveness. The EU digital industrial ecosystem, covering information and communication technology (ICT) manufacturing, telecoms, software, publishing and related services, employed around 6.6 million people and generated around EUR 674 billion in value added in 2019. More broadly, the EU counted 10.3 million ICT specialists in employment in 2024, equal to 5 % of total employment (European Commission, 2023c; 2025e). The strategic challenge is to strengthen the EU's ability to develop and scale key digital technologies, while accelerating uptake across firms and public services and reducing excessive dependencies in critical parts of the digital stack, notably semiconductors, cloud and compute infrastructure (European Commission, 2025l; 2025e). These vulnerabilities matter because they affect both value capture and strategic control. The EU's corporate R&D and intangibles base remain weaker than those of its main competitors. According to the Digital Decade evidence base, between 2014 and 2023, the EU's share of global digital R&D fell from around 13.7 % to 8.9 %, while the number of EU-headquartered large digital R&D investors is limited (European Commission, 2025e).

Upstream technological dynamics

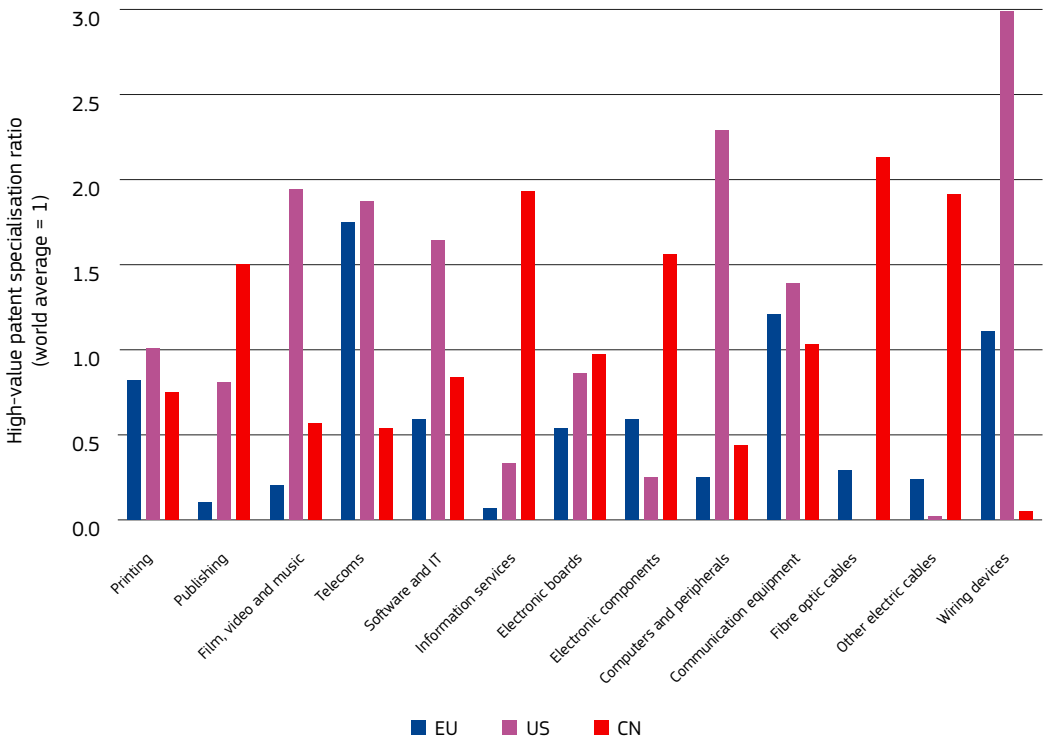
R&I is a strategic factor in this policy area because it shapes both technological leadership and diffusion capacity. It supports enabling technologies and intangible assets such as software, data, algorithms and design capabilities and helps translate them into deployable solutions through testing and pilots. The challenges the EU faces are related not only to the scale of corporate R&D but also to the strength of its intangible base in key digital technologies. Investment in intangibles continues to grow but remains sensitive to uncertainty, while the fast development of AI models is likely to raise future investment needs in innovation, data centres and energy (Calza *et al.*, 2023; European Commission, 2025e; EIB, 2026).

Similar issues apply to high-value patenting. The EU remains present across a broad range of digital activities but rarely holds the largest global share (Figure 4.3-9). Its strongest specialisations appear to be in telecommunications, communication equipment and wiring devices - in all of which the EU retains a high global share - with telecommunications standing out most clearly (Figure 4.3-9). By contrast, the EU is less specialised in software and IT, information services, computers and peripherals, fibre optic cables and other electric cables. The US has a broader and often stronger specialisation profile across software-, content- and device-related activities, especially in film, video and music; software and IT; computers and peripherals; wiring devices; and telecommunications. China is more specialised in several hardware- and infrastructure-related segments, notably publishing, information services, electronic boards, fibre optic cables and other electric cables, while also remaining well positioned in communication equipment. Taken together, the pattern suggests that the EU's strengths in these activities are concentrated in telecoms and selected communications hardware, while the US is stronger in software and device-linked activities, and China has a higher level of specialisation across a wider set of hardware and connectivity inputs.

From R&I to deployment

The main deployment challenge in this set of activities is diffusion at scale. Firms and public services do not only need access to digital technologies; they also need the skills, infrastructure and organisational capacity to use them effectively. AI adoption illustrates both the opportunity and the gap that exist. EU firms' use of big data analytics and AI is broadly comparable to that of US firms, and AI adoption has already made a visible contribution to productivity growth in Europe (EIB, 2026). At the same time, uptake remains highly uneven across firms. Larger firms are much more likely to use digital technologies than very small ones, and the gap is particularly wide for big data analytics and AI. European firms also tend to use generative AI more narrowly across business functions than US firms, suggesting that many are still deploying it selectively rather than at scale. A good example of AI adoption is a targeted EU initiative called OceanEye: the EU Ocean Observation Initiative. This initiative will support EU ocean technology and innovation and will position the EU at the forefront of international efforts to deliver a sustained global ocean observing system.

Figure 4.3-9 Relative specialisation index in high-value patenting by digital transition activity, EU, US and China, cumulative 2000–2023



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on the DG Research and Innovation internal RDI database developed by Idea Consult, drawing on PATSTAT and Technote data.

Note: Values above 1 indicate relative specialisation in that activity. Only distinct patent families are counted. Years are based on patent priority dates.

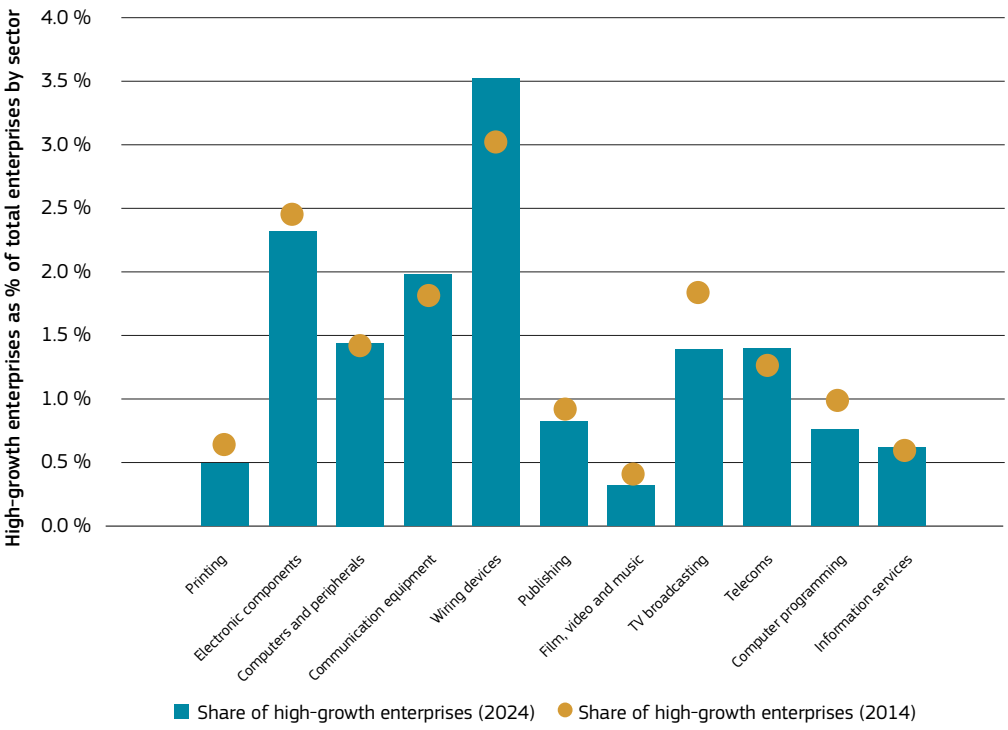
Progress remains uneven across the wider economy. In 2023, only 56 % of individuals had at least basic digital skills. In 2024, 74 % of enterprises reached at least a basic level of digital intensity, but uptake of more advanced technologies remained lower: 45 % had bought cloud services, and 13 % used at least one AI technology. As regards gaps between large firms and SMEs, 70.1 % of small enterprises reached at least basic digital intensity levels, compared with 98 % of large enterprises, while 11.2 % of small enterprises used at least one AI technology, compared with 41.2 % of large enterprises (European Commission, 2025l).

Infrastructure and compute remain key bottlenecks. Advanced fixed connectivity still shows a clear urban-rural divide, and uptake lags behind availability: only 22.3 % of fixed broadband subscriptions were at speeds of 1 gigabit per second or higher in 2024. Data centre deployment also faces constraints linked to costs, permitting and access to energy, slowing the expansion of cloud and AI capacity (European Commission, 2025b). Strategic dependencies add a further layer. In cloud services, market concentration remains high and non-EU providers hold large shares in key segments. In semiconductors, vulnerabilities relate not only to fabrication capacity but also to where value is created, since design and software account for more than half of value added in finished chips, while wafer fabrication represents less than one fifth (Gros, 2024; European Commission, 2025e).

High-growth firm activity in the digital sector is spread across both manufacturing and service activities (Figure 4.3-10). In 2024, the highest shares were visible in wiring and wiring devices, electronic components and communication equipment, with computers and peripherals also ranking highly. Among service activities, relatively high shares were seen in TV broadcasting and telecommunications, while those in computer programming and information services remained more modest. This points to uneven scaling dynamics across the digital innovation related activities: some momentum is visible in selected hardware and connectivity-related activities, but it is not spread across the entire digital stack. Comparison with 2014 suggests mixed evolution rather than uniform strengthening. Shares increased most clearly in wiring and wiring devices and, to a lesser extent, in communication equipment, while TV broadcasting and computer programming were in weaker positions than a decade previously. Electronic components and computers and peripherals remained comparatively solid but without major change.

Taken together, the pattern suggests that the EU's growth dynamics in digital activities are scattered across specific niches rather than anchored in a broad and sustained scale-up push across either digital services or the deeper hardware base.

Figure 4.3-10 High-growth enterprises by sector in the EU, 2014 and 2024



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Orbis data extracted from the DG Research and Innovation internal RDI database developed by Idea Consult.

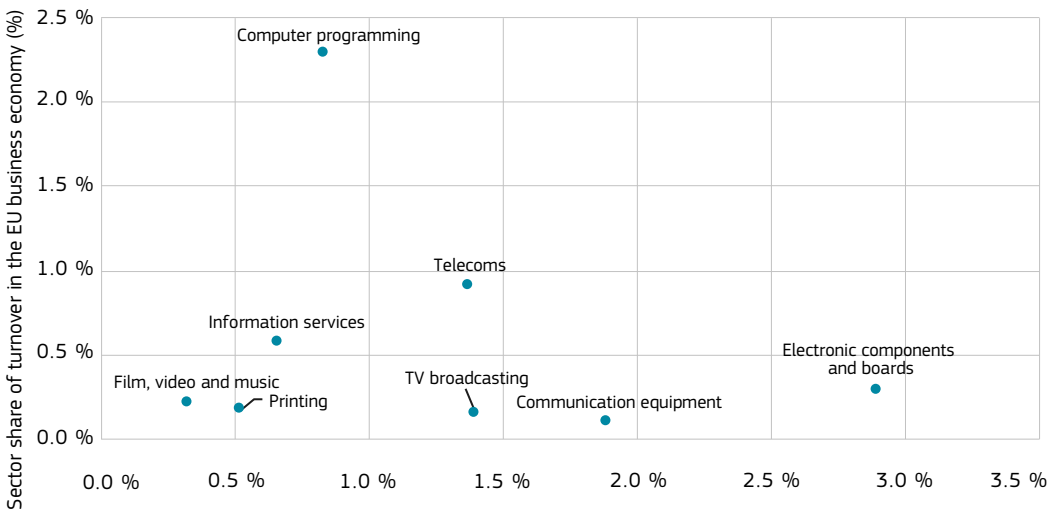
Note: The indicator is calculated as high-growth enterprises as a share of total enterprises in each sector. Dots show baseline values, mostly for 2016, and bars show latest available values, mostly for 2024. Where 2016 or 2024 data were not available, the nearest available year was used instead. Sector groupings follow the Eurostat/OECD technology- and knowledge-intensity classification.

Digital activities show high growth activity across both services and electronics-related activities, but the sectors with stronger firm growth intensity are not always those with the largest turnover (Figure 4.3-11). In 2023, electronic components and boards and communication equipment stood out for their relatively high shares of high-growth enterprises, despite their limited turnover. Computer programming, by contrast, dominated turnover among the activities shown, while posting a more moderate high-growth enterprise share. Telecoms occupied an intermediate position, combining sizeable turnover with a solid high-growth presence. Overall, the pattern points to an uneven relationship between current economic weight and firm growth dynamism across this policy area.

EU policy toolbox

The EU policy toolbox for the digital transition spans research, infrastructure, uptake and strategic capacity building. It is anchored in the *Digital Decade* policy programme, which sets common targets and supports coordination with Member States through national roadmaps, recommendations and multi-country projects. The main EU financing instruments are the Recovery and Resilience Facility, Cohesion Policy, Horizon Europe, the Digital Europe Programme and the digital part of the Connecting Europe Facility. Together, these support research and piloting, large-scale capacity building and uptake and the deployment of backbone and 5G networks needed for EU-wide digital services. InvestEU also supports private investment in digital projects (European Parliament and the Council of the European Union, 2022; European Commission, 2025e). In critical layers of the digital stack, the toolbox combines broad programmes with targeted strategic initiatives. The *European Chips Act*, through the Chips Joint Undertaking, supports pilot lines, design capacity and competence centres. The EuroHPC Joint Undertaking, AI Factories and InvestAI aim to strengthen the EU's compute and AI capacity, while IPCEIs support key digital infrastructures in areas such as microelectronics, communications and cloud. On diffusion, the Digital Europe Programme, particularly the European Digital Innovation Hubs network, supports uptake by SMEs and the public sector. European Digital Infrastructure Consortia help Member States build shared cross-border infrastructures. Framework conditions for uptake are also being reinforced, including through guidance linked to the *AI Act* (European Parliament and the Council of the European Union, 2023b; 2024c; European Commission, 2025e).

Figure 4.3-11 High-growth enterprises and economic weight of selected NACE activities in the EU, 2023



Science, Research and Innovation Performance of the EU 2026

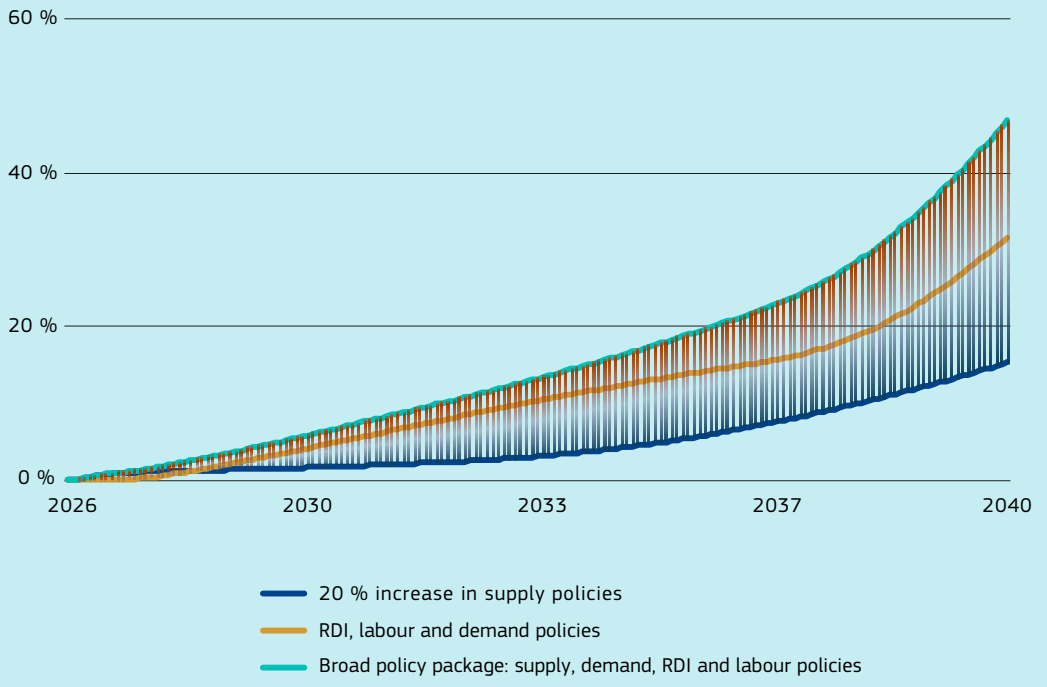
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Eurostat (DOI links: https://doi.org/10.2908/BD_HG and https://doi.org/10.2908/SBS_OVW_ACT).

Note: The x-axis shows high-growth enterprises as a share of total enterprises in each activity in 2024. The y-axis shows each activity's net turnover in 2023 as a share of total turnover in the EU business economy, covering industry, construction and market services and excluding public administration and defence, compulsory social security and activities of membership organisations. Computers and peripherals, wiring devices and publishing are not shown because turnover values are missing in the source.

Box 4.3-3 The case of the EU semiconductor R&I-to-deployment pipeline

Semiconductors are essential enabling technologies, but deployment is not only about manufacturing. It also depends on whether design, R&I, skills, finance, procurement, scale-up support and regulation work together along the entire pipeline. The analysis compares three policy packages: a supply-focused package; a demand, R&I and skills package; and a broad package combining both (Figure 4.3-12). The first focuses on lower costs, stronger public finance and industrial support and faster approval. The second combines EU R&I support, innovative public procurement, skills measures and stronger collaboration and diffusion conditions. The results show that all three packages support semiconductor development in the EU, but they work better together than separately. By 2040, the demand, R&I and skills package should increase development of semiconductor-enabled system modules in Europe by around 30 % relative to the baseline, compared with around 15 % for the supply-focused package. The broad package should increase it by around 45-50 %, showing that the strongest gains come when these measures are combined.

Figure 4.3-12 Increase in development of semiconductor-enabled system modules in Europe compared with baseline



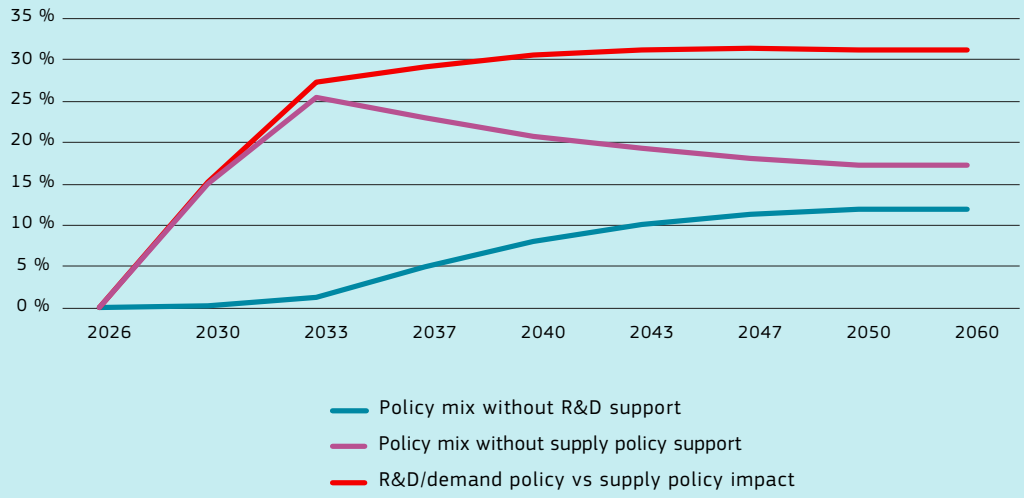
Science, Research and Innovation Performance of the EU 2026

Source: Czermainski de Oliveira and Cavicchi (2026, forthcoming).

Note: The figure shows the cumulative increase in development of semiconductor-enabled system modules in Europe relative to a baseline between 2026 and 2040: blue = supply-focused package; yellow = demand, R&I and skills package; green = broad package combining both. Because the indicator is cumulative, differences widen over time.

In advanced semiconductor nodes, the broad package performs better than a package without R&I and demand support, and the gap widens over time (Figure 4.3-13). This suggests that measures such as EU R&I funding, innovative public procurement, collaboration and skills development cannot replace industrial and scale-up support but do make it more effective. In other words, stronger deployment depends not on one lever alone but on linking technology development, talent, market pull and industrial scale-up.

Figure 4.3-13 Comparative impact of R&D, demand-side and supply side policy mixes on advanced semiconductors deployment



Science, Research and Innovation Performance of the EU 2026

Source: Czermainski de Oliveira and Cavicchi (2026, forthcoming).

Note: The figure shows the relative gain in advanced-node performance under alternative policy mixes. It compares the full policy package with cases in which either supply-side measures or the R&I-and-demand package are removed and compares supply only with R&I and demand only. The results point to a positive and growing contribution of the R&I-and-demand package within the broader mix.

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CHAPTER 4.4

DEFENCE AND SPACE R&I

Jan-Tjibbe Steeman

KEY QUESTIONS

- What are the global trends and the EU's position in defence research and innovation (R&I) investment? How is the EU's defence industry positioned?
- What are the potential benefits of increasing defence spending, especially on defence research and development (R&D)?
- What are the potential outcomes of investment in dual-use technologies and the space economy? How is the EU performing in these areas?

HIGHLIGHTS

- Beyond security objectives, higher defence spending can support economic growth in the short and longer term, especially when focusing on R&D investments.
- Meeting the new NATO targets could require the EU to increase its annual defence spending by at least EUR 384 billion by 2035.
- The increase in European defence investment is primarily driven by equipment procurement rather than R&D expenditure. The R&D share is rather limited and focuses on late-stage development, rather than on research and technology (R&T) demonstration.
- In the development of dual-use technologies, the EU is a global innovation leader in navigation and avionics, aerospace and propulsion and material processing, and also shows scientific strengths in quantum and additive manufacturing.
- In recent years, there has been a reorientation of global arms flows towards Europe, with European countries among the main global importers, driven by the war in Ukraine, and the EU Member States combined the second largest exporter.
- Over the last few years, European defence equipment procurement emphasizes European systems, although US systems still dominate in some segments. European defence companies are well positioned and outpacing US and Chinese firms in revenue growth, but venture capital (VC) investment levels trail those of the US.
- Europe's share in global space investments and orbital launches is limited and declining. Moreover, Europe's space investments are heavily skewed towards civilian purposes, in contrast to the rest of the world, which prioritises defence purposes.

POLICY INSIGHTS

- Rising defence spending puts pressure on the fiscal space of EU Member States, making efficiency and impact essential. The EU's defence spending shows signs of fragmentation, which could limit efficiency, interoperability and cost-effectiveness.
- Limited defence R&D investments could weaken the EU's position in future technologies and innovations, which could compromise its sovereignty and economic growth.
- The development of dual-use technologies can generate economic and societal spillovers but it requires balancing of R&I openness and risk management.
- The recent surge of global orbital launches presents new policy considerations for Europe to speed-up the launch capacity to keep pace with the global trends, while balancing environmental sustainability, and orbital safety and congestion.

As geopolitical tensions continue to shape global coalitions, the EU's security and defence policy has become a central topic in political discussions. With ongoing conflicts heavily affecting the EU and technological advancements influencing how conflicts are conducted, the role of dual-use and defence research and innovation (R&I) in strengthening the EU's strategic autonomy and resilience requires closer attention. The space sector is closely related to defence, with economies trying to secure access to and control over space. Many economic sectors of the economy, including defence, also increasingly rely on space-related services and data. The growing prominence of dual-use technologies, which have both civilian and defence applications, has become a defining feature of contemporary defence readiness. The *Preserving Peace – Defence Readiness Roadmap 2030* underlines that technological innovation and iteration, built on dual-use solutions and developed at speed and scale, will dictate strength on the battlefield, affirming that innovation is a critical component of Europe's defence readiness (European Commission, 2025a). But with global military budgets rising (IMF, 2026b), often financed through public budgets, the macroeconomic impacts of defence-related public expenditure require careful consideration. This section will explore these topics in detail, focussing on the R&I dimension to understand the EU's current performance and pathways in a global perspective.

1. Investing in defence R&D can lead to positive long-term economic impacts

When taking account of both demand-side and supply-side channels, the literature shows that defence multipliers are positive but heterogenous. The defence spending multiplier measures the change in gross domestic product (GDP) generated by an increase in government defence expenditure, capturing both demand-side effects (public procurement, wages and investment) and supply-side channels (productivity, innovation and impact on private investment). The literature generally finds that short-term defence multipliers are positive on average – between 0.6 and just above 1 – but highly heterogeneous, depending on composition, macroeconomic conditions, domestic absorption and fiscal space (OECD, 2026; IMF, 2026a; European Central Bank, 2025; European Commission, 2025b).

Key determinants of heterogeneity of defence spending are domestic absorption capacity, the macroeconomic situation and fiscal space. Multipliers are larger in economies with low import intensity, sufficient fiscal space and high public investment efficiency, whereas less promising conditions lead to substantial leakage through imports and weaker transmission. This implies that economies with greater domestic industrial and supply-chain depth, particularly those with more developed defence-industrial bases, are better positioned to generate higher multipliers (IMF, 2026a; García-Serrador *et al.*, 2025; European Central Bank, 2025).

Defence R&D is associated with large long-term growth effects, generating technological spillovers and productivity gains, while spending on personnel and equipment drives short-term demand. A key insight is that the macroeconomic impact of defence spending depends on its composition. Equipment spending and capital-intensive procurement can generate strong positive short-run demand effects, but these effects can be offset by high import content and implementation lags. Additionally, personnel expenditure can generate immediate demand effects through wages and consumption, but contributes little to long-term productivity (IMF, 2026a; García-Serrador *et al.*, 2025). This contrasts with R&D-related defence spending, which is closely linked to medium- and long-term growth. Studies show that defence-related R&D spending generates substantial productivity gains through innovation spillovers and industrial upgrading (Moretti *et al.*, 2025; Antolín-Díaz and Surico, 2025; European Central Bank, 2025; European Commission, 2025b).

2. New NATO targets will provide room for substantial EU defence investments

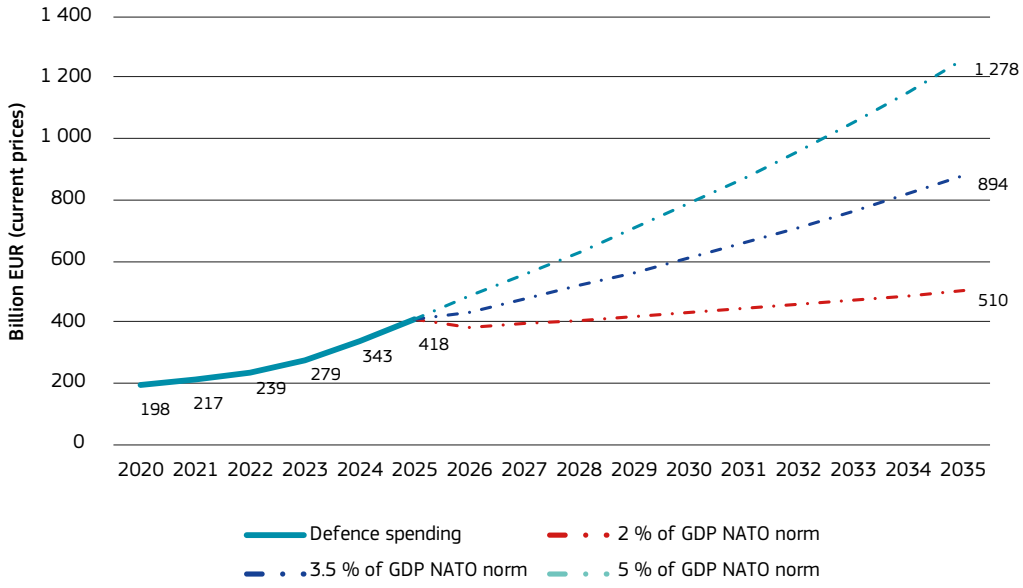
Geopolitical tensions have pushed EU Member States to increase their defence expenditure, and this has been further reinforced by new NATO targets. In recent years, EU countries have intensified efforts to meet NATO's long-standing thresholds of allocating 2% of GDP to defence spending (EDA, 2025). During the 2025 NATO summit in The Hague,

new targets were set, with the aim of reaching annual defence spending of 5% of GDP by 2035, encompassing both core defence requirements and broader security-related expenditure. This includes a minimum of 3.5% of GDP dedicated to core defence spending, alongside up to 1.5% allocated to wider security priorities (NATO, 2025).

Increasing defence spending from 2 % to 3.5 % of GDP will require approximately EUR 384 billion in additional annual defence spending by 2035 for EU Member States. As illustrated in Figure 4.4-1, at the 3.5% threshold, total EU defence spending would rise to an estimated EUR 894 billion by 2035, compared to EUR 510 billion with the 2% threshold. This would represent an increase of EUR 384 billion in annual defence spending. Reaching the 5% benchmark would entail annual spending of EUR 1 278 billion by 2035, an increase of EUR 768 billion annually compared to the 2% level. Currently, based on EDA data, the Member States of the EU have a combined defence spending of 2.2% of GDP, putting the EU on a trajectory towards the upper curve (5% benchmark).

Increasing defence budgets from 2% to 3.5% of GDP could also increase defence investments, which could reach EUR 268 billion by 2035. Under the new NATO expenditure norms, a substantial portion of the additional spending is expected to be directed towards defence investment, encompassing both equipment procurement and R&D. Based on the NATO guideline of 20% as a lower bound and the current EU investment share of approximately 30% as an upper bound (see Figure 4.4-6), total annual defence investments is projected to range from EUR 179 billion to EUR 268 billion by 2035, considering the 3.5 % of GDP threshold. The additional 1.5% of GDP allocated to broader security-related expenditure under NATO's revised framework could provide further fiscal space to reinforce investments.

Figure 4.4-1 Defence expenditures of EU Member States for the previous and new NATO norms



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on EDA and Eurostat (DOI link: https://doi.org/10.2908/NAMA_10_GDP).

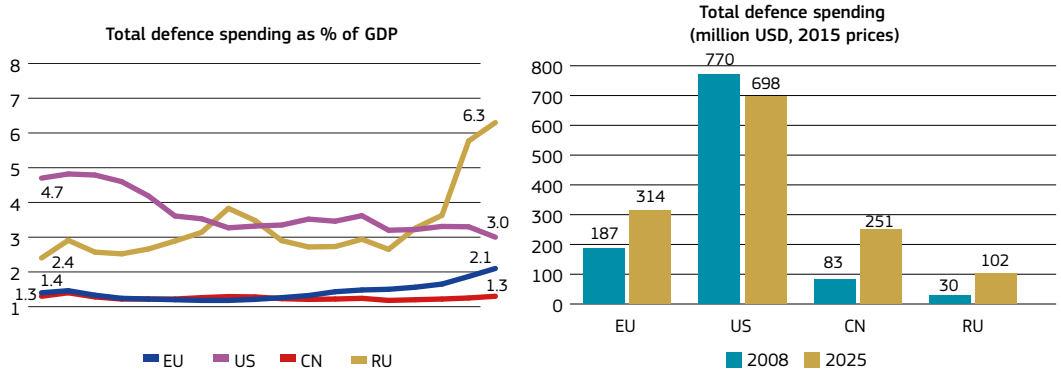
Note: For the years 2025–2027, DG Economic and Financial Affairs forecasts on GDP growth and inflation are used. For the years 2028–2035, 1% GDP growth and 2% inflation are assumed. A linear phasing-in of the new norms is assumed.

The EU has provided temporary fiscal flexibility to support the upward trajectory of Member States' defence spending. Under this framework, Member States are permitted to temporarily deviate from established budgetary rules to increase defence expenditure. The National Escape Clause allows Member States, between 2025 and 2028, to exceed agreed limits on net public expenditure without being deemed to be in breach of the *Stability and Growth Pact* (SGP). During this period, additional defence spending may surpass the usual fiscal thresholds by up to 1.5% of GDP annually, thereby creating the necessary fiscal space to address emerging security challenges (European Commission, 2025c).

3. Geopolitical instability drives EU defence spending and arms trade

Despite sustained efforts by EU Member States, other major international powers, particularly the US, continue to outpace the EU in defence spending. In 2025, the EU allocated approximately 2.1% of its GDP to defence, a share below those of Russia and the US, which spent 6.3% and 3.0% of GDP, respectively, but ahead of China at 1.3% (see Figure 4.4-2, left)[1]. The EU's defence spending share shows a gradual upward trajectory, while Russia has intensified its defence spending in recent years. The US share has remained at around 3% of GDP over the long term, though a slight decline has been reported in recent years. In real terms (Figure 4.4-2, right), US defence spending has declined modestly, yet the country remains the world's largest defence spender, at close to USD 700 billion in 2025, followed by the EU (USD 314 billion), China (USD 251 billion), and Russia (USD 102 billion). The European Defence Agency (EDA) (2025) highlights that, although the EU collectively spends more than China and Russia, these countries – along with the US – likely achieve greater cost-effectiveness due to lower domestic prices, streamlined procurement and higher efficiency.

Figure 4.4-2 Defence spending, EU, US, China and Russia, 2008–2025



Science, Research and Innovation Performance of the EU 2026

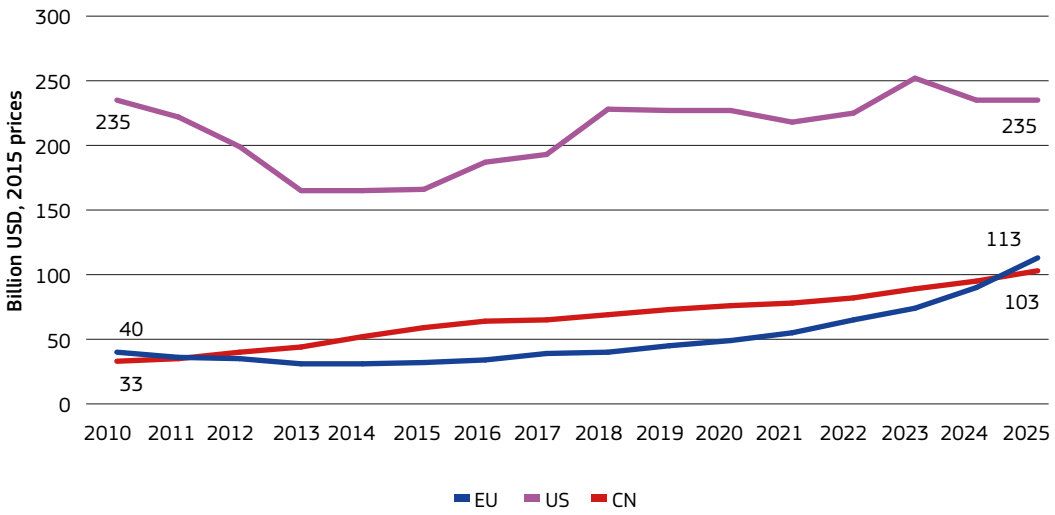
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on DG DEFIS extractions of the IISS Military Balance+.

Note: Defence spending is measured as each country's total defence budgets.

1 Defence data is difficult to assess and compare across databases because of differences in methodologies and data collection practices. Therefore, comparisons and trend analyses are conducted within, rather than across, databases.

Defence investments in the EU have increased in recent years, surpassing the current benchmark and somewhat closing the gap with the US. These investments, which include equipment procurement and R&D expenditures, are important to ensure technological leadership and advancements in the innovative capacity of the EU Member State defence forces. As illustrated in Figure 4.4-3, the US leads in global defence investment, with a somewhat stable budget of around USD 235 billion. The EU has shown a progressively upward trend over the last decade, rising from USD 32 billion in 2015 to USD 113 billion in 2025. This amounts to approximately one third of total EU defence expenditure, notably exceeding the 20% investment benchmark agreed by NATO in the 2014 Wales Summit Declaration (NATO, 2014), as well as the EU's 20% Permanent Structured Cooperation (PESCO) collective investment benchmark (EDA, 2025). China's defence investments have increased more steadily than those of the EU, from USD 59 billion in 2015 to USD 103 billion in 2025, and are currently on a lower growth trajectory.

Figure 4.4-3 Defence investments, EU, US and China, 2010–2025



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on DG DEFIS extractions of the IISS Military Balance+.

Note: Defence investment is measured by the sum of budgets for defence equipment procurement and defence R&D

Germany and France have the largest defence expenditures in the EU, though in relative terms, Poland, Lithuania, Latvia and Estonia spend the most, each exceeding the 3% of GDP threshold. In 2025, Germany and France accounted for the largest shares of EU defence spending, allocating EUR 107 billion and EUR 61 billion, respectively, together representing 40% of total EU defence expenditures (Figure 4.4-4). Italy (EUR 45 billion), Poland (EUR 40 billion), Spain (EUR 34 billion) and the Netherlands (EUR 27 billion) also made substantial contributions, which collectively accounted to an additional 35% of total EU defence spending. Relative to the size of their economies, Po-

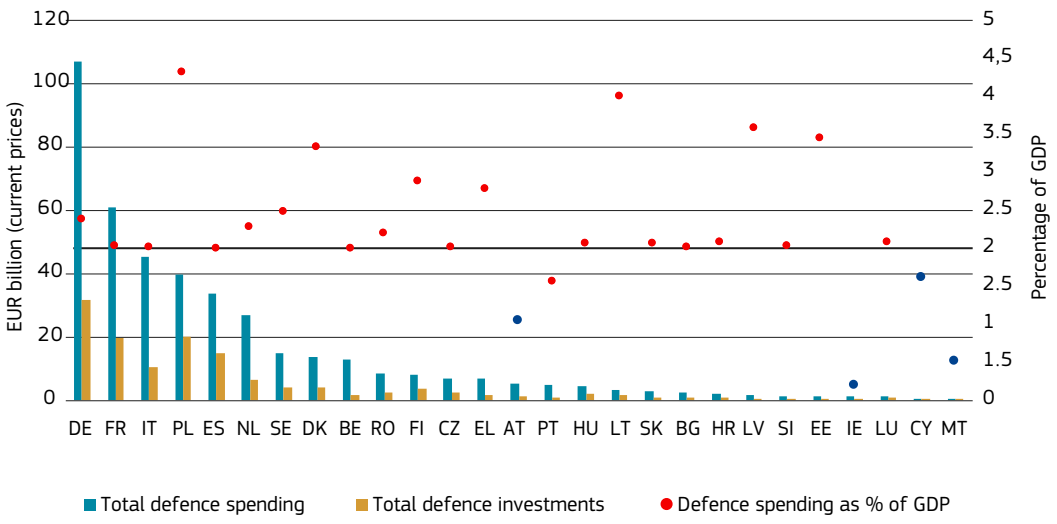
land (4.3 % of GDP), Lithuania (4.0 %), Latvia (3.6 %) and Estonia (3.5 %), have the most defence-intensive economies in the EU, while in contrast Ireland (0.2 %) and Malta (0.5 %) remain below 1 % of GDP. Overall, 22 Member States allocated 2 % of GDP or above to defence in 2025, up from six in 2022.[2]

In the EU, Germany, France and Poland make the largest investments in defence, followed by Spain, Italy and the Netherlands. In 2025, Germany, France and Poland allocate EUR 32 billion, EUR 20 billion and EUR 20 billion, respectively, to defence investments, with Spain (EUR 15 billion), Italy (EUR 11 billion) and the Netherlands (EUR 6 billion), and also contributing substantially (see Figure 4.4-4). Collectively, these six countries account for approximately 77 % of total defence investment by EU Member States.

Defence spending in the EU exhibits fragmentation as EU Member States do not manage defence expenditure as a single entity, unlike the US, for example. Instead, defence budgets are determined independently by 27 national governments. EDA (2025) shows that this pluriform and decentralised approach has led to the use a wide range of different weapon systems across key platforms, complicating joint operations, logistics, maintenance and training. For example, while EU countries, together, can field a larger number of major land-based weapon systems than the US, these capabilities are spread across models, limiting economies of scale and potentially reducing bargaining power.

The US remains the dominant global arms exporter, while EU Member States collectively also account for a substantial share

Figure 4.4-4 Defence spending and investments, EU Member States, 2025



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on EDA data.

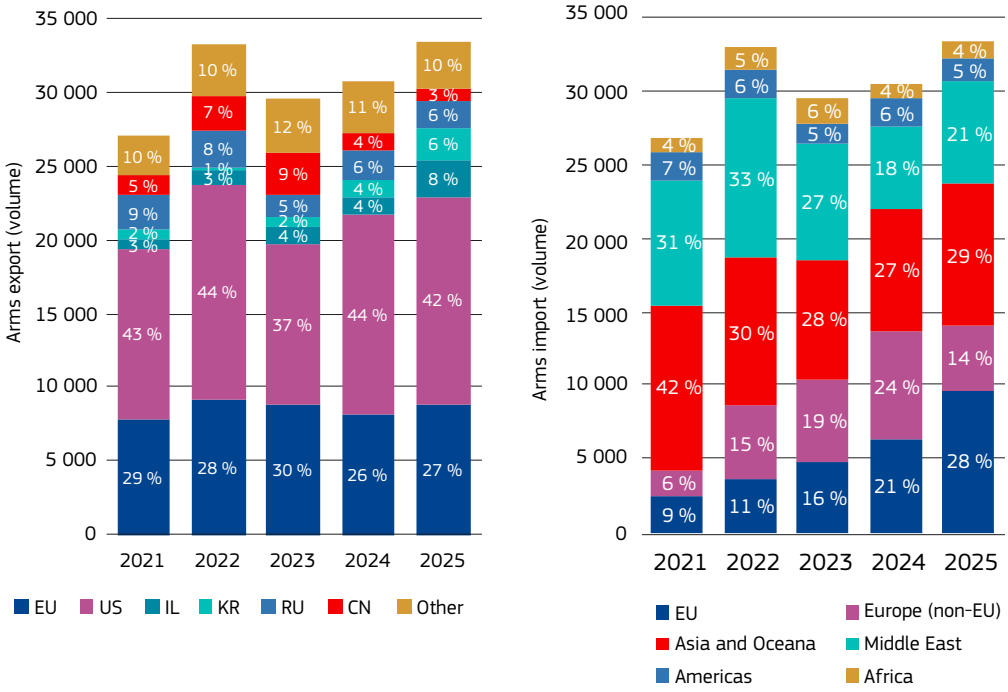
Note: Defence investments consist of defence equipment procurement and defence R&D. Defence spending and investments are measured in billion EUR current prices. Blue markers are non-NATO countries.

2 The EU Member States Austria, Cyprus, Ireland and Malta are not members of NATO.

of global exports, and Russia's position has declined over the past decade. The US accounted for approximately 42% of global arms exports in 2025, followed by EU countries with a combined share of 27%, while Israel, South Korea, Russia and China represent 8%, 6%, 6%, and 3%, respectively (Figure 4.4-5, left). Notably, Russia's share has declined significantly from nearly 30% in 2013, reflecting both geopolitical and industrial shifts in the global arms market. Within the EU, export activity is highly concentrated, with France, Italy and Germany jointly accounting for approximately 79% of EU's share of arms exports. These figures underscore the continued dominance of the US in global defence markets, while highlighting the EU's role as a major exporter.

European countries collectively account for a substantial share of global arms imports, with a sharp increase in defence imports since the start of the war in Ukraine. EU Member States accounted for approximately 28% of global arms imports in 2025, with an additional 14% going to other European countries, including the UK, Ukraine, and Russia (Figure 4.4-5, right). This marks an increase over 2021, when the EU's share stood at around 9%. The surge in European imports is driven by the war in Ukraine, reflected by Ukraine as world's largest arms importer in 2024. Conversely, the relative importance of other regions has declined. Asia and Oceania and the Middle East, which accounted for 42% and 31%, respectively, of global arms imports in 2021, saw their respective shares fall to 29% and 21%, by 2025. These trends point to a reorientation of global arms flows towards Europe in recent years. Nevertheless, Saudi Arabia and India were the two largest importers in 2025 globally.

Figure 4.4-5 Global arms exports and imports, 2021-2025



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on SIPRI Arms Transfers Database.

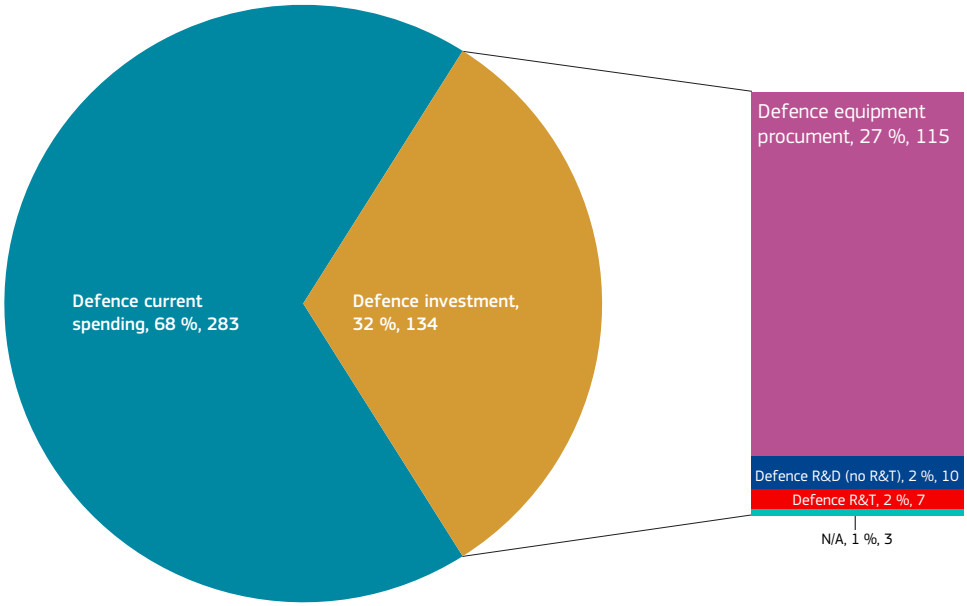
Note: Volumes expressed in millions of SIPRI trend-indicator values, which quantify the military capability of arms transfers rather than their financial value. Data includes both intra- and extra-regional transfers.

4. EU defence R&D is limited and focusses on the later stages of technological development

EU defence investments are primarily driven by equipment procurement rather than R&D expenditure, with a comparatively limited share of defence R&D. EU defence equipment procurement[3] amounted to EUR 115 billion in 2025, representing approximately 27 % of total defence spending (Figure 4.4-6). By contrast, spending on defence R&D[4], including R&T activities, totalled EUR 17 billion in 2025, corresponding to only 4 % of overall defence expenditures (Figure 4.4-6). The R&D share of total EU defence expenditure has remained largely stable in recent years, with similar levels reported in 2018. The US, in contrast, invested approximately EUR 138 billion in defence R&D in 2024, corresponding to around 16 % of its total defence spending (EDA, 2025).

Within the EU defence R&D portfolio, most spending goes towards the later stages of technology development and

Figure 4.4-6 **Distribution of EU defence spending, billion EUR, 2025**



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on EDA data.
Note: Defence investments consist of defence equipment procurement and defence R&D. Spending in current prices, shares reflect the percentage of total defence spending.

3 Defence equipment procurement expenditure includes expenditure for all major equipment categories (missile systems, missiles, aircrafts, artillery, combat vehicles, engineering equipment, weapons and small arms, transport vehicles, ships and harbour craft, electronic and communications equipment, etc.), that are not included in Operation and Maintenance spending.

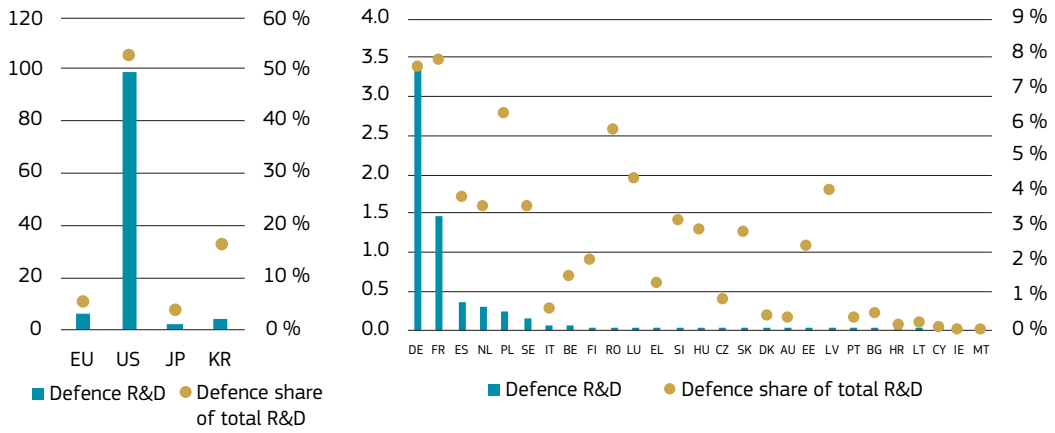
4 Defence Research and Development (R&D) expenditure refers to any payments up to the point where expenditure for production of items starts to be incurred. An element of judgement may be required in allocating expenditure between R&D and production costs. R&D costs should also include those for projects that do not successfully lead to production of equipment. R&D covers the whole scale of Technology Readiness Levels from 1 to 9. R&D includes R&T and defence equipment development expenditure.

production, rather than early-stage R&T demonstration. In 2025, approximately EUR 7 billion was allocated to the R&T component of R&D, while EUR 10 billion was directed to non-R&T activities (Figure 4.4-6). This distribution points to a focus on the maturation and production of defence technologies, rather than on basic research, applied research or technology demonstration.

Since 2022, European NATO countries have mainly procured European systems which signals a strategic emphasis on strengthening Europe's industrial base and knowledge capacity. Between 2022 and 2025, approximately 53% of procurement spending by European NATO countries was allocated to domestically systems or systems of European origin (IISS, 2025). This trend may reflect a strategic emphasis on strengthening Europe's industrial base and knowledge capacity. Nevertheless, US companies continue to dominate in certain sectors, including aerospace and artillery (IISS, 2025) as well as in critical technologies such as software, which could give rise to strategic vulnerabilities (Mejino-López and Wolff, 2025).

Of total public R&D budgets, the US allocates more than half to defence, while the EU allocates only a small fraction for this purpose. In the US, approximately 52% of the total public R&D budget, equivalent to around EUR 99 billion, goes to defence. By contrast, EU governments allocate a modest 5% share of their R&D budgets to defence, corresponding to just over EUR 6 billion. Elsewhere, South Korea devotes approximately 16% of its R&D budget (EUR 4 billion) to defence, while Japan allocates only around 3% (EUR 2 billion), reflecting its long-standing constitutional constraints on military development (see Figure 4.4-7). EU R&D spending on defence is highly concentrated in certain Member States, with Germany (EUR 3.4 billion) and France (EUR 1.5 billion) together accounting for approximately 77% of total government budget allocations to defence R&D within the EU, followed by Spain (EUR 0.4 billion), the Netherlands (EUR 0.3 billion) and Poland (EUR 0.3 billion).

Figure 4.4-7 Defence R&D expenditure, totals and shares, billion EUR, 2025



Science, Research and Innovation Performance of the EU 2026

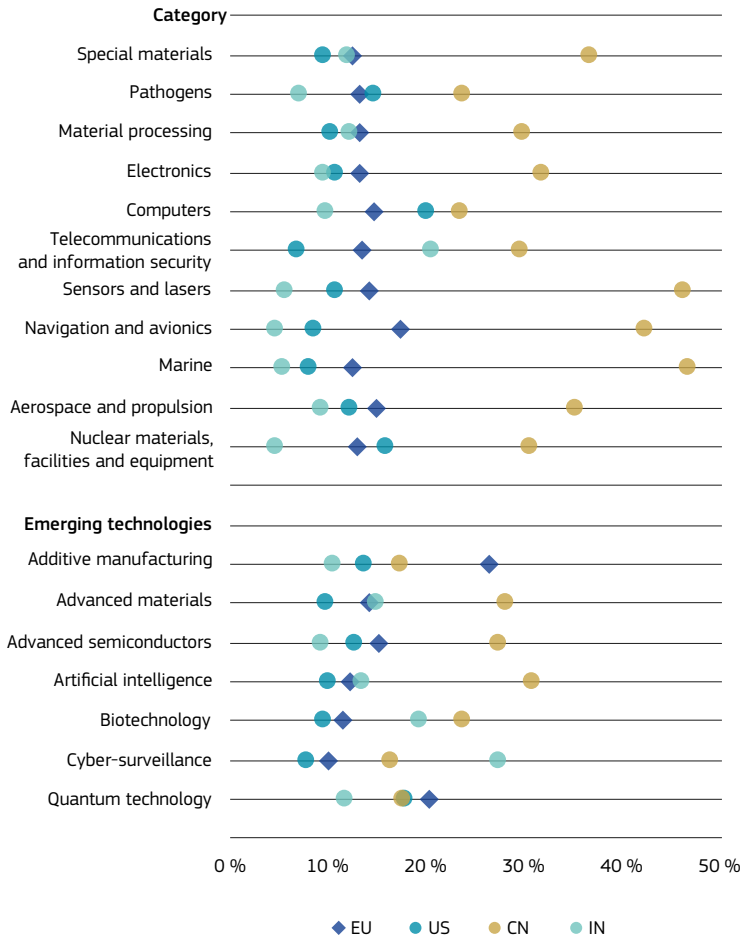
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Eurostat (DOI link: https://doi.org/10.2908/GBA_NABSFIN07).

Note: Billion EUR in current prices. Percentages are the share of the total public R&D budget allocated to defence. EU and US data is for 2024; that for Japan and South Korea is for 2023. No figures are available for China, and there is no recent data for the UK.

5. The EU's defence R&D capabilities display strong foundations for further development

The development of dual-use technologies can lead to economic and societal spillovers, while posing challenges related to international cooperation. Some examples of dual-use technologies are artificial intelligence (AI), biotechnology, advanced materials, aerospace systems and quantum computing (European Commission, 2024). These technologies can generate broad, cross-sectoral spillovers, enhancing productivity and supporting long-term economic growth, but they can also introduce security challenges, as their diffusion may facilitate unintended or adversarial use. At early stages, overlaps between civilian and military applications are common, generating wide-ranging yet relatively less targeted spillovers. As technologies mature, spillovers become more

Figure 4.4-8 The EU's scientific position in dual-use technologies, global scientific publication shares, 2021–2025



Science, Research and Innovation Performance of the EU 2026

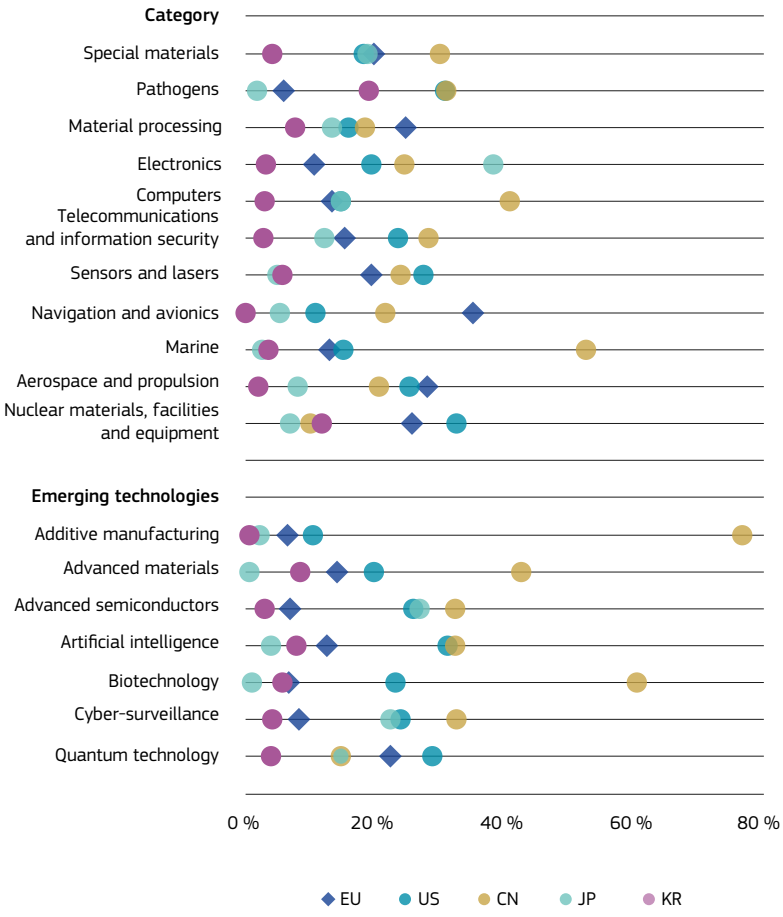
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on TIM dual-use database and Science-Metrix using Scopus (Elsevier).

Note: Shares based on the period from 2021 to November 2025. Patent data covers relevant dual-use applications only. The countries with the largest shares across technologies are presented. Fractional counting at affiliation level.

targeted, particularly in the mid- to high-technology readiness level (TRL) range, increasing both their potential economic impact and security sensitivity. Realising the full potential of dual-use technologies requires mobilising the whole innovation ecosystem, spanning basic research, applied R&I, technology development, and scale-up, and directing significant investments towards prevention of strategic dependencies and facilitation of cost-effective research, innovation, and procurement across the civil-defence axis. (European Commission, 2025d).

The EU shows scientific strength in several dual-use and related emerging and critical technologies, such as navigation and avionics, quantum and additive manufacturing, in which it is often positioned behind China and ahead of the US. The EU's scientific position in dual-use technologies is

Figure 4.4-9 The EU's innovation position in dual-use technologies, global patent shares, 2021–2023



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on TIM dual-use database and PATSTAT.

Note: Shares based on the period 2021–2023 as 2023 is the latest fully available year. Patent data covers relevant dual-use applications only. The countries with the largest shares across technologies are presented. Fractional counting at affiliation level. Country variable is based on applicant.

strong, with shares of global publications ranging from 12% for marine and special materials to 17% for navigation and avionics. Computers and aerospace and propulsion (both 15%) are among the other areas in which the EU's share is high (Figure 4.4-8). China is the frontrunner in all dual-use technologies, with its global shares of publications ranging from 23% for computers to 47% for marine, while the shares of the US range from 7% to 20% and those of India from 5% to 21%, also demonstrating a strong global presence. In emerging and critical technologies, the EU leads in two technologies: additive manufacturing with 26% and quantum with 20%; China leads in four: advanced materials, advanced semiconductors, AI and biotechnology; and India leads in one: cyber-surveillance.

The EU shows innovation strengths in most dual-use technologies and leads in the areas of navigation and avionics, aerospace and propulsion and material processing. Among dual-use technologies, the EU leads globally in patent shares in the areas of navigation and avionics (35%), aerospace and propulsion (28%) and material processing (25%) and has a strong presence in nuclear materials, facilities and equipment (26%) and special materials (20%) (Figure 4.4-9). In emerging and critical technologies, the EU performs less strongly on average but has a sizeable global share in quantum (22%). China leads in most dual-use and emerging and critical technologies, especially marine (53%), additive manufacturing (77%) and biotechnology (61%), while the US also has a strong presence in most technologies, especially nuclear materials, facilities and equipment (33%), quantum (29%) and sensors and lasers (27%).

Despite generally being ranked behind their US counterparts, European arms producers are relatively well positioned globally, and their revenues from arms sales are outpacing those of US and Chinese firms in relative terms. Figures from 2024 show that the arms production industry is mostly driven by US companies, led by Lockheed Martin, RTX and Northrop Grumman (see Table 4.4-1). European and Chinese companies also have a strong presence, with five of each in the top 20 global arms producers. Further analysis shows that, since 2022, European companies' sales revenues have surged. The top five European companies combined have outperformed the top five US companies and the top five Chinese companies in revenue growth over this period, with a 24% increase, compared to 11% and -15%, respectively. The operational experience of the defence of Ukraine, in which civilian deep-tech actors have played an important role in the rapid delivery of critical capabilities, has underscored the strategic importance of building synergies between established defence industry actors and the broader civilian technology sector across the full R&I ecosystem. The new defence industry players, mainly SMEs, small mid-caps, startups and scale-ups with a civilian deep-tech background, are central to the swift delivery of critical capabilities to the armed forces and to the transformation of the defence sector more broadly (European Commission, 2025e).

Table 4.4-1 Company arms sales, global top 20, million USD at 2024 prices, 2024

Rank	Company	Country	Arms revenues (2022)	Arms revenues (2024)	Revenue change 2022-2024	% change 2022–2024
1	Lockheed Martin	US	59 390	64 650	5 260	9
2	RTX	US	39 570	43 600	4 030	10
3	Northrop Grumman	US	32 300	37 850	5 550	17
4	BAE Systems	UK	26 480	33 790	7 310	28
5	General Dynamics	US	28 120	33 630	5 510	20
6	Boeing	US	29 300	30 550	1 250	4
7	Rostec	Russia	16 810	27 120	10 310	61
8	AVIC	China	20 620	20 320	-300	-1
9	CETC	China	21 820	18 920	-2 900	-13
10	L3Harris Technologies	US	12 630	16 210	3 580	28
11	NORINCO	China	22 060	13 970	-8 090	-37
12	Leonardo	Italy	12 840	13 830	990	8
13	Airbus	Trans-European	12 090	13 370	1 280	11
14	CSSC	China	10 440	12 330	1 890	18
15	Thales	France	9 420	11 800	2 380	25
16	HII	US	9 630	10 280	650	7
17	CASC	China	13 960	10 230	-3 730	-27
18	Leidos	US	8 240	9 370	1 130	14
19	Amentum	US	5 730	8 330	2 600	45
20	Rheinmetall	Germany	4 550	8 240	3 690	81

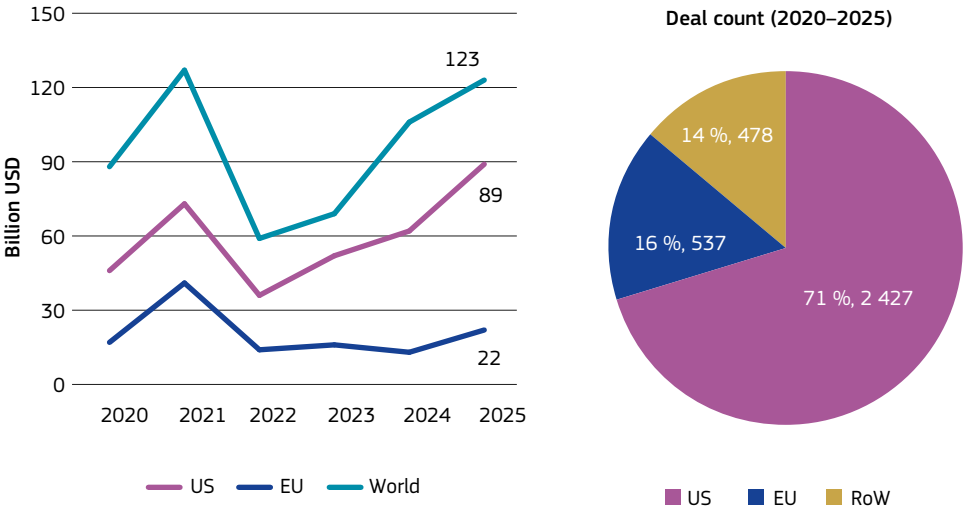
Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on SIPRI Arms Industry Database.

Note: EU companies are shaded in purple, and UK companies are in grey.

Venture capital (VC) investments in EU-based defence companies have been substantial in recent years, yet they continue to lag behind US levels. Global VC investment in defence-related companies totalled USD 123 billion in 2025, of which most was in the US (USD 89 billion), followed by the EU (USD 22 billion) (Figure 4.4-10, left). This mirrored the pattern from previous years. Globally, 2021 stands out as a strong year for VC investments. It was followed by a decline in 2022 and 2023 and a renewed surge in 2024 and 2025. This recent surge has been less noticeable in the EU, where the upward trend has been relatively small. The total number of reported deals (Figure 4.4-10, right) is largely aligned with the amount of capital invested. Over the period 2020–2025, 71% of deals (2 427 deals) were completed in the US, followed by 16% (537 deals) in the EU and 14% (478 deals) in the rest of the world (RoW). The RoW consists almost entirely of non-EU European countries and Canada.

Figure 4.4-10 VC investments in defence companies, 2020–2025



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on PitchBook (cut-off: 13 January 2026).

Note: Defence companies were identified based on PitchBook's broader vertical category of defence and aerospace. Note that due to rounding figures add up to 101 %.

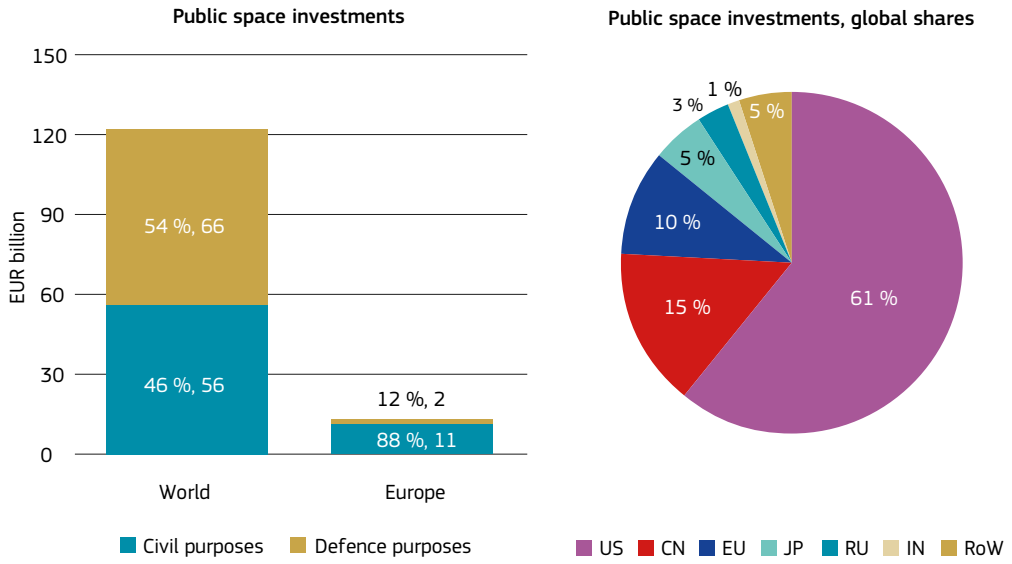
6. The EU's position in the space economy is being challenged at a global level

The European space economy is entering a new and important phase, driven by its dual-use nature and increasing strategic importance for civil, security and defence purposes. Space technologies support a wide range of civil and defence applications, including the monitoring of natural disasters, the strengthening of security and defence capabilities and the deployment of advanced digital, navigation and communication systems. Many of these technologies are inherently dual-use and thus reinforce Europe's technological sovereignty and resilience.

Europe's share of global public investment in the space sector is limited and declining, indicating that its space ambitions could be difficult to achieve. Global public space budgets (civil and defence) reached EUR 122 billion in 2024: a 9% increase compared to 2023. In Europe, the figure was EUR 13 billion: an increase of just 2% (see Figure 4.4-11, left). While, positively, new subscriptions for the European Space Agency (ESA) increased with 17% (corrected for inflation) during the 2025 convention compared to the previous period (European Space Agency, 2025b), the European share in public investments shows a decreasing trend globally, with a 10% share in 2024, compared to 15% five years ago. The US remains the largest public investor in the space economy with a 61% share, but its share has decreased from over 75% in 2000. Conversely, China's public investment has been increasing, with a 15% share in 2024, compared to 2% in 2000 (see Figure 4.4-11, right).

Europe's allocation of public investment in space is skewed towards civilian, rather than defence, purposes, in contrast to the

Figure 4.4-11 Global public space investments, 2024



Science, Research and Innovation Performance of the EU 2026

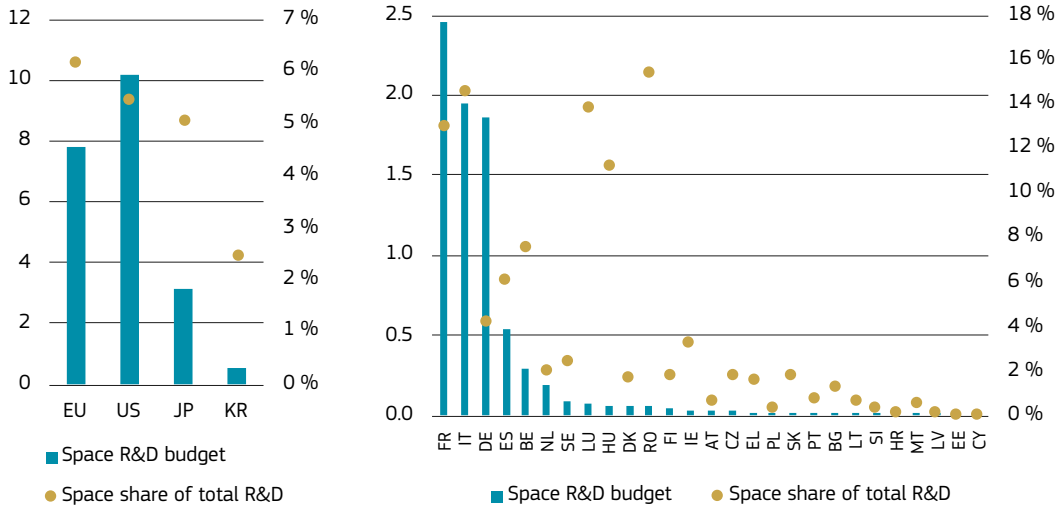
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on ESA (2025a).

rest of the world. In 2024, 88% of the total European space budget was allocated to programmes for civilian purposes, while worldwide, defence purposes were prioritised, accounting for a 54% share (see Figure 4.4-11, left). Globally, governments have favoured defence over civilian purposes in recent years. Consequently, the share of defence-related space expenditure has exceeded that of civilian-related space spending since 2022. In recent years, the EU is undertaking action to strengthen the space capabilities for governmental users, including military use cases, such as IRIS2, Galileo's Public Regulated Service (PRS) and the Commission has launched feasibility studies for an Earth Observation Governmental Service (EOGS). Additionally, ESA has also somewhat shifted from its core focus of peaceful use of outer space and is now working on dual-use capabilities as well, for example though its European Resilience from Space (ERS) programme.

Space transportation, science and earth observation are the ESA programmes receiving the most funding. Details from the November 2025 ESA ministerial meeting show that ESA members provided EUR 22.1 billion in contributions for the 2026-2028 period. Space transportation (contributions totalling EUR 4.7 billion), the scientific programme (EUR 3.8 billion) and earth observation (EUR 3.5 billion) are the programmes attracting most interest (European Space Policy Institute (ESPI), 2025).

The US is the largest public funder of space R&D, while the EU Member States follow closely and, relative to its overall R&D budget, places even greater emphasis on space than the US. In 2024, the EU Member states allocated close to EUR 8 billion to R&D efforts linked to space exploration and exploitation, closely behind the US with more than EUR 10 billion but ahead of Japan (EUR 3 billion) and South Korea (EUR 0.5 billion) (Figure 4.4-

Figure 4.4-12 Global public space R&D budgets, billion EUR, 2024



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Eurostat (DOI link: https://doi.org/10.2908/GBA_NABSFIN07).

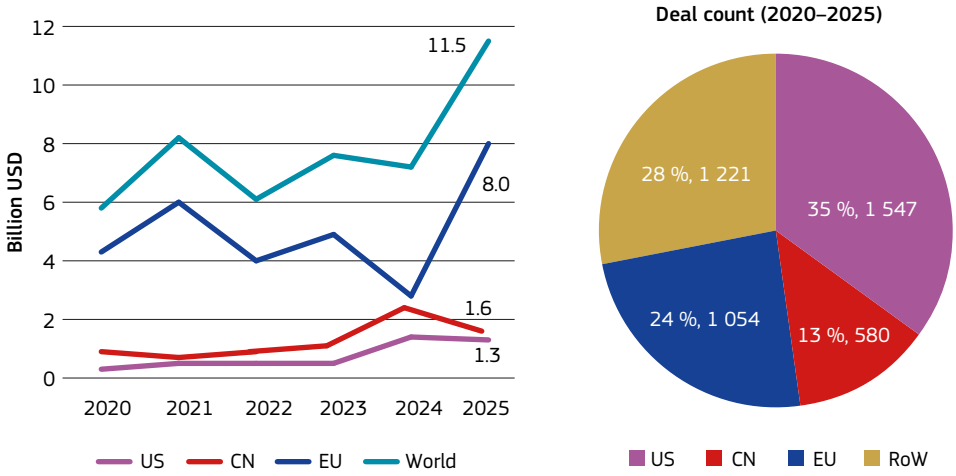
Note: For South Korea, the latest available year is 2023.

12, left). In allocating 6.1% of its overall R&D budget to space, the EU places, in relative terms, greater emphasis on space than the US, Japan and South Korea, whose allocations stand at 5.4%, 5.0% and 2.5%, respectively.

France, Italy and Germany account for most of the EU's space R&D budget. Investments in space R&D are very concentrated in the EU, with France (EUR 2.5 billion), Italy (EUR 2.0 billion) and Germany (EUR 1.9 billion) playing the leading role (Figure 4.4-12, right). These three countries account for 80% of EU government budget allocations to space R&D in absolute terms. Spain (EUR 0.5 billion), Belgium (EUR 0.3 billion) and the Netherlands (EUR 0.2 billion) follow. In relative terms, Romania allocates the highest share of its government R&D budget to space, with 15%, followed by Italy (14%), Luxembourg (14%), France (13%) and Hungary (11%).

EU VC investments in the space economy continuously lag behind those of the US and China yet are nonetheless considerable. EU VC investments in space account for around 10% of global VC investments, totalling EUR 1.3 billion in 2025 and showing an upward trend over recent years (Figure 4.4-13, left). The US and China are outperforming the EU, with EUR 8 billion and EUR 1.6 billion worth of investment, respectively, in 2025. In terms of numbers of deals (Figure 4.4-13, right), the EU's share looks more promising, with almost a quarter of the global total, compared to 35% for the US and 13% for China.

Figure 4.4-13 VC investments in space companies, 2020–2025



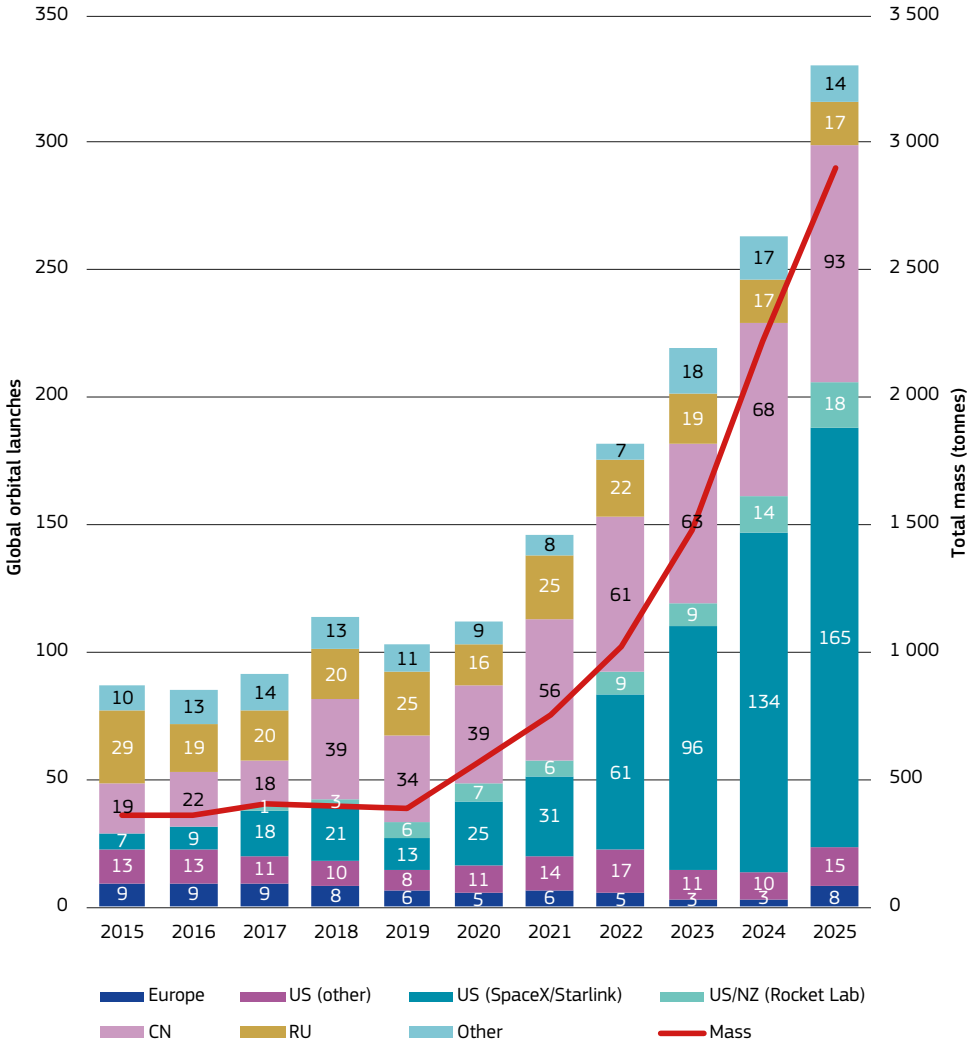
Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on PitchBook Space tech verticals (cut-off: 13 January 2026).

Note: In the PitchBook database, space tech companies are defined as those that provide services, engage in scientific research or develop technology related to spaceflight, satellites or space exploration. This includes micro-satellites, nanosatellites, ground station networks, rocket technology, payload systems, spacecraft development, satellite imagery, satellite telecommunications, space-based data, space materials, space tourism and asteroid mining.

Numbers of orbital launches have risen steeply in recent years, primarily due to a rapid surge in commercial flights (e.g. Starlink) and the Chinese space programme, marking a change in the space economy. In this area, Europe remains behind. Global orbital launches have skyrocketed since 2020, when the commercial space sector really gained momentum, predominantly due to the SpaceX Starlink programme (Figure 4.4-14). In 2025, Starlink launches accounted for 50% of all launches conducted globally. Also, the Chinese space programme has seen a sharp rise, attaining a global share of 28% in 2025. The shares of Europe and Russia have declined over the past decade, from 10% and 33%, respectively, in 2015 to 2% and 5%, respectively, in 2025.

Figure 4.4-14 Global orbital launches by country/region, 2015–2025



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Gunter's Space Page, SpaceX and ESPI data.

Note: Other countries include Australia, India, Iran, Israel, Japan, North Korea, South Korea and Ukraine. Mass is the payload delivered to orbit by launch vehicles.

The surge in commercial orbital launches raises policy questions linked to the balancing of innovation, sovereignty, safety, environmental sustainability and orbital congestion. Regulatory frameworks are an important enabler of innovation in the space economy, while guarding against potential risks in areas such as public and airspace safety. Also, the environmental impacts of rocket emissions, as well as the growing risks related to space debris and orbital crowding, must be considered. It is preferable to develop international approaches and frameworks for the space economy so that countries follow common rules to ensure the long-term sustainability and peaceful use of outer space.

7. Defence and space R&I in the EU policy debate

Investments in collaborative projects can be instrumental in fostering cooperation between EU Member States and creating economies of scale in R&D investments. The new defence spending targets will require EU Member States to create substantial budgetary space. As shown in this chapter, defence spending multipliers are positive on average but highly heterogenous, depending on economic conditions. Also, EU defence spending exhibits signs of fragmentation, which can reduce efficiency and interoperability. Stronger EU-level coordination, supported by common priorities and targeted financial incentives, could gradually mitigate these inefficiencies and strengthen the strategic impact of EU defence spending. To this end, continued investments in collaborative projects via the European Defence Fund could prove instrumental by fostering cooperation between Member States and generating economies of scale in R&D investments (EDA, 2025).

Sizeable investment in defence R&D, including dual-use technologies, is needed if the EU is to lead in future technologies and innovations. Current EU defence R&D investment is somewhat limited, whereas of all defence spending components, R&D is the most closely associated with long-term economic growth. Limited investment could weaken the EU's ability to lead in future technologies and innovations, creating unwanted dependencies. Given the planned increases in defence spending, it should be possible to place more focus on defence R&D, and specifically on R&T, to keep pace with other major economies as regards defence capabilities. To this end, it is essential to create a robust environment for investment, supported by an innovation-friendly regulatory framework. Recent EU legislation and policy frameworks, such as the *Defence Readiness Omnibus* (European Commission, 2025f), the *Preserving Peace – Defence Readiness Roadmap 2030* (European Commission, 2025a), the EU Defence Industry Transformation Roadmap (European Commission, 2025e) and the *Strategic Compass for Security and Defence* (European Council, 2022) collectively orient EU policy towards achieving these objectives.

Reaping the full benefits of dual-use technologies requires careful reflection on how to balance openness and risk management. As shown in this chapter, the EU is well positioned in terms of scientific and innovation capabilities in various dual-use technologies. The challenge, however, lies less in the existence of these capabilities than in their mobilisation: it is vital to direct the full breadth of the EU's innovation ecosystem, from universities and research institutes to deep-tech startups and industrial scale-ups, towards defence readiness objectives and to do so at a pace and scale commensurate with

the security environment. Strengthening and maturing these abilities will require sustained R&D investment and fostering of spillovers between civilian and defence sectors. To reap the full benefits of dual-use technologies, as they pass through maturation and move towards market-readiness, careful reflection is required on how to balance openness and risk management. EU programmes like Horizon Europe and the proposed European Competitiveness Fund can support these efforts at a European scale. Horizon Europe, for example, has already developed space technologies relevant to government and defence users, including in-space computing and in-space services for protecting, upgrading, and servicing space assets (e.g., refuelling). Furthermore, through the *Defence Mini-Omnibus* (European Commission, 2025f), the EIC Accelerator and STEP Scaleup were opened to start-ups and SMEs developing dual-use technologies (e.g. AI, quantum, advanced materials, robotics), offering grants of up to EUR 2.5 million and equity investments of up to EUR 30 million. While in parallel, the EIC launched a new EUR 100 million EIC STEP Defence Scale Up call, providing from EUR 10 to EUR 30 million in direct equity to scale critical defence capabilities such as air and missile defence and drones and counter-drones, thereby co-investing in rounds typically ranging from EUR 50 million to EUR 150 million.

Europe seems to be at a crossroads with its space economy. While the space economy remains important for the EU, this chapter shows that its global shares are declining. The new NATO norms could have the potential to strengthen EU space investment, especially investment for defence purposes. A similar picture can be seen regarding the EU's orbital presence, which remains limited while global commercialisation of space has surged in recent years. In this regard, more launch capacity seems to be needed in Europe to keep pace with the global trends. This also presents new policy considerations concerning the balancing of innovation, sovereignty, safety, environmental sustainability and orbital congestion.

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CHAPTER 5

FINANCING AND SCALING INNOVATION

CHAPTER 5.1

INNOVATION, PRODUCTIVITY AND EFFICIENCY

Haya Al-Ajlani

KEY QUESTIONS

- What factors have been driving labour productivity growth in the EU?
- How efficient are Europe's largest research and development (R&D) spenders compared with those in other major economies?

HIGHLIGHTS

- Over the past 25 years, productivity growth in the EU has been roughly half that of the US.
- EU productivity growth was broadly positive during the COVID-19 pandemic (2020–2022). However, this momentum has since faded, with growth shrinking across most Member States in more recent years.
- Total Factor Productivity (TFP) is the main driver of labour productivity in the EU, the UK and the US.
- Weakened business dynamism is a shared challenge across developed economies, with potential implications for widening of productivity gaps between frontier firms and laggards.
- Artificial intelligence (AI) can offer opportunities to improve productivity through the automation of repetitive or routine tasks at firm level.
- Europe's largest R&D spenders still display scope for technical efficiency improvements. Reducing inefficiencies could strengthen firm productivity and enhance the contribution of TFP to overall labour productivity growth.

POLICY INSIGHTS

- Productivity-related barriers such as market fragmentation and administrative burdens demonstrate the importance of creating a more favourable environment for young firms to emerge and grow. The *EU Startup and Scaleup Strategy* is an important step in this direction.
- Reaping the productivity benefits of AI depends on firms adopting such technologies and integrating them into their operations effectively. In this context, initiatives such as the *Apply AI Strategy* aim to support the uptake of AI and other advanced technologies across a wide range of sectors, particularly among SMEs but also among larger firms.

The need for productivity growth extends beyond the pursuit of economic competitiveness and higher output. Higher productivity levels are closely associated with improved living standards and overall well-being (Banting *et al.*, 2002; Kügler *et al.*, 2018; OECD, 2025a). Similarly to other advanced economies, the EU has experienced a slowdown in productivity growth over the past decade. This trend is often described as the 'productivity puzzle', in reference to the uncertainty surrounding its underlying causes (Gordon, 2016; Bauer *et al.*, 2020).

This productivity slowdown is one of the most pressing challenges facing policymakers today. Weak productivity growth directly threatens a country's ability to raise living standards and maintain competitiveness in an increasingly interconnected global economy.

Productivity dynamics are inherently complex, which makes addressing the productivity slowdown a multifaceted task. Drivers of productivity growth include innovation, technology diffusion, technical efficiency, skills development and institutional frameworks.

1. Labour productivity in the EU has lagged behind that of other economies

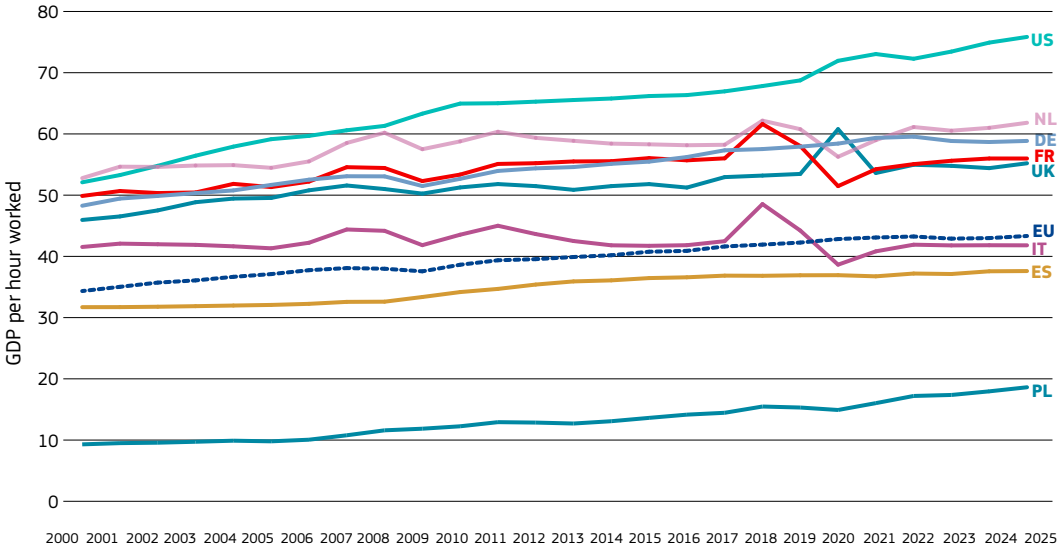
Real labour productivity levels in the EU have consistently lagged behind those of other major advanced economies. Data spanning the period from 2000 up until recently shows that the EU has recorded lower productivity levels than the US (Figure 5.1-1).

Over the past two decades, the US has remained at the productivity frontier, with a steady upward trajectory. In 2025, its level of productivity had increased by around 50 % compared with 2000. The EU has followed a flatter path, with gradual improvements over time but no sustained closing of the gap to the US. Over the past 25 years, the EU's improvement has been around half that of the US, at 26 %. The EU's performance is also below that of another major advanced economy, the UK, although the two have followed similar trajectories over the past 20 years.

Among the large EU economies, the Netherlands, Germany and France display broadly similar trends: productivity levels are consistently above the EU average and have continuously increased at a modest rate, with noticeable peaks in the period preceding the COVID-19 pandemic (2017–2019). Except for in 2020, these countries have also maintained productivity levels above those of the UK (Figure 5.1-1).

Productivity levels in Spain and Poland are persistently below the EU average, although Poland has shown a steady positive trend over the last five years (2020–2025). Since 2020, Italy's performance has fallen below the EU average.

Figure 5.1-1 Real labour productivity in the EU, US, UK and selected Member States, 2000-2025



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on AMECO.
Note: Labour productivity is measured as real GDP divided by hours worked.

The underlying drivers of the EU-US productivity gap remain debated. In part, the divergence in productivity between the EU and the US observed since the late 1990s results from developments in the US technology sector rather than reflecting a broad-based productivity gap across the entire economy (Krugman, 2025). However, recent evidence suggests that around 80% of the euro area- US productivity gap is explained by faster productivity growth within industries in the US. In particular, three sectors- wholesale and retail trade, professional and business services, and administrative and support services- together account for around 40% of the overall productivity growth gap between the two regions (van Ark, 2026). Nonetheless, unlike in the EU, higher productivity growth in the US does not necessarily translate into proportionally larger gains in well-being, as European consumers and firms also benefit from innovations generated by large US technology companies through access to digital services, lower prices and technological diffusion. Therefore, comparisons based solely on traditional productivity indicators should be interpreted with caution as they may overstate the extent of the EU's relative economic underperformance (DeLong, 2025; Krugman, 2025).

Nevertheless, even if part of the productivity gap is sector-specific, the EU's weaker position in the tech sector is detrimental to its growth prospects. Leadership in frontier technologies, particularly artificial intelligence (AI) and advanced digital technologies, can generate substantial spillovers across the wider economy, strengthen industrial competitiveness and shape long-term productivity trajectories (Krugman, 2025; van Ark, 2026). Therefore, the EU's weaker position in frontier innovation may negatively affect its future growth and strategic autonomy (see chapters 4.1 and 4.3).

2. EU labour productivity growth has weakened in recent years, with total factor productivity (TFP) remaining a key driver

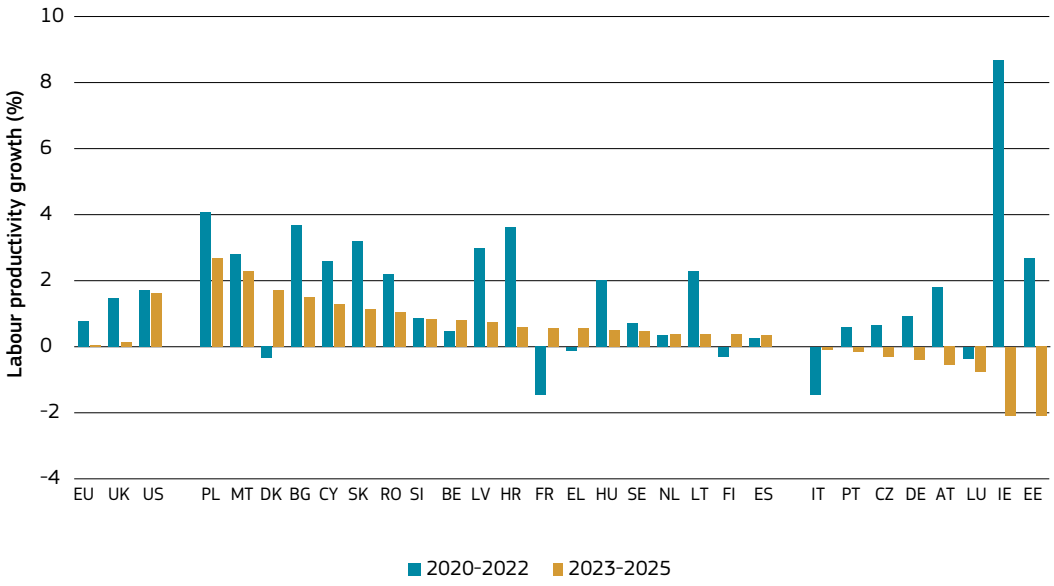
During the COVID-19 pandemic (2020–2022), average annual growth in labour productivity was generally positive across Member States. The strongest growth rates were observed in Ireland, Poland, Bulgaria, Croatia and Slovakia, surpassing 3 % (Figure 5.1-2).

In 2023-2025, productivity growth was modest and below the rates of the preceding period. Poland, Malta, Denmark, Bulgaria, Cyprus, Slovakia and Romania all had average productivity growth of above 1 % (Figure 5.1-2). By contrast, Estonia, Ireland, Luxembourg, Austria, Germany, Czechia, Portugal and Italy recorded negative growth rates.

The gap between productivity growth in the EU and that in the US has also become more evident in recent years. During 2020–2025, the EU recorded moderate gains compared to the growth rates witnessed in the US. This divergence became more pronounced during 2023–2025, when the US growth rate was almost 2 percentage points (pp) higher (Figure 5.1-2).

The UK recorded labour productivity growth rates broadly comparable to those of the EU, with the UK maintaining a lead during 2020–2022. During 2023–2025, the average growth rate of the UK slightly exceeded that of the EU (Figure 5.1-2).

Figure 5.1-2 **Average real labour productivity growth in the EU, US and UK, 2020–2025**

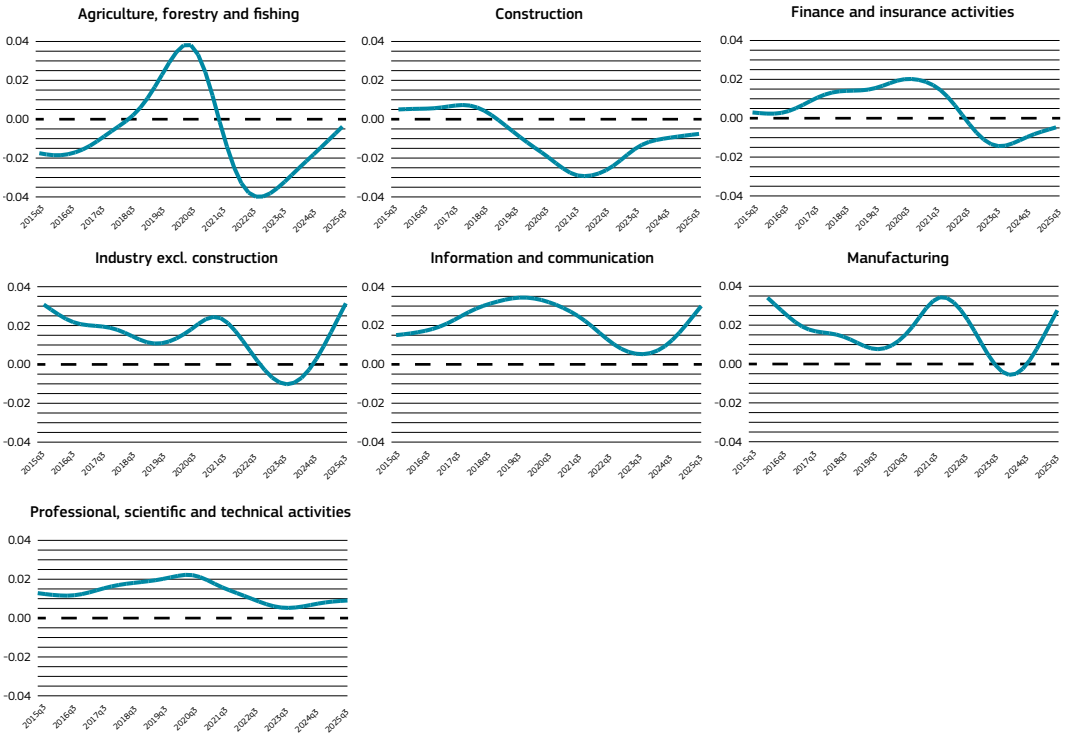


Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on AMECO.
Note: Data is clustered into three-year time periods for ease of illustration. Real productivity is measured as real GDP divided by total annual hours worked. Data is ordered according to 2023–2025 values.

The heterogeneity in labour productivity growth was also evident across key sectors in the EU during 2015–2025. Quarterly growth rates show that the information and communication sector has maintained consistently positive productivity growth since 2015, although it experienced a dip during 2020–2023, which includes the COVID-19 pandemic period. Professional, scientific and technical activities also displayed relatively stable growth, although at more moderate levels. On the other hand, agriculture, forestry and fishing recorded the highest level of volatility. Construction experienced a sustained drop in productivity growth after 2018, remaining below zero. Manufacturing and industry both saw productivity declines during the early 2020s but witnessed improvements in 2024. Finance and insurance activities followed a similar trajectory, shifting from relatively robust productivity growth before 2021 to negative growth thereafter, before partially recovering (Figure 5.1-3).

Figure 5.1-3 Quarterly real labour productivity growth by key sectors in the EU since 2015, quarter-on-quarter comparison, 2015 Q1–2025 Q3



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Eurostat (DOI links: https://doi.org/10.2908/NAMQ_10_A10_E and https://doi.org/10.2908/NAMQ_10_A10).

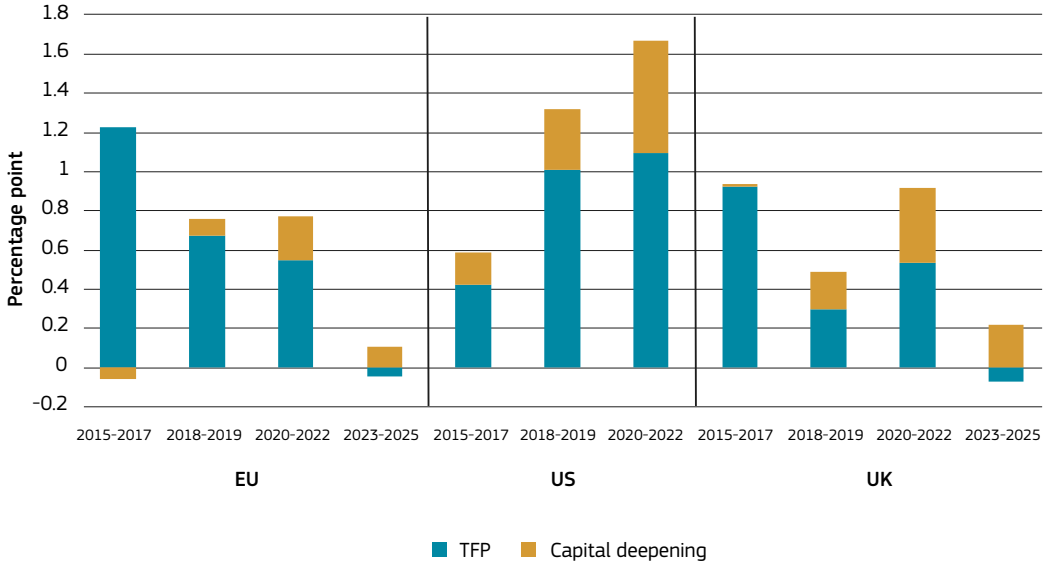
Note: Employment in thousands of hours worked and gross value added in chain-linked volumes, 2020, seasonally and calendar adjusted. Real labour productivity is calculated as gross value added divided by thousands of hours worked. The Hodrick-Prescott smoothing filter was applied to the quarterly growth rates. Only Q3 labels are shown on the x-axis for readability; the underlying series is quarterly throughout.

The decomposition of labour productivity growth during 2015–2025 shows that TFP[1] is the dominant driver in all three economies: the EU, the UK and the US. In the US, TFP made a consistently positive contribution to labour productivity growth throughout this period (Figure 5.1-4). In the EU, TFP also supported productivity growth; however, its contribution turned negative during 2023–2025. By contrast, the contribution of TFP in the UK has been comparatively modest since 2018.

The role of TFP in driving labour productivity growth is most pronounced in the US across all years observed, and its contribution has steadily increased. This trend is not observed in the EU, where TFP fluctuated over the period under consideration. This contrast can be partly linked to greater labour market flexibility in the US, which makes labour productivity and TFP growth less sensitive to business cycle fluctuations, whereas in many euro area economies both move more procyclically – falling sharply during downturns and only recovering as output rebounds (Dossche *et al.*, 2023).

Capital deepening[2] also makes a generally positive contribution to productivity growth across the EU, the US and the UK, with a stronger role in the US. In the EU and the UK, its contribution has fluctuated over the last decade (Figure 5.1-4).

Figure 5.1-4 Contributions to real labour productivity growth in the EU, US and UK, 2015-2025



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on AMECO.
Note: The latest available data for the US is 2022.

1 TFP reflects the overall efficiency with which labour and capital inputs are combined in the production process. Changes in TFP capture the impact of various factors such as management practices, brand value, organisational change, general knowledge, network effects, spillovers, adjustment costs, economies of scale, imperfect competition and possible measurement errors.

2 Capital deepening denotes growth in capital services per hour worked.

Nonetheless, existing evidence suggests that structural, rather than cyclical, factors are behind differences in productivity levels. Recent analysis points to variations in the business environment, innovation capacity and regulatory settings as factors that can help explain differences in performance (see next section).

3. Institutional rigidity, fragmented markets and a resulting lack of business dynamism continue to hold back the EU's labour productivity

The wide range of factors influencing productivity growth makes it difficult to attribute its recent slowdown to a single cause. Nevertheless, existing studies highlight several key drivers and barriers, spanning institutional frameworks, the adoption of emerging technologies and business dynamism. These factors often overlap, amplifying their impact on productivity growth.

Institutional rigidity has been consistently identified as a key barrier to productivity growth in the EU. Rigid institutional frameworks hinder the uptake and diffusion of technological innovation, slowing the transformation of scientific progress into measurable economic gains (see chapter 5.3). Technological innovation alone does not automatically guarantee productivity growth as it must be supported by a flexible regulatory environment that allows firms to adopt, adapt and scale new technologies efficiently (Akcigit *et al.*, 2016; Cevik *et al.*, 2024; Draghi, 2024; Frey, 2025).

The contrast with more flexible institutional environments, such as that of the US, highlights the importance of adaptability. In the US, faster reallocation of capital and labour supports higher productivity growth, allowing new entrants and innovative firms to expand more quickly (Frey, 2025; Draghi, 2024; Cevik *et al.*, 2024).

Fragmentation within the single market further exacerbates the impact of these institutional constraints. The absence of a unified regulatory framework and the persistence of national rules prevent firms from scaling across borders and benefiting from Europe-wide economies of scale (Letta, 2024; Draghi, 2024). This lack of integration constrains cross-border investment and slows the spread of innovation, particularly among smaller firms. Simplifying and aligning rules across Member States would unlock the potential of the Single Market, mobilise private investment in digital and green technologies and strengthen the EU's capacity to translate innovation into sustained productivity growth.

These structural frictions have also weakened business dynamism, which is a key channel through which productivity can grow. A fragmented market and rigid regulatory environment discourage firm entry, scaling and exit, thereby slowing the reallocation of resources toward more productive firms. Evidence shows that the EU has been falling behind the US in several dimensions of business dynamism, which is a worrying trend given that even the US has experienced a slowdown in firm turnover and reallocation in recent years (Fernald and Jones, 2014; Byrne *et al.*, 2016; Syverson, 2017).

The decline in business dynamism is closely linked to widening productivity dispersion between frontier firms and laggards. Large productivity gaps suggest persistent barriers to the diffusion of technology and knowledge, often associated with low levels of competition and limited innovation diffusion (Andrews, 2016; Berlingieri *et al.*, 2020). Factors that contributed to the rise of leading US technology firms, such as high investment in intangible assets and continuous innovation (Crouzet and Eberly, 2019), have also, paradoxically, reduced dynamism by reinforcing market concentration and limiting competitive entry (Akcigit and Ates, 2021; Fernald *et al.*, 2025). As dominant firms consolidate their advantages, smaller firms face growing barriers to expansion, further entrenching the gap between frontier companies and laggards and weakening the overall transmission of productivity gains across the economy (box 5.1-1). For an overview of the challenges facing firms operating in the EU, see chapter 5.3 on conditions for innovation.

Box 5.1-1 The productivity dynamics of different laggard firms

Sara Calligaris, Martin Reinhard, Rudy Verlhac (Organisation for Economic Co-operation and Development, OECD)

Laggard firms[3] display substantial heterogeneity in terms of age, size and productivity trajectories. Evidence from the OECD MultiProd project, which provides granular information on productivity constructed from firm-level data across 13 OECD countries[4], shows that laggards account for nearly one quarter of all firms and just over 10% of total employment, but the laggard group is composed of three distinct categories of firm. More than half of laggards are older micro firms (at least six years old and with fewer than 10 workers). Young micro firms (five years old or younger) are particularly over-represented at the bottom of the productivity distribution, accounting for 34% of laggards (vs 24% of all firms). Non-micro laggards, while fewer (12%), account for most of the employment (57%) in the laggard group.

Market selection among laggards is strong. Of the bottom 10% of firms in terms of productivity in a given year (initial labour productivity (LP) group 0-10 on the horizontal axis in Panel A of Figure 5.1-5), more than one third (35%) exit the market over the following three years on average: an exit rate about twice as high as that among firms in the second-lowest productivity group (10-40: 18%) and around three times as high as that among firms in the central group (40-60: 12%). Only around 28% of bottom-decile firms survive while either remaining in the bottom decile (22.4%) or becoming negative value added (VA) firms (5.6%).

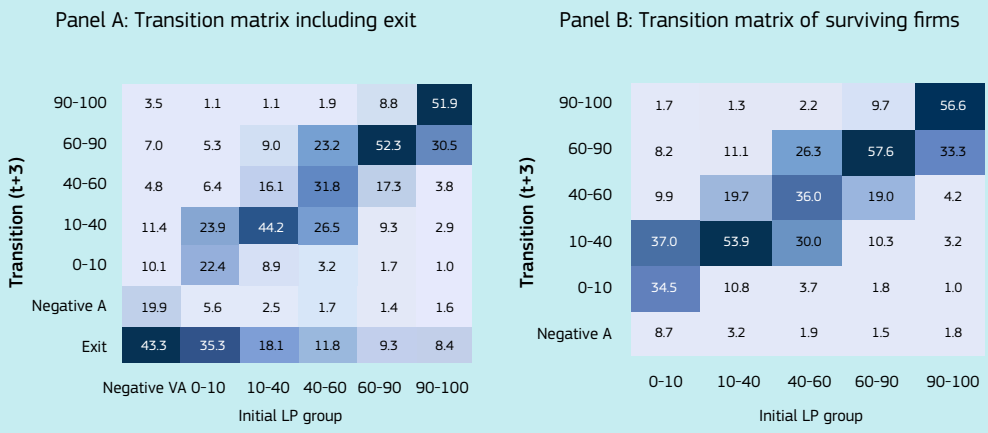
3 Laggards are defined as firms at the bottom of the productivity distribution in the business population. The analysis considers different thresholds of low productivity, defined in reference to percentiles (10th or 40th percentiles), either in the productivity distribution within the full business population or within the population of firms with at least 10 workers.

4 Belgium, Canada, Croatia, Estonia, Finland, France, Hungary, Italy, the Netherlands, Portugal, Slovenia, Spain and the UK. The chart presented in this box covers a subset of countries for which transition matrices are available (Estonia, France, Hungary, Portugal, Slovenia and Finland) and two additional countries (Latvia and Norway).

Surviving laggards demonstrate an ability to climb the productivity ladder. Among surviving firms initially in the bottom decile (group 0-10 on the horizontal axis in Panel B of Figure 5.1-5), around 57 % move up the productivity distribution within three years (groups 10-40 to 90-100 on the vertical axis), with about one third of these making large upward transitions to at least the middle of the distribution (groups 40-60 to 90-100). Similar upward mobility is observed among firms initially positioned in group 10-40, with one third moving to upper segments of the productivity distribution after three years. These 'up-or-out' dynamics are observed across all types of laggards, albeit to a varying extent. This suggests that low productivity is often a transitory state, reflecting normal firm dynamics – notably including life-cycle patterns – rather than indicating that only firms with persistently low quality are likely to remain in activity. At the same time, the results point to incomplete catch-up, as only a small proportion of firms reach the upper segments of the productivity distribution within three years.

The heterogeneity among laggard firms in terms of demographics and productivity trajectories points to unrealised potential which may be tapped into with a differentiated policy mix. The fact that even among laggards of similar size and age, some quickly achieve sizeable productivity gains while others improve less or fail suggests that a firm's low productivity does not necessarily reflect an inherent lack of capacity to improve. Rather, it points to missed opportunities for upgrading performance or barriers to doing so that may keep many laggard firms from catching up with their more productive counterparts. Because laggards vary in both age and size, a comprehensive policy mix is needed to address their potentially differing needs. Young micro laggards are more likely to benefit from policies that support experimentation and scaling, notably those that foster competitive markets and access to skills and finance. By contrast, older micro laggards, which tend to be less growth oriented, may require support aimed at enhancing long-term viability and profitability, as well as low-cost investments in their capabilities (including assistance with accessing basic skills, managerial upgrading or provision of business development services) and financial assistance where appropriate. Additionally, facilitating the orderly exit of failing firms can support the reallocation of resources to more productive businesses but may require streamlined processes for micro and small firms.

Figure 5.1-5 Productivity transition over three years, by labour productivity quantile



Science, Research and Innovation Performance of the EU 2026

Source: OECD (2026, forthcoming).

Note: The figure shows the share of firms transitioning from their initial LP group (x-axis) to future LP groups three years later (y-axis) for nine countries: Estonia, Finland, France, Hungary, Latvia, Norway, Portugal and Slovenia. The firm shares are aggregated across countries (SNA A38 data for industry and initial year denoting 2004, 2007, 2009, 2010, 2012, 2015, 2016 and 2018). Each cell reports the unweighted average across countries based on the aggregated country level using an unweighted average across these years. Data covers manufacturing (Section C of the International Standard Industrial Classification fourth revision, excluding division 19 – coke and refined petroleum) and non-financial market services (sections G-N, excluding section K – financial services – and section L – real estate). Each column sums to 100 %. Deviations from 100 % may arise due to rounding of reported values.

In the absence of business dynamism, weakened competition can further hinder productivity growth. Firms typically require incentives to innovate, and these incentives often arise from competitive pressure or the threat of entry. However, the impact of competition varies depending on a firm's position relative to the technology frontier. Firms operating close to the frontier tend to innovate to maintain their lead over competitors, a mechanism known as the positive 'escape competition' effect. By contrast, laggard firms may become discouraged by stronger competition and reduce their innovative efforts, giving rise to the negative 'discouragement' effect (Aghion, 2017; Aghion *et al.*, 2005; 2009). As a result, productivity dispersion between frontier firms and laggards can widen over time, as innovative firms continue to pull ahead while less productive firms fall further behind.

In addition to market constraints, the EU's productivity is hampered by weaker demand for high-risk innovation. Europe's relatively risk-averse business culture is frequently cited as a constraint on innovation, firm growth and productivity. Comparative research shows that attitudes towards entrepreneurial failure differ markedly between Europe and the US. In many European countries, failure is perceived more often as a stigma than as a learning process inherent to innovation (European Commission, 2025). This cultural framing influences both entrepreneurial behaviour and

the willingness of investors to finance high-risk, high-growth projects, thereby dampening demand for radical innovation. These perceptions are reinforced by institutional settings, including more restrictive insolvency regimes, longer bankruptcy procedures and lower tolerance for business failure, which reduce incentives to experiment, scale new technologies and reallocate resources to more productive activities (Adilbish *et al.*, 2025; Draghi, 2024). See chapter 5.2 for more information on access to finance, startups and scaleups.

4. AI and technical efficiency offer a pathway for improved labour productivity among European firms

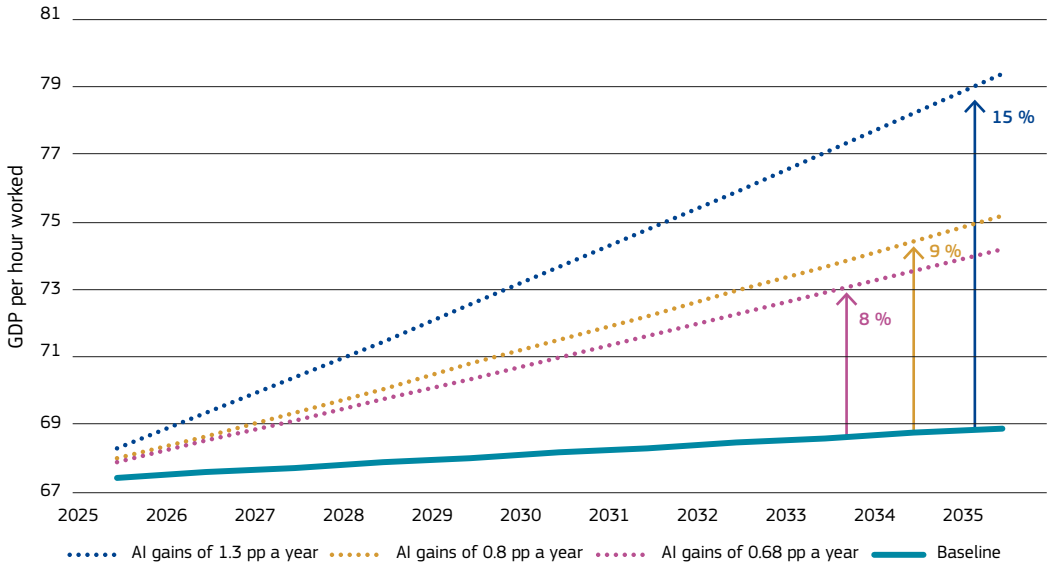
The precise impact of AI on productivity is difficult to assess. This partly reflects the fact that, as with previous major technological innovations, its effects are likely to take time to materialise (David, 1990). Similarly, the impact of AI is expected to be delayed, as it requires substantial organisational changes within firms, as well as complementary investments (Aghion and Bunel, 2024).

Estimates of the expected productivity gains arising from the AI revolution range from conservative to optimistic. One approach to gauging the potential impact of AI is to draw on historical innovation waves. Using this perspective, two benchmark scenarios can be identified starting in 2024: an annual productivity gain of around 1.3 pp, based on the productivity effects of electrification in Europe, and a gain of around 0.8 pp, reflecting the information and communication technology (ICT) revolution in the US (Bergeaud *et al.*, 2016; Aghion and Bunel, 2024). Other estimates suggest that AI-related productivity gains could amount to an annual increase of around 0.68 pp[5] (Aghion and Bunel, 2024). All three scenarios are illustrated in Figure 5.1-6.

In the most optimistic scenario of a 1.3 pp gain per year, labour productivity would be 15% higher than the baseline; in the moderate estimate of a 0.8 pp gain, it would be 9% higher; in the more conservative scenario, the difference with the moderate scenario would be negligible, with the gain equal to around 8%. In fact, existing literature indicates that AI adoption may initially reduce productivity before generating longer-term gains, creating a 'productivity J curve' driven by the organisational adjustments and complementary investments required for effective integration (Brynjolfsson *et al.*, 2021; Babina *et al.*, 2024). Overall, AI-related productivity gains are expected to vary significantly across Member States, reflecting differences in underlying structural conditions and rates of AI uptake (see chapters 7 and 11).

5 The authors base this estimation on the following: around 60% of tasks in advanced economies are exposed to AI, AI adoption will be profitable for approximately 50% of these tasks, and AI enables productivity gains of about 40%.

Figure 5.1-6 Expected labour productivity in the EU based on uptake of AI, 2025-2035



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Aghion and Bunel (2024).

Note: The baseline growth rate corresponds to the growth rate observed in 2024 and is assumed to remain constant over the subsequent 10 years.

Beyond technological uptake, productivity growth is also affected by how efficiently firms use their inputs. Improvements in productive efficiency – the ability of firms to convert labour, capital and intangible assets into output – form an important channel through which aggregate productivity can advance. In practice, shifts in productivity can stem from multiple sources, including changes in physical capital, intangible assets, technical efficiency and organisational practices (OECD, 2023). Aggregate productivity growth is therefore shaped not only by innovative activities carried out by leading frontier firms and dynamic entrants but also by efficiency gains among firms that are further behind the productivity frontier (International Monetary Fund (IMF), 2024). Existing evidence also shows that the rate of technological diffusion is shaped by, among other things, a firm's human capital (see chapter 11).

Where inefficiencies are present, TFP growth can indicate technological advancement, as well as improvements in efficiency. When a firm operates at below the optimum level of efficiency, productivity may stagnate even when technology improves (Fried *et al.*, 1993). Evidence also shows that TFP measurement captures factors beyond technological efficiency alone, including managerial practices, workforce quality and tacit knowledge more broadly (Hulten, 2001; OECD, 2025b).

By addressing inefficiencies, firms can enhance their productivity. A firm's productivity performance reflects the contribution of its entire workforce, including both the composition of labour inputs and the way employees interact (OECD, 2025b). Management in particular plays a central role, as stronger managerial capabilities support sound decisions on what to

produce, how to produce it and with which resources (Gibbons and Henderson, 2012; OECD, 2019). The importance of management for productivity outcomes is well established (Adams, *et al.*, 2005; Bertrand and Schoar, 2003; Kaplan, *et al.*, 2020; Bandiera *et al.*, 2020; Bianchi and Giorcelli, 2021; van Ark, 2026). Moreover, both management quality and management training have been shown to have distinct, causal effects on firm performance (Giorcelli, 2019). Across a wide range of countries, firms that adopt more structured management practices tend to be more productive (Bloom and Van Reenen, 2007; Bloom *et al.*, 2014; Bloom, *et al.*, 2016; Bloom *et al.*, 2018).

Inefficient firms are less likely to engage in innovative activities. When capital and labour remain concentrated in firms with weaker managerial capabilities and lower absorptive capacity, innovation contributes less to overall productivity growth. By contrast, firms with stronger management practices are more likely to adopt and make effective use of new technologies (Bloom *et al.*, 2013; Pellegrino and Zingales, 2017; Nicoletti *et al.*, 2020). Efficiency gains achieved through firm growth are also closely tied to adjustments in managerial structure (Caliendo, *et al.*, 2015; Caliendo *et al.*, 2020).

The EU's largest research and development (R&D) spenders show scope for further efficiency improvements. When examining the efficiency of firms featured in the EU Industrial R&D Investment Scoreboard[6] over the past decade, most frontier firms are located in non-EU countries (box 5.1-2). An output-oriented data envelopment analysis (DEA) model that includes pooled data of firms across different countries, years and sectors shows that US firms dominate the frontier (33 firms: 39 %), followed by China (seven firms: 21 %). The EU is represented by six firms (18 %) (Figure 5.1-7).

The divergence in efficiency between EU and non-EU firms is also evident across sectors. A subsequent DEA analysis for each sector reveals that among ICT producers and ICT services, the most efficient firms are non-EU players. Efficient EU firms appear primarily in the automobile and energy sectors. These findings suggest that, given their inputs (number of employees and total assets), EU firms may have room to strengthen their organisational and managerial capabilities in order to maximise revenues (output).

6 https://iri.jrc.ec.europa.eu/scoreboard

Box 5.1-2 How efficient are the biggest R&D spenders?

Al-Ajlani, H. and Ravanos, P. (2027, forthcoming). 'How Efficient Are the EU's Largest R&D Spenders? Insights from Data Envelopment Analysis'.

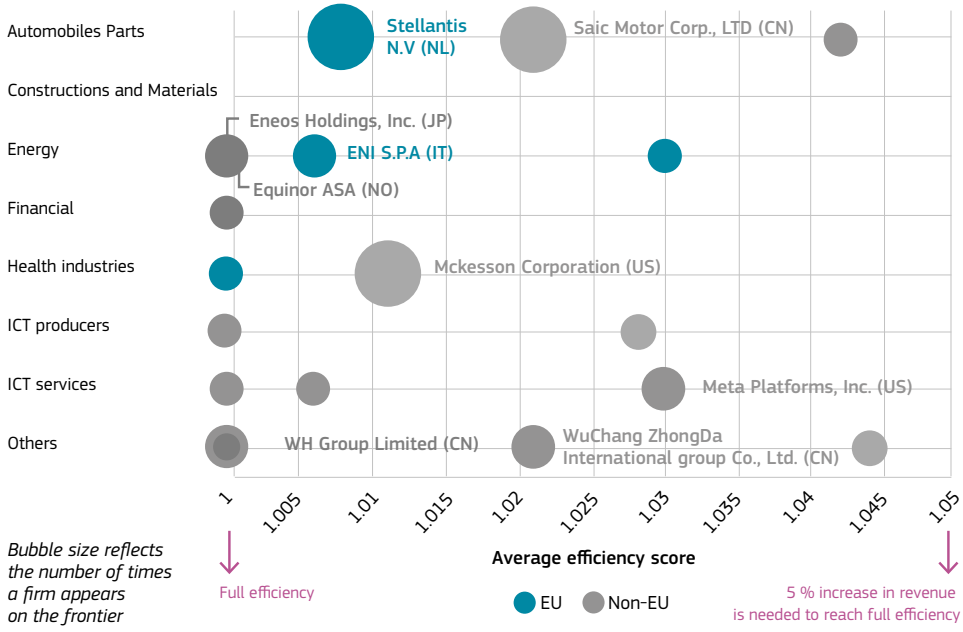
Using DEA, this analysis evaluates the efficiency of EU Industrial R&D Investment Scoreboard firms in turning their fixed assets and employees (input) into revenue (output).

The analysis covers 2 195 firms included in the EU Industrial R&D Investment Scoreboard between 2010 and 2023. The firms are matched with financial data in the Orbis database. Over the period in question, 49 countries are considered, of which 38 % are EU Member States. In terms of firms, 335 are headquartered in the EU and 1 860 are based outside of the EU. This combination is reflective of the usual geographic composition of the Scoreboard firms.

Using an output-oriented model, the analysis aims to identify which firms are at the frontier of efficiency, the sectors in which these firms operate and the dispersion of efficiency.

For the purposes of this analysis, a firm is considered to be among the frontier firms if its DEA score is less than 1.05, indicating a need to increase its revenue by less than 5 % to reach the efficiency frontier.

Figure 5.1-7 EU Industrial R&D Investment Scoreboard firms on the efficiency frontier



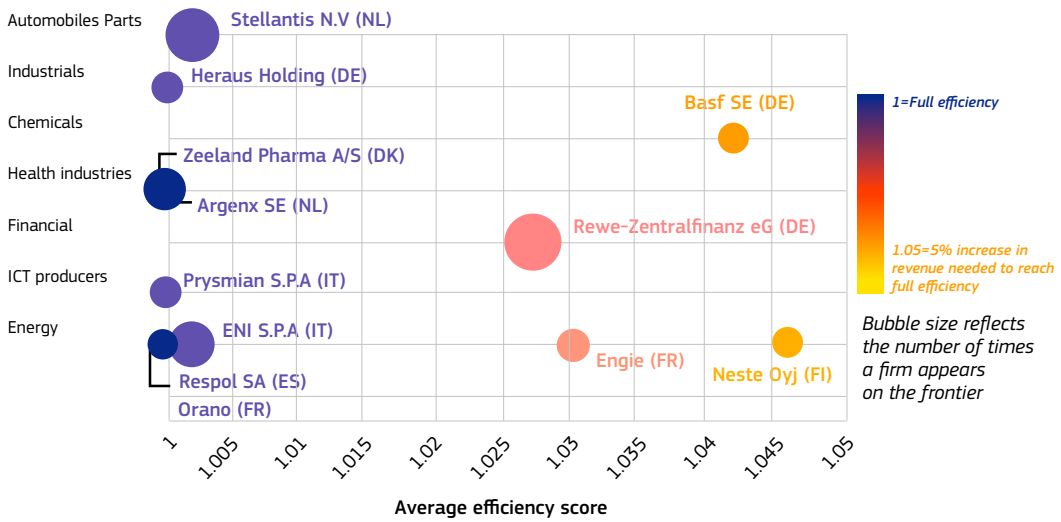
Science, Research and Innovation Performance of the EU 2026

Source: Al-Ajlani and Ravanos (2027, forthcoming) based on EU Industrial R&D Investment Scoreboard and Orbis.
Note: The efficiency measure reported in this analysis corresponds to the output-oriented DEA expansion factor φ, where a score of 1 indicates a fully efficient frontier firm and values above 1 represent the proportional increase in outputs required to reach the frontier. The efficiency scores are calculated using pooled data across years, firms and sectors. Only firms that appear on the efficiency frontier more than once are labelled.

Within the EU, the most efficient firms are concentrated in the health and energy industries. When restricting the EU Industrial R&D Investment Scoreboard data to firms headquartered in the EU, only 11 firms out of a total of 335 are considered efficient[7] (Figure 5.1-8). Geographically, these firms are largely based in western Europe, including Denmark, Germany, France, the Netherlands and Finland.Two southern European firms from Spain and Italy also appear on the frontier, both operating in the energy sector. It is notable that no firms in the ICT producers sector reach the frontier, and only one Italian firm is classified as efficient within ICT services.

Closing productivity gaps is a challenging task that entails addressing multiple interlinked weaknesses within firms. Beyond improving access to technologies, firms may also stand to gain from strengthening employee skills, such as organisational capabilities and managerial practices that shape how effectively labour and capital are combined (OECD, 2025b). Policies that facilitate the attraction and development of the right mix of skills, foster high-quality management and support organisational renewal can play a decisive role in reducing performance dispersion across firms and strengthening aggregate productivity growth.

Figure 5.1-8 The most efficient EU firms on the EU Industrial R&D Investment Scoreboard



Science, Research and Innovation Performance of the EU 2026

Source: Al-Ajlani and Ravanos (2027, forthcoming) based on EU Industrial R&D Investment Scoreboard and Orbis.

Note: The efficiency measure reported in this analysis corresponds to the output-oriented DEA expansion factor φ, where a score of 1 indicates a fully efficient frontier firm and values above 1 represent the proportional increase in outputs required to reach the frontier. We consider a score of 1.05 and below (that is, needing only a 5 % improvement in outputs) as sufficiently close for a firm to be considered a frontier firm. The efficiency scores are calculated using EU firm data pooled across all years and sectors.

7 As outlined in box 5.1-2, a firm is considered efficient if its average DEA score is less than or equal to 1.05, meaning it needs, at most, a 5 % increase in its revenue to reach full efficiency.

5. Labour productivity growth lies at the heart of EU policies

Enhancing productivity growth has become a central objective of the recent EU policy agenda, reflecting growing concerns over the EU's long-term competitiveness, weak business dynamism and slower technological diffusion relative to other major economies. *The Competitiveness Compass*[8], launched in January 2025, places innovation-led productivity at the core of the EU's economic strategy. Building on the Draghi report, it identifies innovation, decarbonisation and economic security as the main pillars underpinning Europe's future growth model.

Several initiatives launched under the Competitiveness Compass seek to improve the framework conditions for firms to innovate, scale and compete within the single market. In particular, the *EU Startup and Scaleup Strategy*[9] aims to address structural barriers that continue to restrict the growth of innovative young firms, including fragmented capital markets, regulatory complexity and difficulties in scaling across borders. Improving these framework conditions is particularly relevant given the role that young firms and frontier innovators play in driving productivity growth, technological diffusion and business dynamism.

The proposal for a 28th regime[10], EU Inc., recently put forward by the European Commission seeks to provide firms with a single optional legal framework applicable across all Member States. By reducing administrative and regulatory burdens associated with operating across jurisdictions, such a regime could facilitate cross-border investment, strengthen competition and support the scaling-up of innovative firms.

The potential of AI to enhance firm-level productivity is reflected in the Apply AI Strategy[11], launched in 2025, which aims to accelerate the adoption of such technologies across strategic sectors of the economy, including among SMEs. The strategy recognises that productivity gains from AI are unlikely to materialise automatically and will depend on complementary investments in infrastructure, skills and organisational transformation. In parallel, the recent *EU Cloud and AI Development Act*12 is expected to mobilise public and private investment for the establishment of AI Gigafactories specialised in training large AI models and strengthening European AI ecosystems.

At the same time, the EU continues to support long-term productivity growth through investments in research and innovation. Horizon Europe, the European Innovation Council and initiatives under the European Research Area remain central instruments for supporting scientific excellence, technology transfer and knowledge valorisation. Strengthening the translation of research into deployable technologies and scalable business models is increasingly recognised as an important condition for sustaining the EU's productivity growth and competitiveness over the longer term.

8 https://commission.europa.eu/topics/competitiveness/competitiveness-compass_en
9 https://research-and-innovation.ec.europa.eu/strategy/strategy-research-and-innovation/jobs-and-economy/eu-startup-and-scaleup-strategy_en
10 https://commission.europa.eu/topics/business-and-industry/doing-business-eu/company-law-and-corporate-governance/eu-inc-new-harmonised-corporate-legal-regime_en
11 https://digital-strategy.ec.europa.eu/en/policies/apply-ai
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CHAPTER 5.2

THE EUROPEAN STARTUPS AND SCALEUPS LANDSCAPE AND VENTURE CAPITAL MARKET

Valentina Di Girolamo

KEY QUESTIONS

- Why is a strong startup and scaleup ecosystem essential for the EU's long-term competitiveness, and how is the EU performing?
- How does the EU venture capital (VC) market compare to that of the US, and what are the main structural barriers to its growth?
- What are the policy initiatives the EU is launching to support startup and scaleup companies?

HIGHLIGHTS

- The EU continues to trail the US in startup and scaleup performance, showing far fewer scaleups companies and a large late-stage funding gap. However, startup creation has grown strongly, and the performance of the VC market has also improved.
- Despite holding approximately USD 12 trillion in assets, EU institutional investors allocate relatively little to VC, favour debt over equity, and show strong domestic bias, limiting large-scale, risk capital.
- Foreign capital is essential for EU innovative companies to scale (around 50% of deep tech funding at the growth stage originates from non-European investors), but also highlights Europe's reliance on external capital.
- VC funding in the EU remains highly concentrated and fragmented, with western Europe accounting for 67% of all capital deployed by EU fund managers. This limits pan-European scaling and can encourage innovative companies to relocate outside Europe.
- While the performance of the EU exit markets has improved, the presence of exit routes in the EU remains limited compared to the US and China. In addition, investors rely heavily on innovation signals to make investment decisions, with patents being positively linked to IPO valuations and playing a key role in M&A decisions, whereas scientific output alone is undervalued unless it demonstrates high-impact quality.

POLICY INSIGHTS

- Despite accounting for only about 5% of the funding from the Framework Programme (FP) for R&I, EU support to startups has been highly catalytic, helping EU-backed startups companies to raise EUR 70 billion in VC since 2010 and generate over EUR 520 billion in enterprise value, as well as around 600 000 jobs globally.
- The European Innovation Council (EIC) has become a major deep tech investor, mobilising over EUR 4 billion in additional private investment (with more than EUR 3.5 attracted for every euro invested) and delivering strong firm-level impacts, as supported companies record higher sales (+37%) and employment (+27%), with even larger gains (+119% sales) for those receiving direct equity support.

As global competition intensifies, the EU's ability to remain competitive will increasingly hinge on its capacity to nurture a dynamic startup and scaleup ecosystem. The EU's approach to competitiveness places entrepreneurship at its core, recognising startup and scaleup companies as central players in driving technological breakthroughs and translating research into market-leading solutions, supporting the twin digital and green transition and delivering broader societal value. Yet, these firms continue to face significant challenges, with limited access to finance remaining one of the most significant barriers to growth. Being able to channel investment at scale thus remains a key priority and a necessary condition for Europe's long-term growth, technological leadership and strategic autonomy.

1. Startup and scaleup companies are key engine for growth and competitiveness

Despite significant improvements, productivity growth remains one of EU's main Achilles' heels. Over the past two decades, the EU's economic growth has been persistently slower than in the US (see chapter 5.1), with lower productivity being the main driver of the different economic performance between these two economies (Draghi, 2024).

The EU-US productivity gap is in large part due to the EU's weaker dynamism in scaling up innovative companies (Adilbish *et al.*, 2025). The EU is characterised by a more static industrial structure, mainly relying on more mature technology industries (e.g., automotive) which, although remaining globally competitive, typically tend to foster more incremental innovation rather than generating breakthroughs (see chapter 2.1). This, in turn, translates into slower productivity growth and weaker industrial dynamism, with Europe being characterised by fewer innovative companies operating in frontier sectors (Draghi, 2024).

A vibrant startup and scaleup ecosystem is essential to foster growth and competitiveness. Economic growth is strongly linked to the concept of entrepreneurship and, in particular, the entry and exit process of new and young firms (Schumpeter, 1942). However, many new firms tend to remain small or fail, suggesting that the growth-entrepreneurship link is not merely the result of having many new companies in an economy, but rather of nurturing a subset of high-growth, innovation-driven startups (Botelho *et al.*, 2021). The latter play a key role in fostering employment, contributing disproportionately to net job creation compared to older firms (Adelino *et al.*, 2017). Furthermore, scaleups tend to be more productive than average companies (EIB, 2024) and can bring cutting-edge ideas to market, thereby challenging established incumbents and driving economic growth and competition.

Supporting startups is crucial not only to fostering innovation and job creation, but also to improving the overall efficiency of entry–exit dynamics and resource allocation in the economy. Encouraging the entry of high-performing startups rather than less productive ones helps redirect resources more efficiently. The efficient reallocation of labour, capital, and talent is critical to enhance productivity, generate higher wages and, ultimately, strengthen the overall economy's macroeconomic performance through a healthier churn of firms (De Haas *et al.*, 2022).

The European tech ecosystem has experienced significant growth over the past decade. The number of early-stage companies in Europe has more than quadrupled between 2015 and 2024, increasing from 7 800 in 2015 to 35 000 in 2024 (Atomico, 2024). The European tech workforce is expanding, with company creation increasing by up to 35 % between 2024 and 2025 (Atomico, 2025). In addition, 2025 marked the year with the highest number of people founding a new company in Europe, reporting a 60 % increase compared to 2023. In the same year, the number of funded tech companies in Europe exceeded 40 000, with nearly 4 000 generating over USD 25 million in annual revenue, and roughly 1 200 surpassing USD 100 million in revenue or reaching billion-dollar valuations (Atomico, 2025).

Nevertheless, the US continues to dominate the global startup ecosystem landscape[1]. The US remains home to the world's top-ranked hubs, including Silicon Valley, New York and Boston. Asian ecosystems have also reported a rapid growth, especially in China, India, Singapore and South Korea. On the contrary, Europe continues to lag behind despite some improvements and the presence of strong hubs, such as London, Berlin, Paris, and Stockholm (Startup Genome, 2025).

European performance improves when considering emerging startup ecosystems[2]. Hubs in central and eastern Europe, as well as in southern Europe, have experienced an increase in their ecosystem value[3], although Asian emerging ecosystems appear to scale faster and attract more capital, putting Europe under increasing competitive pressure (Startup Genome, 2025).

While both the US and the EU are able to generate startups capable to scale, the US is more effective at enabling firms to transition to the most advanced stages of growth (Calligaris *et al.*, 2026). The number of scaleup companies[4] reported in the EU is only one-fifth of those observed in the US (EIB, 2024). This gap is in part due to EU companies being more severely constrained when accessing the necessary financing resources to scale as compared to their US counterparts. These financial constraints are particularly relevant for scaleups, which require increasing amounts of funding and a diversified portfolio of financing instruments as they grow (EIB, 2024).

Furthermore, scaleups in the EU tend to patent less in the early phases of their lifecycle. Inventive capacity in the EU remains strong among startups, but weakens at the scale-up phase. Interestingly, those scaleups that report patenting activities tend to accumulate slightly more inventions before scaling, but take longer to reach the growth stage than their US counterparts (Calligaris *et al.*, 2026).

1 A 'startup ecosystem' is defined as a shared pool of resources, generally located within a 62-mile (100 kilometer) radius around a center point in a given region, with a few exceptions based on local reality. Resources typically include policymakers, accelerators, incubators, coworking spaces, educational institutions, and funding group (Startup Genome, 2025).

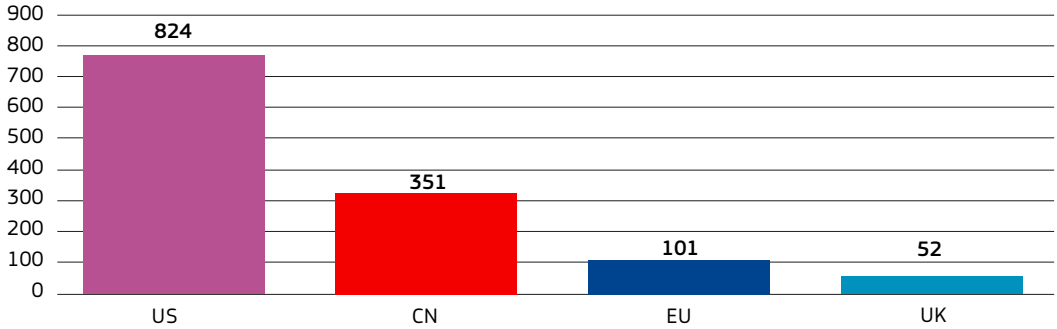
2 Emerging ecosystems are startup communities at earlier stages of growth. The methodology for ranking the Top 100 Emerging Ecosystems is designed to reflect this, showcasing the ecosystems displaying high potential to become top global performers in the coming years. The factor weights used to rank these ecosystems differ slightly from those used with the top ecosystems to reflect their emerging status and emphasise the factors that have more influence in ecosystems that are just beginning to grow. Less weight is given to the number of exits over USD 50 million, and startup activity is more focused on early-stage funding than in the Top 40 ecosystem (Startup Genome, 2025).

3 Ecosystem Value reflects the economic impact of the ecosystem, calculated as the total exit valuation and startup valuations over a two-and-a-half-year time period (Startup Genome, 2025).

4 Here defined as VC-backed companies with a market valuation between USD 500 million and USD 10 billion (EIB, 2024).

The EU also keeps trailing back when looking at unicorn companies. As of September 2025, the US remains in the lead in absolute numbers, with 824 unicorns, compared with 351 in China and 101 in the EU (Figure 5.2-1). Nevertheless, the EU has been improving its performance, reporting a 62% increase in the number of unicorns since 2021[5].

Figure 5.2-1 **Number of unicorn companies in the EU, US, China and the UK, as of September 2025**



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Pitchbook (2025; as of 8 September).

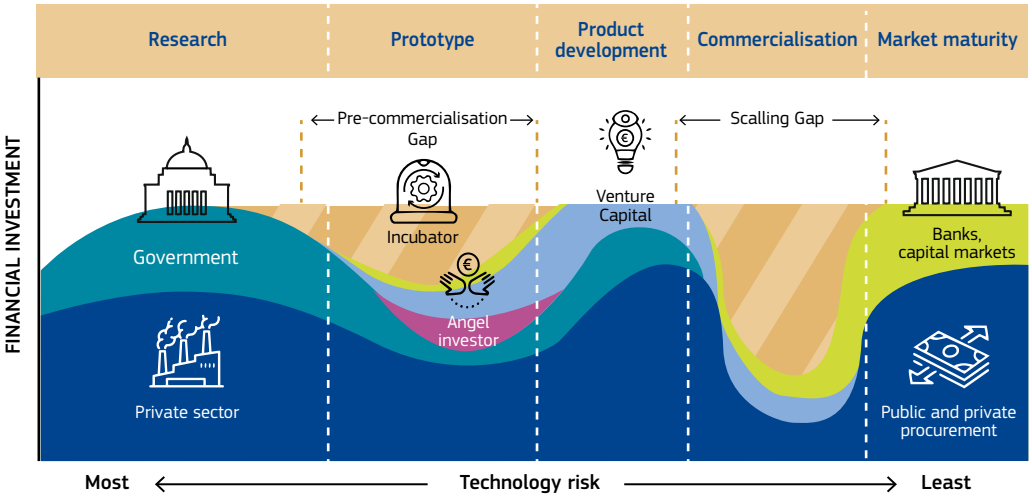
Note: A unicorn is defined as a venture-backed company that has raised a venture round with a post-money valuation of at least 1 billion USD. An 'active' unicorn is one that has not been exited, meaning that it is/was venture-backed as of the year shown. Companies are geolocalised based on the headquarter locations.

2. The performance of the EU VC market remains positive, but barriers to growth persist

When moving from research activities to market maturity, European startups typically face a double valley of death, grappling with two critical funding gaps (Figure 5.2-2). The first one is the pre-commercialisation gap, occurring between the prototype and product development phase. At this stage, technology risk is particularly high, and financing resources are more limited. While public funding can support startups' research activities, securing the financing needed to demonstrate a product's market viability remains more complicated, leaving startups largely reliant on incubators and angel investors with limited resources. The second gap is the so-called 'scaling gap', which arises when the startup transitions to the full commercialisation phase. Even with a viable product, scaling production, entering the market, and competing with established players remain challenging for European startups, as they often fail to access the substantial capital needed to scale their operations (European Commission,

5 DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Pitchbook Data, as of 8 September 2025. Please note that these figures are not directly comparable with those reported in the EU Startup and Scaleup Scoreboard (based on Dealroom data), due to differences in definitions and coverage. PitchBook's figure refers to active, venture-backed private companies valued at USD 1 billion or more, whereas Dealroom applies a broader, cumulative definition covering tech companies that have reached a USD 1 billion valuation or a USD 1 billion+ exit, including qualifying former unicorns. Additionally, differences in company coverage and geographical attribution may further contribute to the discrepancy.

Figure 5.2-2 Startups' double valley of death



Science, Research and Innovation Performance of the EU 2026

Source: European Commission (2025a).

2025a). These barriers can be particularly challenging for capital-intensive innovations with longer development, deployment and market uptake timelines (such as, for instance, those developed by green startups).

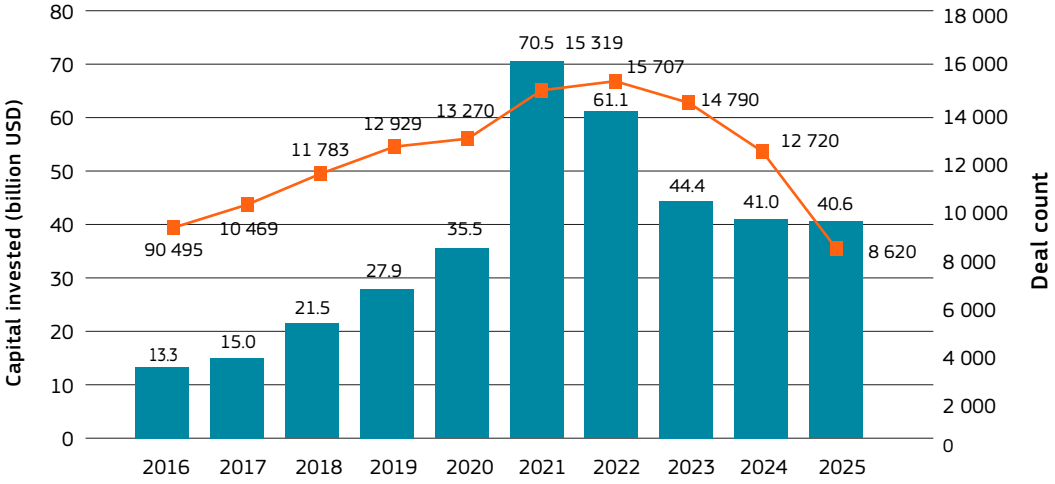
The banking system plays a central role in the European financial market, but it is not always best placed to address startups' financing problems. Bank risk management heavily relies on collateral, which puts young innovative firms at a disadvantage as they can typically provide only intangible assets. Additionally, bank risk models are not well-suited to assess the uncertain growth prospects of high-tech companies, which need time to develop their product, scale up and generate revenues (Greenwood *et al.*, 2022). This time lag is typically incompatible with banks' debt maturities and debt-service requirements, as well as with their regulatory obligations. The latter requires banking institutions to hold significant capital buffers against high-risk exposures, further lowering the attractiveness and profitability of lending to startups (Arnold *et al.*, 2024).

These structural constraints of the banking system highlight the importance of a strong VC market to provide the risky finance that startups need. VC funds play a key role in boosting innovation and growth (Akcigit *et al.*, 2022). On the one hand, VC-backed companies appear to be more R&D intensive and prone to grow faster than their non-VC-backed counterparts (Greenwood *et al.*, 2022). On the other hand, VC funding also increases the likelihood of filing patents, suggesting the existence of a positive relationship between VC financing and innovation capacity (Pavlova and Signore, 2021).

The benefits of VC financing go beyond financial support. VC funds are important not only because they provide critical financing resources to fast-growing innovative startups, but also because they offer deep industry expertise, mentorship, and access to vast professional networks. These additional services accelerate startups' market entry and help them better address the challenges of early growth stages (Arnold *et al.*, 2024).

The performance of the European VC ecosystem has consistently improved over the last decade. Besides the unprecedented peak observed in 2021, VC capital investments in the EU have reverted to their long-term growth trajectory, closing 2024 with an investment level (USD 41 billion) more than three times as large as in 2016 (USD 13.3 billion). In 2025, the decline in deal volumes started in 2022 continued, with the EU's VC market reporting a 32% drop in the number of deals closed. However, deal value has been resilient and VC investment in the EU held relatively steady compared to 2024 (Figure 5.2-3).

Figure 5.2-3 VC invested, and deal counts in the EU, 2016–2025



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Pitchbook (2026; as of 11 February).

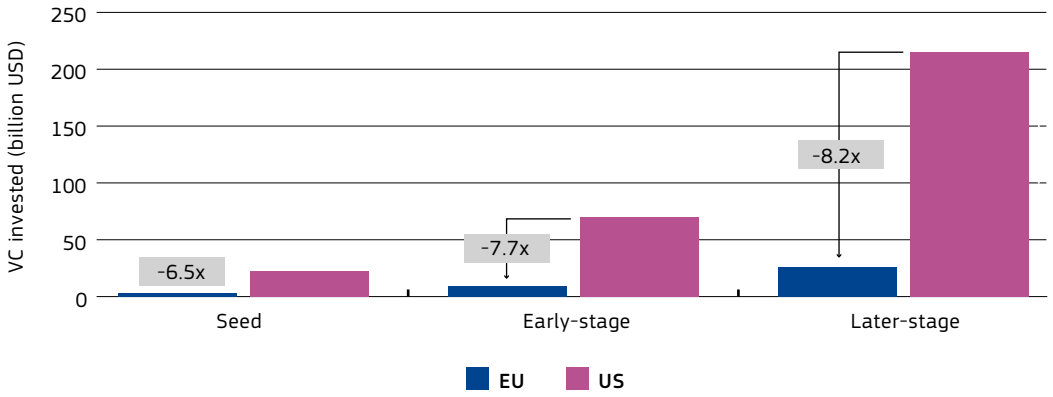
Despite these positive trends, the European VC industry remains less developed than in the US. Between 2013 and 2023, the EU's annual VC investments averaged around 0.2% of GDP, below 0.7% in the US (Arnold *et al.*, 2024). A significant heterogeneity also exists across Member States, with only a few countries (such as Sweden, Estonia and the Netherlands) showing shares comparable to the US performance, whereas southern and eastern European countries have much lower levels[6].

Furthermore, the performance of the US was particularly remarkable in 2025. Over the first nine months of 2025, US tech companies raised about twice as much capital as in the same period in 2024, approaching the record levels reported in 2021. Thanks to this performance, the US currently accounts for two-thirds of all global private tech investments, mostly fueled by massive funding rounds targeting leading US AI firms such as OpenAI, Anthropic, and xAI (Atomico, 2025).

6 DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Pitchbook Data, as of 11February 2026.

The VC investment gap between the EU and the US remains significant and is particularly pronounced for later-stage financing, which remains a structural weakness across the EU. In 2025, seed-stage and early-stage investments in the EU were about 6.5 and 7.7 times lower than in the US, respectively. The largest gap is observed for growth-stage financing, where the EU's performance was almost 88% lower, with a total later-stage VC investment of USD 26 billion compared with about USD 215 billion in the US (Figure 5.2-4).

Figure 5.2-4 VC invested in the EU and the US, by deal type, 2025



Science, Research and Innovation Performance of the EU 2026

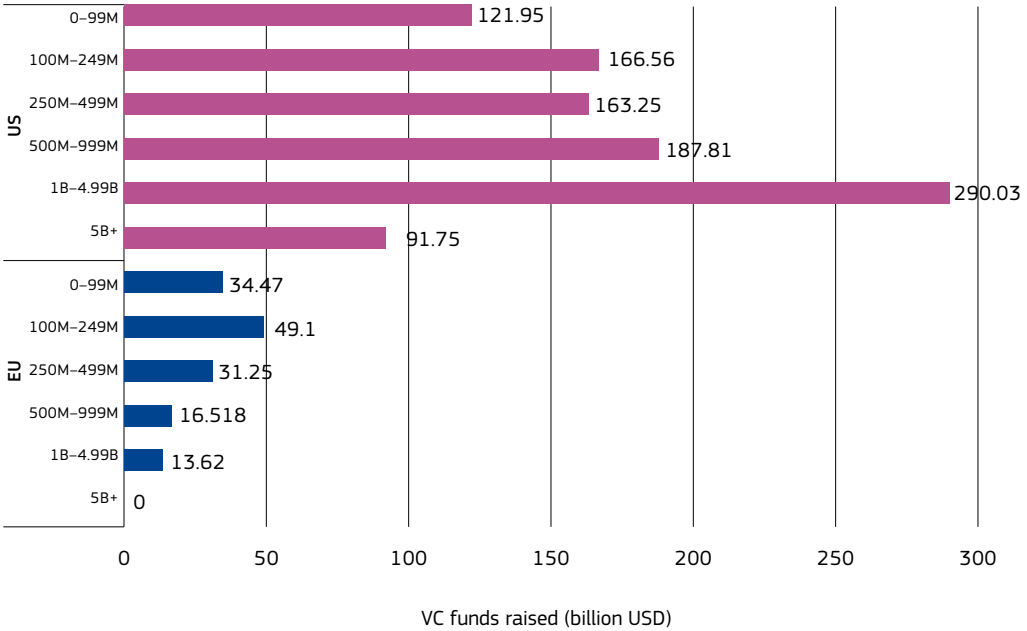
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Pitchbook (2026; as of 11 February).

VC funds in the EU are smaller than in the US both in size and number. The US raised substantially higher level of VC capital (USD 1 021.3 billion) than the EU (USD 145 billion) over the entire period of 2017 to 2025[7]. Although the gap between the EU and the US is observable across all size buckets, it increases with ticket size (Figure 5.2-5). Furthermore, only 12 VC funds in the EU managed to raise a ticket above USD 1 billion over the same period, against the 169 in the US[8].

European startups are significantly less likely to raise large rounds from Series B[9] funding onwards. Companies founded in Europe in 2016 are half as likely as their US peers to secure growth rounds of more than USD 50 million. This results in a significantly lower number of European scaleups reaching valuations of more than USD 10 billion, USD 50 billion, or USD 100 billion (Atomico, 2025).

7 Pitchbook Data, as of 11 February 2026.
8 Pitchbook Data, as of 11 February 2026.
9 Series B VC financing is the second stage of venture capital funding, typically following Series A financing. It is aimed at companies that are looking to expand their operations and customer base.

Figure 5.2-5 VC funds raised in the EU and the US by bucket size, 2016–2025



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Pitchbook (2026; as of 11 February).

Moreover, some distinctive features of the European financial sector and of European households' financial behaviour also play a role. In the EU, bank assets total to 300% of GDP, compared to 85% in the US (EIB, 2024). Additionally, EU households allocate a larger share of their savings (30%) to cash or highly liquid assets, compared to just 12% in the US, thereby limiting the pool of capital available for high-risk investments (EIB, 2024).

Equity remains the dominant instrument for financing the scaleup phase in the EU, but the use of venture debt has grown rapidly in recent years, supported by public financial institutions and specialised lenders, notably the European Investment Bank (EIB) Group. In 2024, venture debt volumes reached EUR 17.2 billion, with 81% directed towards growth-stage companies, highlighting the instrument's alignment with the funding needs of later-stage innovators (European Commission, 2025b).

While this expansion broadens the funding options for scaleups, an overreliance on debt could exacerbate the EU's existing structural imbalance. Ensuring that equity financing remains sufficiently available is, thus, critical to support innovation, as debt instruments alone are less suited to early or high-risk ventures that require patient capital (European Commission, 2025b).

The performance profile of EU growth capital funds is broadly comparable to that of their US counterparts. European growth capital funds have achieved net Internal Rate of Returns

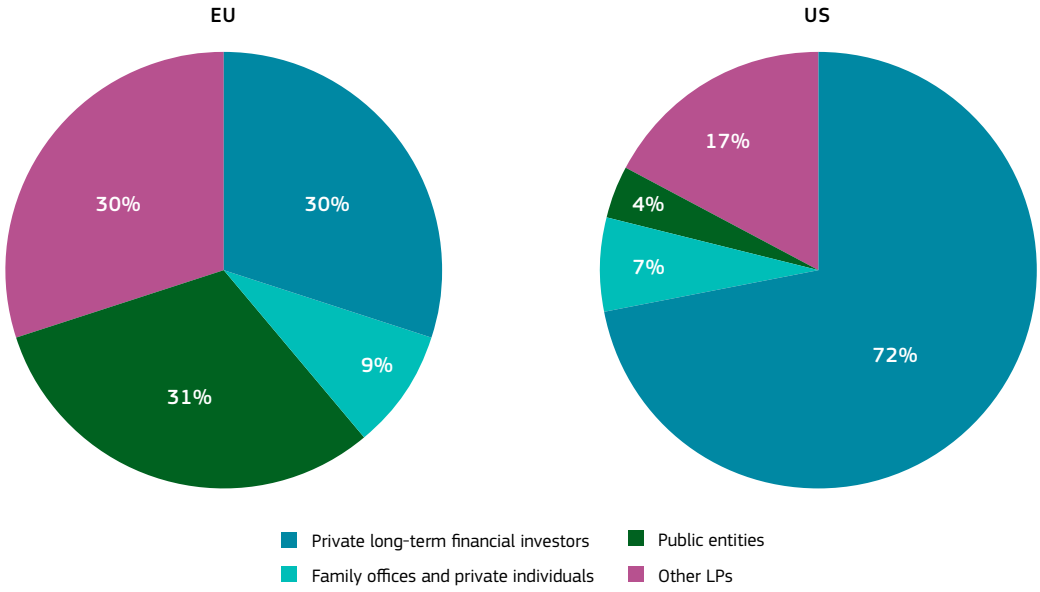
(IRRs) of around 14.8%, close to those of North American funds. However, returns exhibit significant heterogeneity and strong J-curve effects[10], making growth and venture funds less appealing to investors seeking predictable cash flows. As a result, many institutional investors in the EU continue to favour buyout[11] strategies, which offer more stable and faster return profiles, reinforcing structural imbalances in capital allocation within Europe (European Commission, 2025b).

The role of institutional investors

A substantial difference exists in the investors' composition of VC funds in the EU and the US. Between 2013 and 2023, public entities played a significantly larger role in the EU VC market, accounting for 31% of total VC funding compared to the 4% in the US (Figure 5.2-6). On the contrary, private long-term financial investors (e.g., pension funds and insurance companies) dominate the US landscape, accounting for 72% of total VC raised, compared with 30% in the EU (Arnold *et al.*, 2024). This highlights the EU's strong reliance on public funding, as well as the comparatively limited engagement of private institutional investors in its VC ecosystem (see also chapter 12).

The limited role of institutional investors partly explains why EU pools of private capital remain significantly smaller than those in the US. Private pension funds and insurance companies in the EU collectively hold around USD 12 trillion in assets (Arnold *et al.*,

Figure 5.2-6 Source of VC funds by investor type as average % of total VC raised, 2013–2023



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit, based on Arnold *et al.* (2024).

10 J-curve effects refer to the typical return pattern of private equity and VC funds, where returns are negative in the early years due to fees and investment costs, before rising in later years as successful investments mature and generate exits.

11 Buyouts are private equity investments in which a fund acquires a controlling stake in an established company with the aim of improving performance, restructuring, or expanding the business before exiting through a sale or IPO.

2024) and about 27% of EU household financial assets (Lappe and Pinkus, 2025). This is in stark contrast to the US, where assets held by institutional investors amount to USD 42.5 trillion (Arnold *et al.*, 2024).

Strengthening the role of institutional investors remains critical to reduce the EU investment gap. The EU faces an estimated annual investment gap of EUR 800 billion to fund its strategic priorities related to the green and digital transition, defence and, more generally, innovation (Draghi, 2024). Being large, long-term investors, insurance companies and pension funds are well placed to help tackle this challenge. Shifting around EUR 1 trillion of households' savings from cash and deposits into pension and insurance products could mobilise approximately EUR 416 billion for EU-listed equity and debt markets, increasing institutional investors' investment in the EU by around 9% (Lappe and Pinkus, 2025).

Additionally, EU institutional investors exhibit a strong EU bias, tending to allocate a large share of their investments to domestic markets' rather than diversifying in line with global asset distribution. This bias is particularly pronounced for debt securities[12], while equity[13] portfolios are more internationally diversified. At the same time, EU pension funds and insurance companies underinvest in the US market relative to their size, challenging the idea of excessive capital outflows to the US (Lappe and Pinkus, 2025). The tendency to allocate a much larger share of their portfolios to debt securities rather than equity reflects a broader European preference for safer, lower-risk investments over risk capital. By contrast, US insurance companies and pension funds are more oriented toward equity and VC markets, further highlighting the structural difference between the EU and US financial ecosystems.

Nevertheless, the observed domestic bias can be strategically leveraged to channel additional capital into EU markets, provided that it is accompanied by measures to enhance portfolio diversification, thereby supporting innovation and growth while safeguarding savers' interests (Lappe and Pinkus, 2025).

Fragmentation

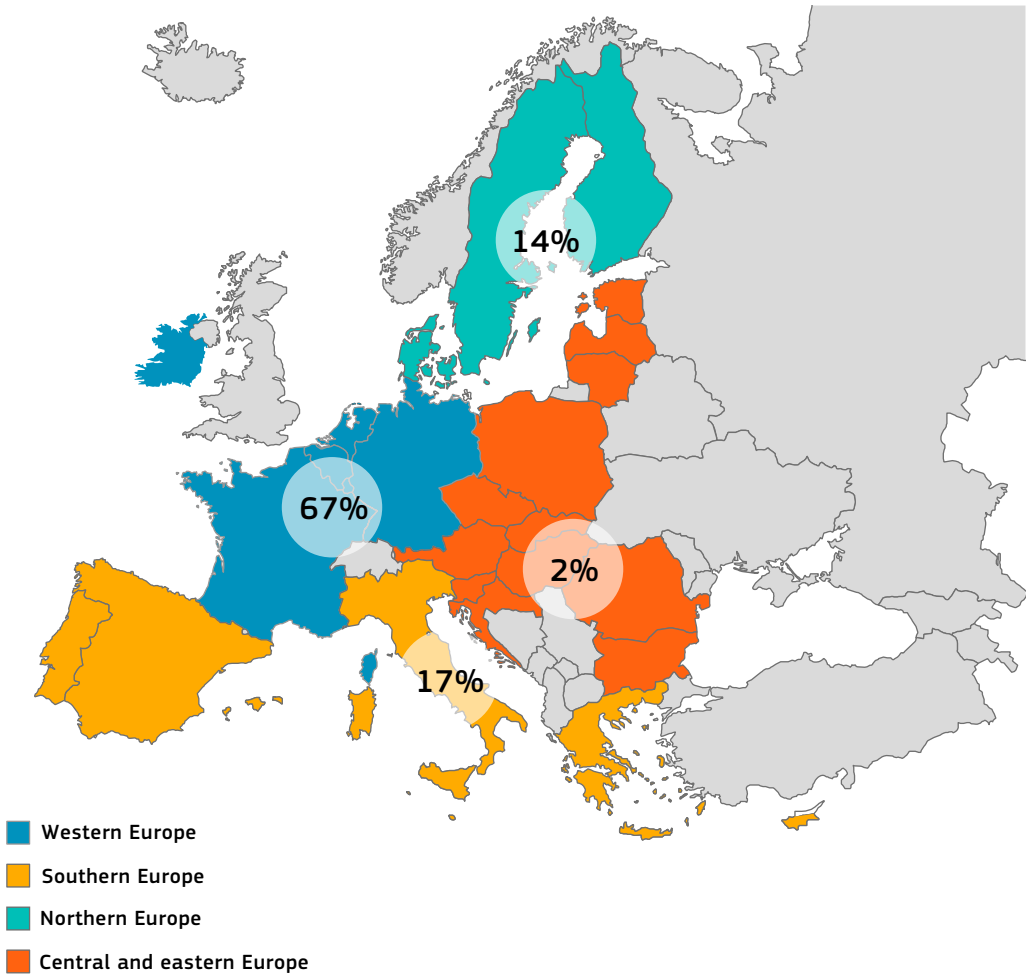
The EU's VC ecosystem is further weakened by its high degree of fragmentation across national markets. Institutional investors in the EU often also display a home-country bias, favouring domestic VC over cross-border opportunities. As a result, already limited resources tend to further concentrate within national silos, reducing the capital available to pan-European VC funds and limiting the ability of European tech companies to attract larger-scale financing (European Commission, 2025c).

Most fund managers and activity are concentrated in western Europe, with southern and eastern Europe remaining largely underrepresented. Western Europe dominates the EU VC landscape, both in terms of the number of fund managers and their maturity and activity, accounting for 67% of all capital deployed by fund managers in the EU (Figure 5.2-7). By contrast, central and eastern European (CEE) countries account for only 2%, signalling the limited regional investor base available to support later-stage growth (European Commission, 2025b).

12 Debt securities are fixed-income instruments (such as bonds), through which investors lend money to issuers in return for interest payments and repayment at maturity.

13 Equity refers to listed shares that represent ownership stakes in companies.

Figure 5.2-7 Distribution of venture and growth capital in the EU by fund managers location in 2024, as % of EU total



Science, Research and Innovation Performance of the EU 2026

Source: European Commission (2025b).
Note: The amount invested by EU investors headquartered in a given region in 2024, expressed as a percentage of the total growth equity investment into EU companies in transactions that were between 15 million and 250 million EUR.

Fragmentation and lower growth perspectives encourage innovative companies to relocate outside Europe. The decision by European startup and scaleup founders to relocate is driven by several strategic and structural factors. These include the possibility to access larger markets with a vast and unified customer based, and higher propensity to adopt deep and digital technologies; higher availability of strategic and significant financing opportunities, especially for larger ticket size funding critical for startups to scale; less fragmented regulatory environment (see chapter 5.3); and, the presence of more entrepreneurship-prone investment culture which better favour high-risk investment in disruptive innovation activities (EIB, 2025; StepUP Startups, 2025)

Startups and scaleups' relocation carries high economic costs, contributing to entrepreneurial brain drain and reducing opportunities for the development of local

ecosystems (European Commission, 2025c; Domnick *et al.*, 2026). Although relocating abroad can enable firms to access broader pools of capital, it also limits potential positive spillovers to other companies in the European ecosystem (EIB, 2024).

Relocation affects a small but non-negligible share of European startups. Between 3.3 % and 4.3 % of VC backed European startups relocate abroad, compared to 0.3 % and 0.5 % of non VC-backed ones. Furthermore, European startups tend to relocate mostly to the US, which account for around three quarters of VC-backed and around half of non-VC-backed relocations. Within the US, relocation is highly concentrated in the San Francisco Bay Area, Greater Boston, and the New York metropolitan area (Domnick *et al.*, 2026).

The likelihood of EU scaleups[14] to relocate is also higher than that of their counterparts in the US and the UK. 15 % of scaleup companies founded in the EU have moved abroad, compared with the 9 % and the 12 % observed in the US and the UK, respectively. Additionally, while the US companies that relocate tend to do so mostly within the US, 74 % of EU relocations occurred outside the Union (EIB, 2024).

Deep tech companies

These bottlenecks have important implications for Europe's competitiveness and capacity to support highly innovative firms, especially deep tech ones. The lack of scale up financing limits the ability of EU VC funds to support high-risk and capital-intensive innovations. This is particularly concerning for deep tech startups, including those contributing to the twin digital and green transition, which typically require larger-scale and long-term investment to reach maturity and scale globally. As an example, the largest share of AI startup funding (see chapter 7) goes to US companies, while the EU accounts for only a modest share (Draghi, 2024). Similarly, US quantum computing firms attract 50 % of global private investment, while EU companies secure just 5 % (Draghi, 2024).

Deep tech funding in Europe has shown remarkable resilience compared to the broader tech market. Deep tech accounts for almost one-third of all VC funding in Europe. In 2024, VC funding in deep tech declined 28 % from its 2021 peak (from USD 20.9 billion to USD 15.1 billion), but still outperformed regular tech, which fell by 60 % over the same period (Dealroom, 2025a). In 2025, deep tech attracted 36 % of all European VC investment, a significant increase from 19 % reported in 2021 (Atomico, 2025).

However, despite its rapid growth, the overall scale of the European deep tech sector remains small compared to the US, which is characterised by funding rounds of a significantly larger order of magnitude. As an example, tech companies such as OpenAI can raise a gigaround of USD 40 billion, showcasing the firepower in the US ecosystem still lacking in Europe (Atomico, 2025).

Such a gap cannot be overlooked and has important implications for competitiveness. Tech ecosystems are typically shaped by power-law dynamics, characterised by a few exceptional companies that disproportionately drive impact, job creation and returns. Europe's competitiveness in the tech sector hinges on its ability to build capital markets able to sustain such dynamics, ensuring that sufficient capital is injected into the system (Atomico, 2025).

14 For this study scaleups are defined as VC-backed companies with a market valuation between USD 500 million and USD 10 billion (EIB, 2024).

The role of foreign investors

Foreign investors play a growing role in European deep tech. Around 50% of deep tech funding at the growth stage originates from non-European investors, highlighting the continent's reliance on foreign capital at the most critical stages of company growth. While domestic capital dominates early stages (71% and 64% of pre-seed and seed stage, respectively), US investors alone contribute to 33% of mega-rounds above USD 250 million (Dealroom, 2025a).

Foreign investors' decisions are shaped not only by firm-level characteristics, but also by regional contextual factors. When entering a new market, foreign investors grapple with both informational and institutional asymmetries. Cross-border VC flows are negatively affected by the geographical distance between investors and targeted companies, especially for seed and early-stage deals for which monitoring needs and information asymmetries are higher (Compano *et al.*, 2025). Nevertheless, the presence of strong regional entrepreneurial ecosystems is an important pull factor, signalling investment readiness and attractiveness. Regions equipped with higher levels of domestic VC activity, skilled human capital and infrastructure are significantly more likely to attract foreign investment (Compano *et al.*, 2025).

Foreign VC has important implications for regional development. It acts as a catalyst for growth by providing additional funding, expanding access to international networks, and facilitating the diffusion of knowledge and entrepreneurial practices. These dynamics play a key role in improving companies' growth prospects, thereby strengthening the overall competitiveness of regional innovation systems (Compano *et al.*, 2025).

Nevertheless, Europe's reliance on foreign capital at the growth stage can hinder its ability to develop globally competitive, homegrown champions. While progress has been made, European investors still provide far less late-stage financing than in the US and Chinese ecosystems, where around 80% of growth funding is self-financed (Atomico, 2024). To reach a similar level, Europe would have needed an additional USD 75 billion in rounds above USD 15 million between 2015 and 2024 (Atomico, 2024). Attracting more domestic growth capital remains, thus, critical for Europe to scale promising startups and capture the full economic value of its innovation.

In addition to addressing funding imbalances, understanding the evolving geography of investment remains key. Beyond more traditional factors such as geographical distance and economic dynamism, new dimensions are also becoming increasingly important in shaping cross-regional VC investment patterns. In particular, the presence of broadband access and the density of newly formed VC connections represent important enablers, reflecting the growing role of digital infrastructure and network embeddedness in overcoming spatial frictions. At the same time, divergent technological specialisations and heterogeneous degree of regional institutional quality keep hindering VC activity, indicating that misalignments in innovation capacity and regulatory environments act as barriers to cross-border capital flows (Asdrubali and Testa, 2025).

Furthermore, investors' characteristics play a key role in shaping both the likelihood and speed at which innovative startups scale. Startups reporting syndicated early funding rounds are more likely to scale and do so faster, reflecting the importance of accessing broader investor networks. Moreover, recent evidence shows that EU innovative companies particularly benefit from the presence of US investors, which is associated with both higher scaling success and earlier

scaling compared to other foreign investors (Calligaris *et al.*, 2026). This suggests that access to capital alone may not be sufficient to help innovative startups to raise follow-on funding, enter new markets, and accelerate growth, as scaling also hinges on access to globally connected investors who bring expertise, credibility, and international networks (Calligaris *et al.*, 2026).

Exit strategies

Exit strategies play a critical role in the VC cycle and are essential for the scaling up of innovative firms. When a company reaches a certain stage of growth, it faces the choice of going public, being acquired, or remaining private. Acquisitions and public exits are particularly relevant to investors, who can, through these operations, monetise the returns on their investments (EIB, 2024). A well-functioning exit environment is therefore crucial to attract investment at earlier stages, support the emergence of large innovative firms, and strengthen the overall depth and dynamism of the European VC market.

The volume of exits in Europe has significantly grown in the last decade. The total value of Initial Public Offerings (IPOs) in Europe has increased to USD 321 billion, compared to USD 100 billion reported in the previous decade (European Commission, 2025c). Nevertheless, IPOs remain concentrated in a few countries, with almost half of all exits exceeding USD 1 billion having occurred in the UK over the past decade (Atomico, 2024). Additionally, the presence of exit routes for investors in the EU remains limited compared to other jurisdictions, notably the US and China (European Commission, 2022). In particular, the US accounted for more than 80% of global exit value in 2025 and for around 55% on average over the past decade (Atomico, 2025).

Over the past decade, around 130 European companies, mostly from the tech and biotech sectors, moved to the US stock market. Half of the European companies that went public in the US were biotech firms, while the IPOs of biotech companies in Europe accounted for only 4%, suggesting that Europe is losing some of its most dynamic companies to the US (Wright *et al.*, 2025).

While these trends highlight the overall stronger attractiveness of US markets, partly due to their higher valuations and deeper liquidity, European equities have recently outperformed US stocks. The valuation gap between the European and US stock markets is estimated at over 30% (Wright *et al.*, 2025). However, this premium appears to reflect differences in growth expectations and profitability, rather than a structural valuation discount applied to European assets. Similarly, the liquidity gap between European and US markets also reduces once differences in market structure and trading data are accounted for (Wright *et al.*, 2025). Furthermore, at the beginning of 2025, European markets have benefited from unexpectedly strong corporate earnings and increased fiscal spending in infrastructure and defence. These, coupled with a lower starting valuation base, have helped narrow the historical valuation gap with the US[15]. At the same time, a compression in equity risk premia (ERP) has also contributed to the rise in European companies' valuations, as investors have started demanding lower returns to hold European equities[16]. Overall, this evidence suggests that the core challenge for Europe lies more in addressing its internal weaknesses, in particular the fragmentation of its capital and equity markets (European Commission, 2025c).

15 https://www.goldmansachs.com/insights/articles/why-european-stocks-are-outperforming-the-us

16 https://www.bis.org/publ/qtrpdf/r_qt2503x.htm

As companies reach the stage of exiting through IPOs or Mergers and Acquisitions (M&A), investors face significant uncertainty when assessing the potential of young, highly innovative companies. This is mostly due to information asymmetries, as these types of companies typically lack extensive financial track records and must rely on alternative signalling mechanisms to flag their long-term growth prospects to potential investors.

In this regard, patents play a critical role in conveying a firm's R&D capabilities, innovation potential and technological leadership to investors. For example, there exists a positive relationship between corporate patents and IPO valuations (Useche *et al.*, 2025). Additionally, patents serve as important signals also in the context of M&A operations, helping acquirers better assess the innovative quality of target firms. In the EU, acquisitions of innovative startups appear to be mostly driven by patent portfolios, especially in cross-border transactions within the Union (Berger *et al.*, 2025).

By contrast, scientific knowledge remains undervalued in European capital markets. Companies' records of scientific activity, as measured by the number of publications, do not significantly affect companies' valuations. On the contrary, investors appear more responsive to high-impact science, as measured by citation intensity, which acts as a proxy for the quality of a firm's research base and its potential to generate breakthrough innovation (Useche *et al.*, 2025). From a policy perspective, this undervaluation of science calls for increasing efforts to better valorise Europe's scientific excellence and translate it into viable market solutions (see chapter 4.2). This remains critical to make European scientific output more visible, credible, and relevant to investors, thereby enabling it to generate greater market value.

Box 5.2-1 Women in VC

Oriane Gilloz (European Commission, DG Research & Innovation)

Women remain significantly underrepresented in the VC ecosystem, both as founders receiving VC and as investors shaping allocation decisions. This persistent imbalance reduces the pool of entrepreneurial talent able to scale in Europe and limits the diversity of innovation financed by VC.

On the demand side, i.e., founders receiving VC, the gap is stark. Women accounted for around 10% of founders and CEOs who received VC funding in Europe between 2011 and 2021 (EIF, 2023). Over the same period, founding teams composed by all female members received less than 2% (1.8%) of total VC volumes, despite representing approximately 2.1% of total founders and CEOs. On the contrary, all-male teams absorbed approximately 82% of total VC investment, whereas mixed-gender teams received around 15% of the funding (EIF, 2023).

The gender gap widens as ticket sizes increase, with all-female teams accounting for about 3% of VC deals below EUR 1 million, but only 0.88% of deals above EUR 10 million. This

confirms that women face increasing barriers in follow-on and growth rounds (EIF, 2023). These patterns align with the Gender Investment Gap evidence that, for every EUR 100 invested by VC in Europe, less than EUR 3 goes to women-led teams and around EUR 15 to mixed teams (European Commission, 2025e).

On the supply side (investors and decision-makers), women are also underrepresented within VC funds. Across European VC firms, only 14-15% of top-level investors (e.g. partner, fund or senior investment manager) are women, and 90% of women in top-level VC roles work in male-majority teams. Furthermore, 25% of total VC volumes in Europe involve no women at top level on either side of the table (all-male investor teams funding all-male founders). In contrast, the share of investment volumes involving no men at top level is 0.003% (European Commission, 2025e).

These imbalances remain at odds with Europe's talent base. 48% of PhD graduates in the EU are women (European Commission, 2025f). Yet, these highly qualified women remain significantly underrepresented among startup founders, particularly deep-tech domains and in high-growth finance channel that is central to scaling innovation.

Furthermore, EU-supported measurement initiatives, including GENDEX[17], WIDCON Index[18], the Gender Gap in Investments Pilot[19] and She Figures (European Commission, 2025f), confirm **systemic barriers along the innovation and investment pipeline**. These include unequal access to networks and finance, gender biases in investment decision-making, limited visibility in entrepreneurial ecosystems, and slower progression into leadership and investor roles.

17 https://eurogendex.org/

18 https://widigital.eu/

19 https://gendergap-investments.eu/

3. Creating a vibrant startup and scaleup ecosystem is at the core of the EU's competitiveness strategy

Supporting startups and scaleups is a high priority on the EU policy agenda to strengthen global competitiveness. As highlighted in the European Commission's 2024–2029 Political Guidelines, Europe's competitiveness strongly hinges on starting a new age of invention, placing research, innovation and entrepreneurship at the centre of its economic strategy[20]. Within this new strategic vision, startups and scaleups play a key role as important drivers of innovation-led growth and industrial renewal. After the 2024 European elections, the European Commission has for the first time appointed a dedicated Commissioner for Startups, Research and Innovation, with the clear objective of better integrating entrepreneurship into its competitiveness agenda[21].

The EU provides financial support to startups and scaleups through several programmes and institutions, designed to cover the full innovation lifecycle from early-stage research to growth capital. Specifically, there exist three main channels through which the EU finances innovative companies (Dealroom, 2025b). The EIB offers large-scale financing to support innovation, infrastructure, and expansion projects mainly through loans. The European Investment Fund (EIF) is one of the EU's VC and SME-focused arms, indirectly funding innovation by investing in VC and private equity funds, and providing guarantees to financial intermediaries. Finally, the EU's Framework Programme (FP) to R&I, Horizon Europe, also plays an important role in supporting startup companies, providing direct grants and equity investment to breakthrough innovators via instruments such as the European Innovation Council (EIC) and its VC Fund focusing on deep tech startups (Dealroom, 2025b).

The EU's support to startups through the FP has proven to be a highly effective catalyst for innovation, investment, and job creation. Despite only 5% of the EU's FP funding being directed to startups since 2007, EU-backed startups have raised EUR 70 billion in VC since 2010 and generated over EUR 520 billion in enterprise value, as well as around 600 000 jobs globally (Dealroom, 2025b).

20 https://commission.europa.eu/document/download/e6cd4328-673c-4e7a-8683-f63ffb2cf648_en?filename=Political%20Guidelines%202024-2029_EN.pdf

21 https://commission.europa.eu/document/download/130e9159-8616-4c29-9f61-04592557cf4c_en?filename=Mission%20letter%20-%20ZAHARIEVA.pdf

Box 5.2-2 Innovation Funding and Startup Growth – the role of the European Innovation Council

Sivasegaram Manimaaran and Aminata Sissoko (European Commission, DG Research & Innovation)

The Accelerator scheme of the European Innovation Council (EIC) is now one of the largest deep tech investors in Europe. It has crowded-in over EUR 4 billion of additional investment into EIC-supported startups and other SMEs, with a leverage effect of over EUR 3.5 for every euro of equity invested by the Fund.

The EIC is also addressing the later stage funding gap through support of the Strategic Technologies for Europe Platform (STEP) to catalyse rounds in the range of EUR 50 to 150 million, and a Trusted Investors Network (a group of over 100 investors from across Europe) has also been assembled to mobilise capital to help companies scale here in Europe.

A flagship initiative of the Commission's Startup and Scaleup Strategy, the Scaleup Europe Fund, has also been launched. The fund will have the scale to invest in a diversified portfolio of the most promising, young and fast-growing companies in strategic technology areas. To unlock superior returns, the Scaleup Europe Fund will fully operate on market terms and will be managed by a private investment fund manager. This will be set up jointly by the European Commission with anchor investors. The Fund will also tap into the best expertise and facilities from corporate and investments partners to provide European companies with a dynamic ecosystem to grow globally competitive from Europe.

The EIC Accelerator delivered significant impact over the period of 2018 to 2021. With a particular focus on the Blended Finance stage (including both the grant and direct equity components initiated in October 2019), the EIC Accelerator produced overall positive causal effect on firm performance, measured by sales (+37%), capital stock (+53%), wage bill (+31%), employment (+27%) overall starting to emerge the year of the EIC award, and the value of deals (EUR 1.1 million appearing two years after the award) (Mion and Sissoko, 2026).

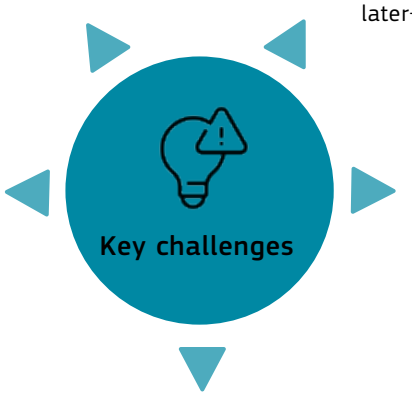
The EIC Fund direct equity investment represents a key driver of heterogeneous impacts on firm production factors and output. Notably, recent evidence suggests a significant causal effect of larger magnitude on sales, wage bill and employment for the firms having received the EIC Fund equity. Specifically, the EIC Fund investee companies appear to register 119% higher sales, 91% higher wage bill and 94% higher employment (Mion and Sissoko, 2026).

Despite the important results achieved so far, more efforts are needed to unlock the full potential of the EU startup and scaleup ecosystem. To this end, the European Commission launched a new *Startup and Scaleup Strategy* in May 2025, aiming to make Europe the best place in the world to launch and grow global technology-driven companies, including deep tech companies (European Commission, 2025a).

Fostering innovative entrepreneurship is at the core of the EU's competitiveness strategy to promote growth and innovation. Building on the *European Competitiveness Compass*, the *Single Market Strategy* and other efforts to improve the business environment, the new *Startup and Scaleup Strategy* aims to shift the European economy towards a more entrepreneurial, innovative model. In doing so, the Strategy identifies a set of challenges European startups and scaleups typically face during their lifecycle (Figure 5.2-8), as well as a set of actions to remove structural barriers to growth, simplify access to EU funding instruments, and create a more coherent and supportive regulatory environment for high-growth companies (European Commission, 2025a).

These efforts are closely aligned with another flagship action of the Competitiveness Compass, the Saving and Investment Union (SIU). The latter aims to improve how the EU financial system channels savings to productive investment, creating more and a wider range of financial opportunities for people and sustainable businesses (European Commission, 2025d).

Figure 5.2-8 Key challenges addressed by the Startup and Scaleup Strategy



REGULATORY AND BUREAUCRATIC BURDENS AND FRAGMENTATION

Fragmented reporting requirements, taxation & employment conditions and high failure costs.

Slow regulatory approval for new technologies and slow adaptation of existing regulatory frameworks to innovation.

ACCESS TO FINANCE

Underdeveloped EU financial market and a patchwork of national measures regulating various aspects of private investment.

The EU's VC market remains significantly underdeveloped compared to that in the US. The highest gap is observed at later-stage financing.

ACCESS TO INFRASTRUCTURE, NETWORKS AND SERVICES

Difficult access to and fragmentation of research and technology infrastructures, business acceleration services, coaching and networking support.

ACCESS TO MARKETS

Low participation rate to public procurement in the EU, the link with corporates, expanding the customer base.

Lack of commercialisation of research.

ACCESS TO TALENT

Bureaucracy, regulations, tax rules and costs prevent startups and scaleups from tapping into the highly-skilled talent they need to develop innovative products and solutions.

Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit.

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CHAPTER 5.3

ENABLING CONDITIONS FOR INNOVATION: TALENT AND REGULATORY FRAMEWORK

Alessio Mitra, Julien Ravet, Milena Isakovic Suni, Eleonora Bonel

KEY QUESTIONS

- How is technological change reshaping labour demand, and does the EU have the talent needed to develop and deploy the next generation of technologies?
- How can well-designed regulatory frameworks support experimentation, investment and the diffusion of innovation across the EU economy?

HIGHLIGHTS

- Technological change is increasing demand for high-skilled, non-routine tasks while reducing that for routine occupations.
- The EU faces persistent talent shortages in occupations expected to experience the strongest future demand.
- The EU has a lower share of employment in knowledge-intensive services and fewer researchers in business enterprises than the US.
- The EU is a global leader in the use of impact assessments and evaluations to inform policymaking, although the innovation dimension remains underused in these analytical processes.
- Regulatory fragmentation across Member States increases compliance costs and can slow the scaling of innovative companies.
- Several EU Member States are actively using regulatory sandboxes to test innovative solutions and address regulatory uncertainty.

POLICY INSIGHTS

- The transformation of labour demand increases the importance of scientific, technical and digital talent for innovation performance.
- Well-designed regulatory frameworks can reduce uncertainty and enable experimentation with new technologies.
- Regulatory sandboxes and other regulatory experimentation frameworks become increasingly important to help adapt regulation to emerging technologies. However, regulatory sandboxes should not be seen as a default option or a one-size-fits-all solution.
- Public procurement can stimulate innovation by creating early demand for innovative solutions.

Innovation performance depends not only on investment and entrepreneurship but also on the broader conditions that enable new technologies to emerge, scale and diffuse across the economy. Technological change is transforming labour demand, increasing the importance of scientific, technical and entrepreneurial talent able to develop and apply new knowledge. At the same time, the regulatory environment shapes firms' incentives to experiment, invest and expand, influencing how easily innovative solutions can reach the market. Demand-side instruments such as public procurement can further support innovation by facilitating market formation and accelerating the adoption and diffusion of new technologies. Together, talent and the regulatory and institutional environment constitute key enabling conditions for innovation and competitiveness.

1. Technological change and the transformation of labour demand

Technological progress, particularly in automation, digitalisation and, more recently, artificial intelligence (AI), is reshaping labour demand across advanced economies. These technologies tend to take over routine tasks, whether manual or cognitive, while complementing non-routine tasks, especially those requiring problem-solving, creativity and interpersonal interaction. As a result, employment has become increasingly polarised: demand is rising for high-skilled workers performing complex tasks, while many routine, medium-skilled occupations are declining (Goos *et al.*, 2014).

Automation (e.g. industrial robots) primarily replaces routine manual tasks, historically concentrated in manufacturing and some service activities. This reflects the fact that such tasks are typically repetitive, predictable and codifiable, making them easier to automate using rule-based or programmable technologies. Industrial robots, for instance, are particularly effective in structured environments where tasks follow clearly defined sequences, such as assembly, welding or packaging. Acemoglu and Restrepo (2020) show that increased robot adoption in the US is associated with significant declines in employment and wages in routine manual occupations, especially in manufacturing regions. Similarly, Graetz and Michaels (2018), using evidence from a panel of advanced economies, including several EU Member States, find that robot adoption increases productivity while reducing the share of routine labour in affected sectors. Acemoglu *et al.* (2020), using data for France, show that firms adopting industrial robots experience increases in productivity and value added, alongside a decline in the share of workers performing routine manual production tasks.

Computerisation (e.g. accounting and database software), in turn, displaces routine cognitive tasks, such as bookkeeping or administrative processing, which are typically performed by medium-skilled workers. This reflects the fact that such tasks are rule-based and repetitive and rely on explicit procedures that can be codified into software and executed at low marginal cost. Advances in information and communication technologies (ICT) have enabled firms to automate data processing, record-keeping and transaction management, reducing the need for clerical and administrative labour. Michaels *et al.* (2014), using cross-country evidence from advanced

economies, including several EU Member States, show that ICT adoption reduces demand for routine medium-skilled tasks while increasing demand for high-skilled workers performing non-routine analytical activities. Similarly, using firm-level data from Finland, Bokerman *et al.* (2019) show that increased use of ICT within firms is associated with a decline in routine task intensity and a shift in workforce composition towards more abstract, non-routine activities.

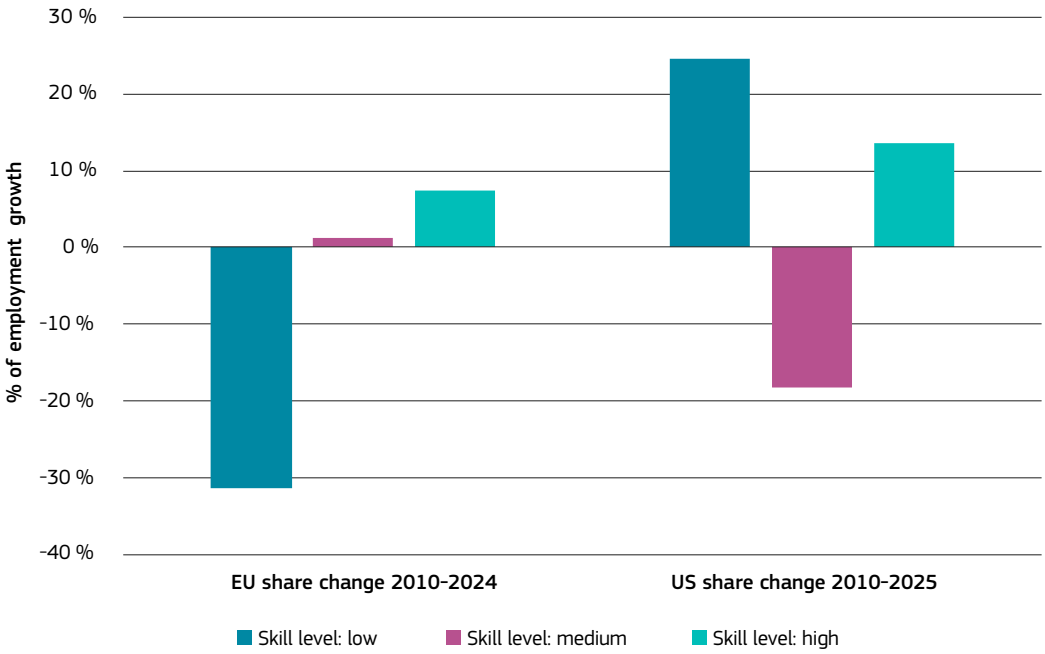
AI is likely to intensify these trends, but its effects are more nuanced. Unlike earlier technologies, AI (especially generative, agentic and cognitive AI) can perform not only routine tasks but also some non-routine cognitive tasks, including tasks traditionally carried out by highly educated workers (e.g. drafting, coding, data analysis). However, in many cases AI acts as a complement rather than a substitute, increasing the productivity of skilled workers rather than replacing them entirely. This tends to increase returns for those who can use such tools effectively. At the same time, some entry-level positions within high-skilled occupations where tasks rely on structured cognitive processes (e.g. data entry, basic legal drafting, reporting, routine coding tasks or literature review and summarisation tasks performed by research assistants) may be particularly exposed to substitution. This raises concerns about potential impacts on career entry and progression, as such positions traditionally provide opportunities for skill acquisition and learning-by-doing and serve as stepping stones to more advanced roles.

Empirical evidence on the effect of generative AI points to clear implications for worker productivity. Eloundou *et al.* (2024), using task-level exposure measures, estimate that around 80 % of the US workforce has at least some exposure to large language models, with particularly high exposure in high-skilled, knowledge-intensive occupations such as law, writing and programming. This shows that AI technologies extend beyond routine tasks and affect non-routine cognitive work. Noy and Zhang (2023), based on a controlled experiment, show that access to a generative AI tool significantly improves the quality and reduces the time required to complete professional writing tasks among college-educated workers, indicating that AI can augment performance in non-routine cognitive activities. Similarly, Brynjolfsson *et al.* (2023), using field data from more than 5 000 customer support agents, show that access to a generative AI assistant increases worker productivity and improves the quality of responses in customer interactions, particularly for less experienced agents, highlighting the complementarity between AI and human labour in non-routine cognitive tasks. Peng *et al.* (2023), using a randomised controlled trial with professional developers, found that access to an AI coding assistant (GitHub Copilot) significantly reduced the time participants needed to complete programming tasks, providing evidence that AI can augment productivity in high-skilled, non-routine technical work.

At the same time, recent theoretical and emerging empirical evidence suggests that, while AI may improve short-term productivity, it may also negatively affect learning processes and the accumulation of skills. Ide (2025) argues that AI can accelerate task completion and improve performance, but it can also alter learning-by-doing processes and reduce opportunities for workers to develop skills through independent problem-solving, particularly in the early stages of their careers. Together, this emerging literature points to a potential trade-off between short-term productivity gains and longer-term human capital accumulation, with implications for career progression and workforce development.

Figure 5.3-1 illustrates how these technological and structural drivers have translated into changes in the composition of labour demand by skill level in the EU and the US over the past decade. Consistent with the literature on job polarisation, both economies exhibit a clear increase in the share of high-skilled employment. However, the patterns diverge across lower and medium skill levels. In the EU, the share of low-skilled employment has declined markedly, while medium-skilled employment has remained broadly stable. In contrast, the US shows an increase in the share of low-skilled employment alongside a pronounced decline in medium-skilled jobs.

Figure 5.3-1 EU vs US structural change trends in skills



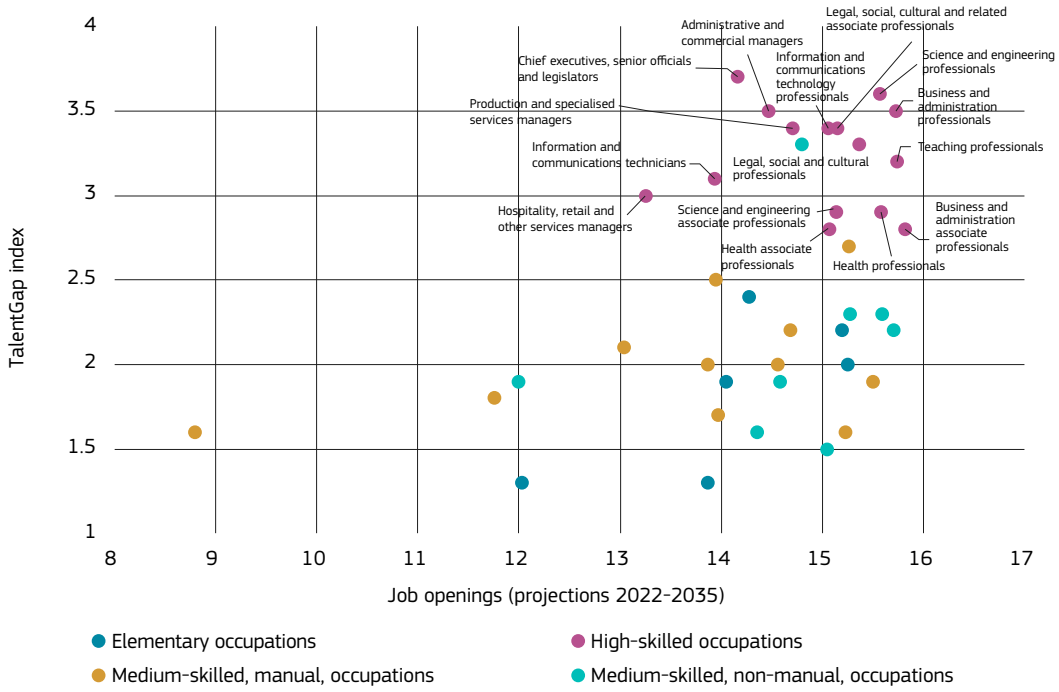
Science, Research and Innovation Performance of the EU 2026
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on ILO.

These differences can be understood in light of structural and institutional factors. In both economies, technological change has reduced demand for routine medium-skilled occupations. However, in the US, this has been accompanied by stronger growth in low-skilled service jobs, reflecting higher labour market flexibility and greater expansion of low-wage service employment. In the EU, by contrast, the decline in low-skilled employment suggests a combination of factors, including stronger labour market regulation, higher minimum wages in some Member States and slower expansion of low-productivity service sectors, which may limit the growth of low-wage jobs (Nellas and Olivieri, 2012). As a result, while both regions experience increasing demand for high-skilled labour, the adjustment at the lower end of the skill distribution differs, leading to distinct patterns of labour market polarisation (Hoftijzer and Gortazar, 2018).

The structural labour market transformation described above implies that the skills for which demand is most likely to increase and which are most likely to command higher wage premia are those combining technical, analytical and non-routine

capabilities with strong interpersonal and socio-emotional skills. Figure 5.3-2 illustrates this relationship by comparing projected total job openings in the EU over the period 2022-2035 with current talent shortages, as measured by the TalentGap Index. A positive correlation emerges, indicating that occupations currently facing greater talent shortages are also those expected to experience stronger future demand. In particular, occupations located in the upper-right quadrant of the figure (such as science and engineering professionals, ICT professionals and administrative and commercial managers) combine high current shortages with high projected job openings, highlighting areas of persistent and growing labour market pressure.

Figure 5.3-2 Relationship between talent shortages in the EU and projected job openings

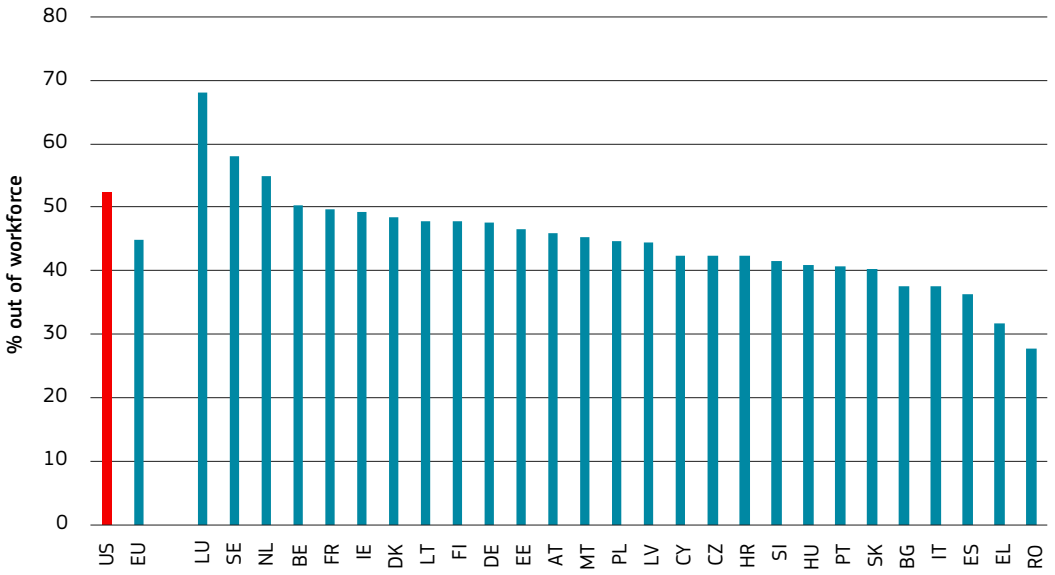


Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on CEDEFOP.

Furthermore, compared to the US, the EU faces a relative shortfall in scientific and technical human capital. Figure 5.3-3 shows that the share of employment in knowledge-intensive sectors (such as ICT, professional and scientific services, finance and research and development (R&D)) is lower in the EU on average, with significant variation across Member States. Only Luxembourg, Sweden and the Netherlands exceed the US in terms of employment in knowledge-intensive services.

Figure 5.3-3 Employment in knowledge-intensive services, 2025 or latest available



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on the Global Innovation Index (2025).

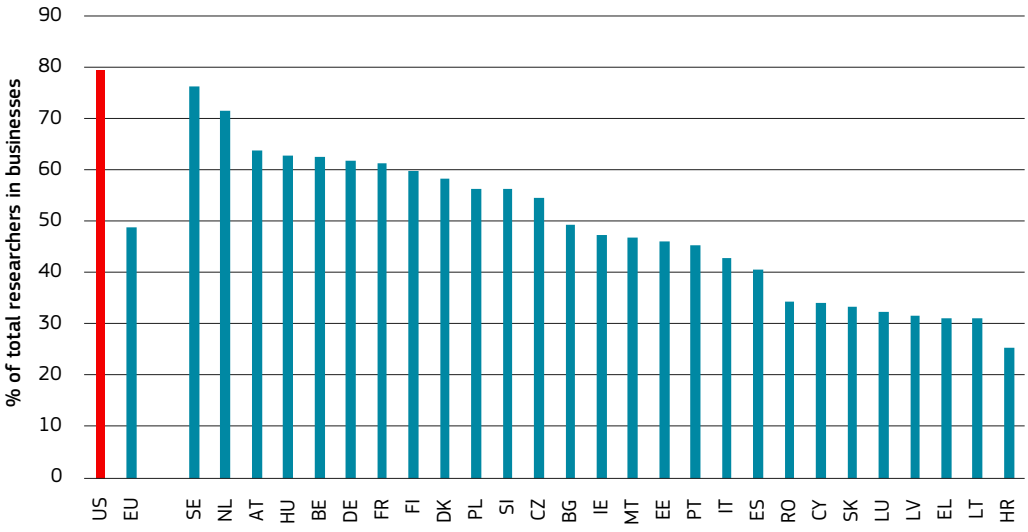
Note: The share is calculated as the sum of people in categories 1 to 3 as a percentage of total people employed, in accordance with the International Standard Classification of Occupations (ISCO). Categories included in ISCO-08 are 1 Managers, 2 Professionals and 3 Technicians and Associate Professionals. Expressed in % of workforce aged 15 and above.

Similarly, researchers in the EU are less integrated into the business sector than those in the US. Figure 5.3-4 shows that, in the EU, around 49 % of researchers are employed in business enterprises, compared to 81 % in the US. No EU Member State reaches the US level. Among Member States, Sweden, the Netherlands and Austria record the highest shares, each exceeding 63 % of researchers employed in the business sector.

2. An innovation-friendly regulatory framework

In a rapidly evolving technological and economic landscape, innovation-friendly regulation is crucial for mobilising Europe's competitiveness and protecting its strategic autonomy. Beyond research and innovation (R&I) policy and entrepreneurship stimuli, EU regulation itself is a major innovation enabler – one that has often been overlooked even though it can have significant impacts (Renda and Pelkmans, 2023). When well designed, regulation can stimulate innovation by providing legal certainty, proportionate obligations and predictable enforcement, while preventing misalignment between regulatory frameworks and innovation cycles, which can lengthen time to market for new products and services. Such regulation can also create space for controlled experimentation, allowing new technologies and business models to be tested while preserving core regulatory objectives. Together, these ele-

Figure 5.3-4 Researchers in business enterprises, 2025 or latest available



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on the Global Innovation Index (2025).

Note: '% of total researchers in businesses' expresses the number of researchers employed by firms as a percentage of all researchers. It is measured in full-time equivalence and refers to professional researchers engaged in the conception or creation of new knowledge, products, processes, methods and systems, as well as in the management of these projects.

ments reflect the Innovation Principle and the notion that if done smartly, regulation can serve as a driver of innovation (Clausen *et al.*, 2023).

At EU level, this perspective is reflected in recent simplification initiatives and Omnibus regulations, as well as in amendment proposals in biotechnology and other innovation sectors. The European Commission's standards on *Better Regulation* are also being assessed to ensure they remain fit for purpose in the current geopolitical and economic environments and are able to meet future challenges.

Regulation as an enabler for innovation

Well-designed legislation can foster innovation by providing legal certainty, predictable enforcement and proportionate obligations that align private incentives with socially desirable experimentation and investment. By reducing regulatory uncertainty and limiting unnecessary fixed compliance costs, effective legislative frameworks lower entry barriers and allow firms (particularly startups and scaleups) to allocate resources to productive activities such as R&D, market discovery and organisational learning (Blind and Münch, 2024; Acemoglu and Robinson, 2019).

Conversely, poorly designed legislation can undermine innovation by increasing compliance costs, introducing legal ambiguity and distorting firms' intertemporal investment incentives. When regulatory requirements are complex, unstable or weakly tailored to firm size and risk, they disproportionately burden younger and smaller firms, for which fixed costs and uncertainty are more binding. This can discourage experimentation, delay scaling decisions and bias investment toward safer, short-term projects or regulatory arbitrage rather than genuine innovation (Pelkmans and Renda, 2014).

Despite progress in deepening the EU single market, regulatory barriers continue to constrain investment, firm growth and the diffusion of innovation across Member States. Firms operating across borders face a fragmented regulatory environment that generates substantial administrative and compliance costs over the firm lifecycle. Differences in registration, certification, authorisation and compliance requirements across Member States raise entry costs and delay market access, reducing the effective size of the market and weakening competitive pressures (European Commission, 2025).

As firms expand their activities, regulatory fragmentation further increases operational complexity by requiring them to comply with multiple national regimes in areas such as taxation, labour and social security, corporate law, licensing, public procurement and reporting obligations. These fixed and quasi-fixed costs absorb financial and managerial resources that could otherwise be devoted to productive investment, innovation and scale-efficient expansion. Hence, while Europe has many talented researchers and entrepreneurs, innovative companies wanting to scale up can be hindered by inconsistent and restrictive regulations (Draghi, 2024). From an economic perspective, such fragmentation distorts firms' growth trajectories, discourages cross-border activity and favours incumbents and domestically oriented firms, ultimately limiting competition, reallocation and productivity growth within the single market (European Commission, 2025). This is echoed in the 2025 Eurobarometer survey[1] where SMEs identified regulatory obstacles or administrative burdens as their main problem. This issue was reported by 64% of respondents, up from 55% in 2020. Principal barriers to cross-border expansion include divergent business environments (reported by 33% of respondents), unclear rules (30%) and taxation issues (29%).

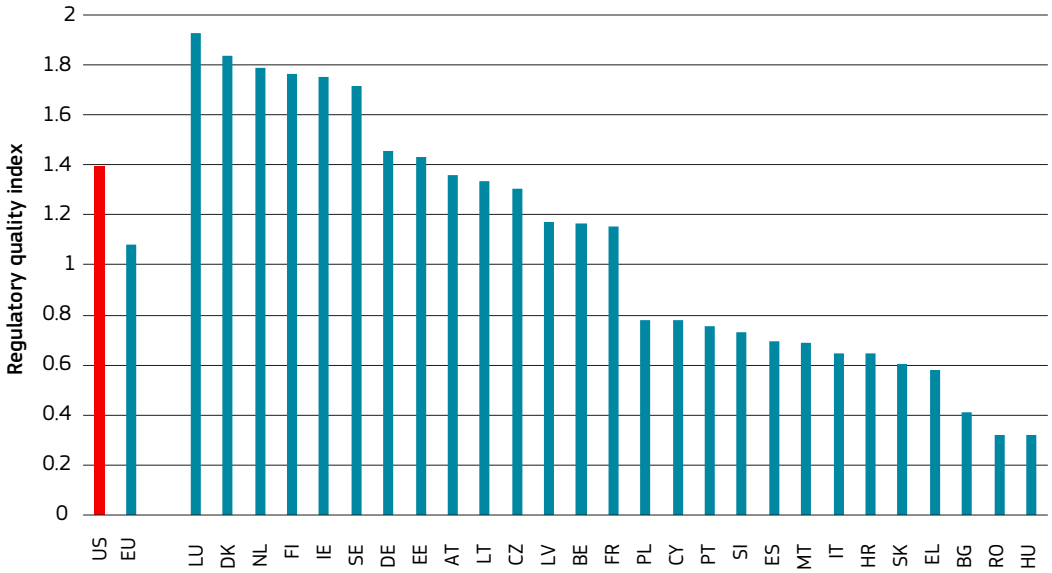
Overall, the EU regulatory environment is less business-friendly than those of international competitors such as the US. As shown in Figure 5.3-5, the EU underperforms the US on the Regulatory Quality Index, which captures perceptions among households, firms and experts of governments' ability to design and implement sound policies and regulations that support private sector development. Similarly, as shown in Figure 5.3-6, the EU scores lower than the US on the entrepreneurship policies and culture index, which captures experts' perceptions of entrepreneurial policies and entrepreneurial culture. At the same time, some EU Member States, such as Luxembourg, Denmark, the Netherlands, Finland, Ireland and Sweden, consistently outperform the US on regulatory quality.

Evidence-based policymaking and policy evaluation

A well-functioning regulatory environment depends on evidence-based policymaking. Policies that help shape innovation, markets and skills need to be designed and implemented on the basis of reliable data and systematic analysis. Evidence-based policymaking relies on the use of ex-ante assessments and ex-post evaluations to assess the effectiveness of public interventions. Ex-ante assessments help anticipate the potential impacts of proposed measures, compare policy options and identify risks before policies are adopted. Ex-post evaluations assess whether implemented policies have achieved their intended objectives in an efficient way, have demonstrated EU added value and remain relevant and coherent with other initiatives. Together, these evaluation practices support more data-driven policymaking, allowing governments to refine policies over time and adjust or discontinue measures that do not produce the expected outcomes.

1 The 2025 survey gathered insights from more than 17 000 companies, including 13 000 in the EU (of these, 5% identified as startups and 18% as scaleups), https://europa.eu/eurobarometer/surveys/detail/3359.

Figure 5.3-5 Regulatory quality, 2023

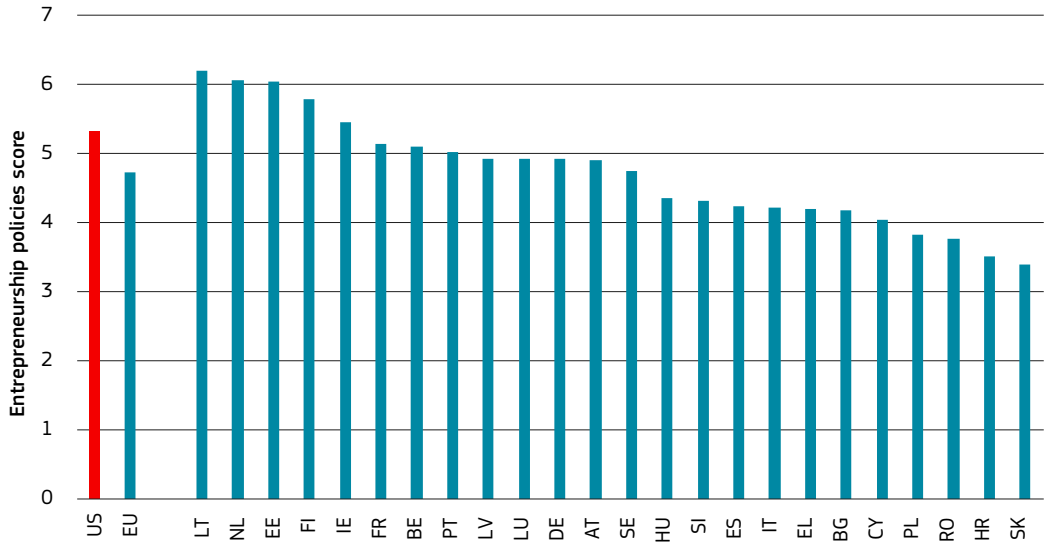


Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation based on World Bank Worldwide Governance Indicators (2023).

Note: The Regulatory Quality Index captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.

Figure 5.3-6: Entrepreneurship policies and culture, 2024



Science, Research and Innovation Performance of the EU 2026

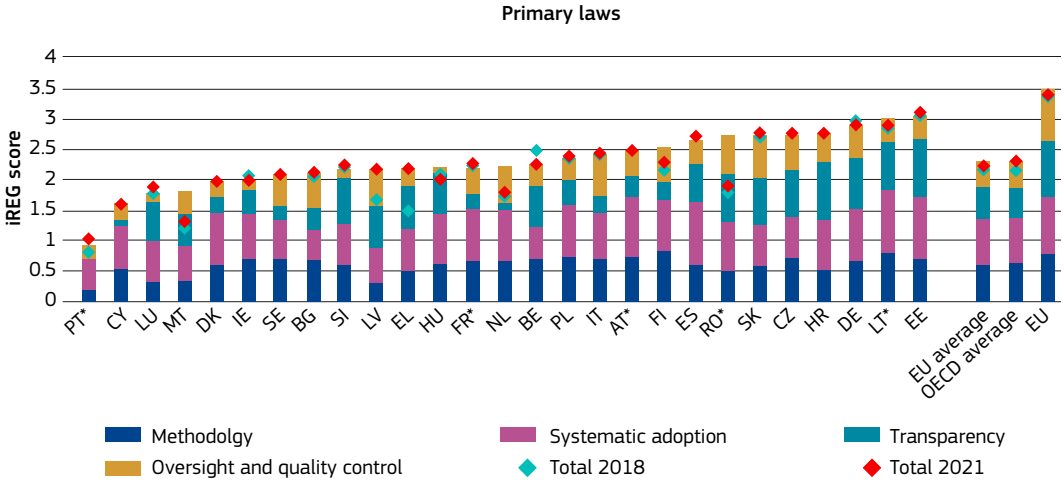
Source: DG Research and Innovation based on the Global Innovation Index (2025).

Note: Average perception scores (five-year average) of experts on entrepreneurial policies and entrepreneurial culture (0 = completely false; 10 = completely true).

At EU level, evidence-based policy-making is supported by the European Commission's Better Regulation framework, which provides guidance and tools for designing, implementing and evaluating EU policies. The *Better Regulation* guidelines and toolbox set out common standards for the preparation of ex-ante and ex-post evaluation of EU legislation. Stakeholder engagement is supported through the Commission's 'Have your say' portal, which allows citizens, businesses and organisations to provide feedback at different stages of the policy process. The quality of impact assessments and major evaluations is also reviewed by the independent Regulatory Scrutiny Board. Based on the OECD regulatory policy and governance indicators, the European Commission ranks among the leading administrations in the use of regulatory impact assessments (RIA) and stakeholder engagement, scoring above all EU Member States in several dimensions of Better Regulation practices. However, innovation remains underrepresented in these assessments. A multiannual study by the European Parliamentary Research Service (2025) found that out of 143 impact assessments reviewed between 2019 and 2024, only 24 examined economic innovation impacts, 21 examined environmental innovation impacts, and 4 examined social innovation impacts.

EU countries display diverse combinations of RIA practices and innovation performance, indicating that RIA contributes to an enabling framework for innovation but operates alongside a broader set of structural factors shaping innovation outcomes. Figure 5.3-8 maps EU Member States according to their OECD indicator for RIA

Figure 5.3-7 Regulatory impact assessment in rulemaking, 2018–2024



Science, Research and Innovation Performance of the EU 2026

Source: OECD (2025).

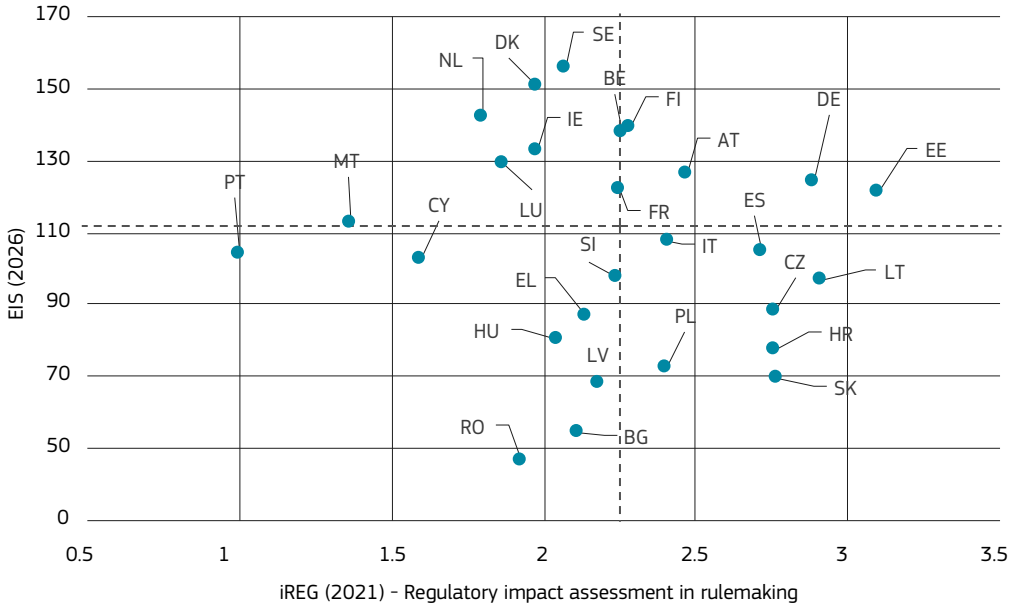
Note: The more regulatory practices as advocated in the OECD Recommendation a country has implemented, the higher its iREG score. The indicator for primary laws only covers practices in the executive. * Most primary laws are initiated by the executive in the majority of EU Member States, except for Austria, France, Lithuania, Portugal and Romania where a higher share of primary laws is initiated by the legislature.

practices and their overall innovation performance as measured by the European Innovation Scoreboard (EIS), highlighting the relationship between policy assessment practices and innovation performance. Member States in the top-right quadrant, such as Belgium, Germany, Estonia and Austria, combine above-average innovation performance with relatively strong RIA practices. Interestingly, a number of other innovation leaders, including Sweden, Denmark, the Netherlands and Ireland, appear in the top-left quadrant, where innovation performance is high, despite having RIA scores closer to or slightly below the EU average. The bottom-right quadrant includes countries such as Czechia, Lithuania and Slovakia, which score relatively well on RIA practices but exhibit more moderate innovation performance. Finally, countries in the bottom-left quadrant, including Latvia, Hungary, Poland and Portugal, record lower scores on both innovation performance and RIA practices.

Regulatory experimentation: the rise of regulatory sandboxes

Innovative solutions are often subject to regulatory uncertainty and disproportionate barriers under existing regulatory frameworks, which can hinder their

Figure 5.3-8 Innovation performance and regulatory impact assessment practices in EU Member States



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation based on the European Innovation Scoreboard (2026) and OECD (2025).

development and commercialisation. This occurs because innovation frequently evolves faster than regulatory frameworks can adapt. Regulations are typically designed around existing technologies, products or business models and therefore reflect the characteristics, risks and operating conditions of the solutions available at the time they were adopted. When a genuinely new technology or service emerges, it may not fit neatly into these predefined categories. As a result, innovators may face uncertainty about which rules apply and how compliance should be demonstrated.

In some cases, existing rules may unintentionally create barriers because they are based on assumptions regarding specific technical standards, production processes or market structures to which new innovative solutions do not adhere. For example, a novel digital service, AI-based application or advanced manufacturing technology may combine features that fall across several regulatory domains. This can lead to overlapping requirements, legal ambiguity or delays. Such uncertainty can discourage investment and slow down the deployment of potentially beneficial innovations (Attrey *et al.*, 2020; Crootof and Ard, 2021).

For this reason, innovation experimentation environments, such as regulatory sandboxes, testbeds and living labs, have gained traction across the EU and globally. These frameworks allow competent authorities and innovators to co-design environments where new technologies, products or services can be developed and tested in controlled or real-world conditions. By enabling companies to trial innovative solutions under nearly real or real-world operational settings, while maintaining regulatory oversight, they help clarify how existing rules apply, identify potential risks and reduce regulatory uncertainty before wider market deployment.

Importantly, regulatory sandboxes differ from testbeds and living labs because they are formal regulatory experimentation tools in the strict sense. They allow firms to test innovative products, services or business models under regulatory supervision, which, in some cases, can include well-defined and temporary regulatory flexibility. By contrast, testbeds and living labs are usually seen as R&I funding instruments for technical or real-world testing environments. They can respond to different testing needs by providing different types of evidence and learning, from technical to societal and legal aspects. They can also support innovation and regulatory governance at different stages of the R&I process, from conceptualisation to proof of concept and demonstration (European Commission, 2023).

After the legal base is defined, a regulatory sandbox is usually opened through a formal call or application window launched by a competent authority, via which eligible firms or innovators submit proposals describing the innovative solution, testing plan, risks and expected regulatory issues. The competent authority then screens and selects participants based on predefined eligibility and selection criteria (such as innovation level, market readiness and potential public benefit); agrees on a tailored testing framework and safeguards; and authorises a time-limited, supervised market test subject to close monitoring and reporting obligations. The primary purpose is to promote regulatory learning for competent authorities, while reducing legal uncertainty for innovators.

Recent strategic reflections on Europe's competitiveness and the single market, including the Letta Report on the Future of the Single Market and the Draghi Report on the Future of European Competitiveness, have also highlighted the need for more adaptable regulatory approach-

es to address emerging technological and market developments. These reports point to instruments such as experimental clauses, regulatory sandboxes and greater regulatory harmonisation across Member States.

Empirical evidence suggests that regulatory sandboxes can have positive effects on firm performance and access to finance. Using detailed firm-level data from the UK, Cornelli *et al.* (2024) found that firms admitted to the UK regulatory sandbox experience significantly improved financing outcomes. The study shows that participating firms have around a 50% higher probability of raising venture capital and raise approximately 15% more funding than similar firms outside the sandbox. The study also finds that participation is associated with improved firm survival rates, with the risk of business failure among participating firms around 18 % lower than among other firms. The authors interpret these effects as evidence that sandbox participation can reduce regulatory uncertainty and provide credibility signals to investors. Complementary evidence compiled by the World Bank (2022) indicates that regulatory sandboxes can help reduce regulatory uncertainty, facilitate access to finance and support the commercialisation of innovative solutions.

However, regulatory sandboxes should not be seen as a default option or a one-size-fits-all solution. Their establishment and operation require time, resources and specialised expertise from the responsible public authorities. Significant public sector capacity is thus needed to run them effectively. As a result, they are not a quick fix. Rather, they are targeted instruments that can support innovation-friendly EU legislation when real-world experimentation is necessary to address a clear regulatory challenge or uncertainty.

Several Member States were at the forefront of these developments before the first regulatory sandboxes were introduced at European level. At national level, a 2025 Commission survey of Member States identified 132 regulatory sandboxes in 15 Member States[2]. A similar survey conducted by the Council in 2021 found 40 regulatory sandboxes in Member States. Lessons learned that were shared by the 2025 survey respondents included the following.

- During preparation, there is a need for a clearly defined scope and objective, as well as an exit plan. It is also important to have a clear communication strategy for disseminating results.
- During implementation, sufficient resources should be set aside for management, and flexibility should be provided, within the limit of each Member State's legal framework.
- Throughout the process, effective communication among stakeholders and between the competent authority and participants is essential. There should be a plan for evaluating the results to make sure that the lessons learned feed into regulatory improvements if needed.

2 As of December 2025, the existence of at least one regulatory sandbox was reported in Austria, Denmark, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, Luxembourg, Portugal, Slovakia, Spain and Sweden. No responses were received from Malta or Romania.

Box 5.3-1 Examples of regulatory sandboxes at national level

France adopted this approach almost 10 years ago with the launch of France Expérimentation[3], a cross-sector framework allowing regulatory exemptions for experimentation. An example of this is the SmartFertiReuse[4] project led by SEDE Veolia, which utilised a temporary derogation[5] from restrictive 2010 decrees to test pilot sprinkler irrigation using nutrient-rich treated wastewater. The experimentation proved effective, demonstrating a 30% reduction in water consumption and a 10% decrease in fertiliser use, results which directly informed the permanent authorisation of such systems under Regulation (EU) 2020/741, which entered into force in mid-2023.

Germany has mapped over 70 ongoing and completed regulatory sandboxes, notably through its Reallabore[6] innovation portal. For example, the U-Space real-world laboratory in Hamburg served as a national blueprint for the digital integration of drones into shared airspace. By putting the European U-Space concept into practice before its formal adoption in national law, the project demonstrated that automated flight authorisations and geo-awareness services could significantly reduce administrative burden while maintaining high safety standards. This experiment directly informed Germany's 2023 implementation of Regulation (EU) 2021/664.

The Danish government has designated the GreenLab[7] project in Skive as an official regulatory energy test zone, exempting it from existing electricity regulations to permit the testing of new renewable energy solutions. This allows companies to explore how renewable energy can be shared directly and at large scale between actors such as hydrogen producers and farmers without using the national grid.

At the same time, the use of regulatory sandboxes across the EU remains uneven, reflecting the absence of broadly harmonised principles governing their design and operation. Eligibility criteria, application procedures, timelines and supervisory approaches vary significantly across Member States and are often determined at the discretion of national authorities.

As a result, similar experimentation may be accepted for regulatory sandbox testing in one jurisdiction but rejected in another, while in some Member States, no regulatory sandbox framework exists at all. Ahern (2021) analyses this uneven deployment, further noting that in jurisdictions where regulatory sandbox frameworks are less developed, SMEs and startups face greater regulatory uncertainty, which can

3 https://www.entreprises.gouv.fr/files/files/Priorites-et-actions/Proximite-et-territoires/France%20Exp%C3%A9rimentation-brochure.pdf

4 https://www.modernisation.gouv.fr/presse/simplifier-le-developpement-de-projets-innovants-au-service-de-la-filiere-agricole-stanislas

5 https://www.legifrance.gouv.fr/loda/id/JORFTEXT000036596241

6 https://www.reallabore-innovationsportal.de/

7 https://www.greenlab.dk/knowledge/test-zone-designation-paves-the-way-for-the-use-of-green-power/

hinder experimentation and innovation activities. Building on this, Ahern (2025) shows that divergent national designs (particularly in the context of the AI Act) risk leading to inconsistent application of EU law and may incentivise 'sandbox arbitrage'. In a similar vein, Raudle *et al.* (2024) document diverging national trajectories in the uptake of sandboxes across the EU, driven by differences in administrative capacity, legal constraints and policy preferences. Consistent with these findings, Parenti (2020) points to the proliferation of heterogeneous sandbox models in the EU, raising concerns about regulatory arbitrage, race-to-the-bottom dynamics and distortions to the playing field.

Several EU regulations include provisions for the establishment of regulatory sandboxes, but only one regulatory sandbox (on distributed ledger technology) has become operational at EU level so far.

- The pilot regime for market infrastructures based on distributed ledger technology (*DLT Pilot Regime*)[8] is one of the first regulatory sandboxes in the EU, having started work in 2023. The market integration package[9] includes a proposal to amend the DLT Pilot Regulation on the basis of two years of experience.

- The *Interoperable Europe Act*[10] enables public sector bodies or EU entities to establish an interoperability regulatory sandbox in order to address the specific cross-border innovation and interoperability-related needs of public sector authorities.

- The *AI Act*[11] requires Member States to establish at least one national-level AI regulatory sandbox. Some Member States have gone further. For example, the Dutch AI sandbox will provide a helpdesk so that SMEs and startups with straightforward queries regarding the AI Act can receive immediate expert guidance, while being redirected to the relevant regulatory sandbox project where eligible[12].

- The *Cyber Resilience Act*[13] states that Member States may, where appropriate, establish cyber resilience regulatory sandboxes. These will provide, for a limited period of time, controlled testing environments for innovative products with digital elements to facilitate their development, design, validation and testing for the purpose of complying with the Act prior to being placed on the market.

- The *Net-Zero Industry Act*[14] provides the possibility for Member States to establish a net-zero regulatory sandbox at their own initiative. It also stipulates that Member States shall establish regulatory sandboxes, in close collaboration with industry and, where relevant, with research institutes, social partners and civil society, at the request of any company, organisation or consortium developing innovative net-zero technologies.

8 https://eur-lex.europa.eu/eli/reg/2022/858/oj/eng

9 https://finance.ec.europa.eu/publications/market-integration-and-supervision-package_en

10 https://eur-lex.europa.eu/eli/reg/2024/903/oj/eng

11 http://data.europa.eu/eli/reg/2024/1689/oj

12 https://www.rdi.nl/documenten/2025/03/25/vormvoorstel-regulatory-sandbox-ai-verordening

13 https://eur-lex.europa.eu/eli/reg/2024/2847/oj/eng

14 https://eur-lex.europa.eu/EN/legal-content/summary/eu-net-zero-industry-act.html

Box 5.3-2 Regulatory clarity without derogations: lessons from Japan and the UK

International experience highlights the added value of experimentation and guidance that do not explicitly include derogations from existing legislation but help enhance regulatory clarity. In Japan, as a complement to the Regulatory Sandbox Scheme, entrepreneurs who intend to engage in a new business activity can reach out to the competent minister via the System to Remove Grey Zone Areas[15]. In fact, 10 times more applications (more than 300) have been submitted under this system than under the Regulatory Sandbox regime (around 30). Applicants can request clarification on regulations that are applicable to their new activity. The procedure ensures a response within a month, giving entrepreneurs legislative certainty at an early stage of their business development.

A comparable approach can be observed in the UK, where the Regulatory Innovation Office (RIO)[16] was established in October 2024 within the Department for Science, Innovation and Technology. The RIO's mandate is centred on enhancing regulatory clarity and reducing uncertainty for innovators. Through its Front Door pilot, businesses and investors can directly flag the regulatory challenges they encounter. They thus have a structured channel for early-stage dialogue with government. In addition, the RIO has partnered with the Digital Regulation Cooperation Forum to develop a unified digital library offering a single point of access to digital policy and regulation. Complementing this, the Regulatory Horizons Council provides independent, forward-looking policy recommendations to ministers on emerging technologies, while the Regulators' Pioneer Fund offers grants of up to GBP 1 million to help regulators and local authorities develop experimental regulatory approaches. The RIO model illustrates how dedicated institutional capacity focused on knowledge, strategy and capability-building can reduce regulatory fragmentation and build innovator confidence, without necessarily requiring formal derogations from existing legislation.

15 https://www.meti.go.jp/policy/jigyou_saisei/kyousouryoku_kyouka/shinjigyo-kaitakuseidosuishin/sankyouhou_kiseikaikaku_gaiyou_english.pdf

16 https://www.gov.uk/government/organisations/regulatory-innovation-office/about

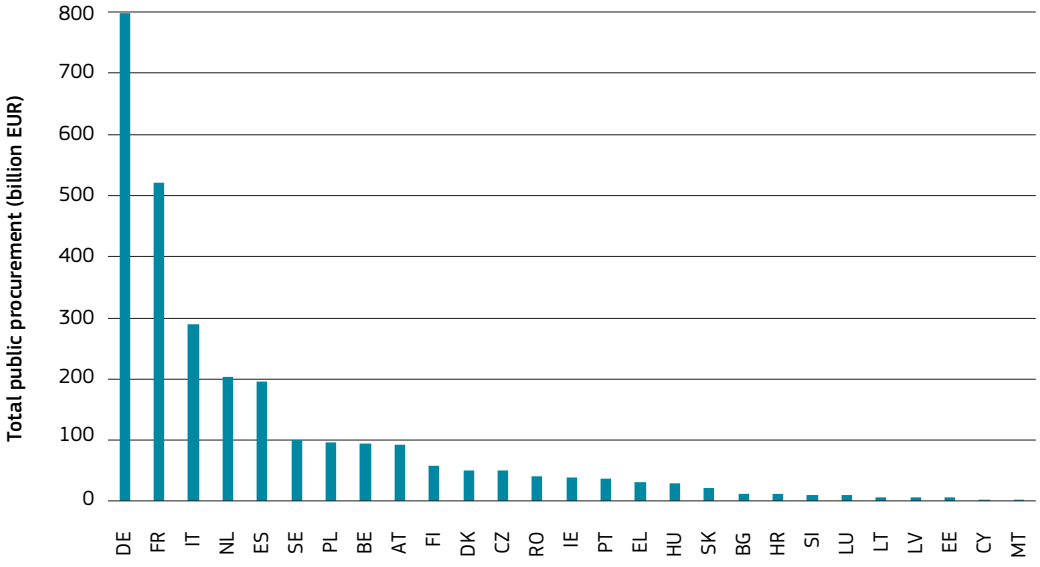
3. Procurement as a driver of innovation

Procurement plays an important role in the economy because it determines how large organisations purchase goods, services and technologies. Through procurement, buyers create demand for products and solutions developed by firms, influencing which technologies are adopted and which companies grow. Public procurement[17] alone accounts for roughly 17 % of EU GDP (EUR 2.8 trillion per year), meaning governments are among the largest buyers in the economy. Large private firms also spend significant amounts on procurement.

Public procurement and private procurement follow different rules and often serve different objectives, although both involve the purchase of goods, services and works by organisations.

Public procurement is subject to specific legal frameworks designed to ensure transparency, equal treatment of firms and value for money in the use of public funds. In the EU, contracts above certain value thresholds must comply with harmonised procurement rules laid down in Directive 2014/24/EU on public procurement and related EU legislation, while contracts below these thresholds are primarily governed by national rules. Furthermore, at the time of writing, the European Commission is preparing a proposal for a European Public Procurement Act, expected by the end of 2026, to modernise the EU public procurement framework. The proposal will then be subject to the ordinary legislative procedure. Because governments purchase infrastructure, defence equipment, health services,

Figure 5.3-9 Total public procurement in the classical, utilities and defence sectors, 2022



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on European Commission and PwC (2026).

[17] From the classical and utilities sectors to the defence sector, all included.

digital technologies and energy systems, public procurement can also serve broader policy objectives and is increasingly used to promote innovation, sustainability and the participation of SMEs. Figure 5.3-9 illustrates total public procurement spending across the EU.

By contrast, private procurement is primarily driven by business considerations such as cost efficiency, reliability of suppliers and strategic supply management. Firms generally have greater flexibility in selecting suppliers, negotiating contracts and organising purchasing processes. Unlike public procurement, private procurement does not typically pursue broader policy objectives, except where companies respond to regulatory requirements or policy incentives.

Innovation procurement is a type of public procurement that aims to stimulate or acquire new or significantly improved products, services or processes that are not yet widely available. According to the EU's 2021 guidance, innovation procurement includes pre-commercial procurement (PCP) and public procurement of innovative solutions (PPI).

- **PCP** refers to the procurement of R&D services to develop solutions that are not yet commercially available. Public authorities procure R&D from several competing suppliers through successive phases, such as design, prototyping and testing. A defining feature of PCP is that the risks and benefits of the R&D are shared with suppliers, who typically retain the intellectual property rights, while public authorities obtain usage rights.

- **PPI** refers to the procurement of innovative goods or services that are close to market or already available in limited form but have not yet been widely deployed. Through PPI, public authorities act as early adopters, purchasing innovative solutions to support their market uptake and wider diffusion.

While the EU provides definitions of innovation procurement, in practice many tenders that stimulate innovation are not explicitly labelled as such. Whether a procurement process can be considered as innovation oriented often depends on the nature of the solution being purchased and on how the tender is structured, for example through the inclusion of outcome-based rather than specification-based requirements.

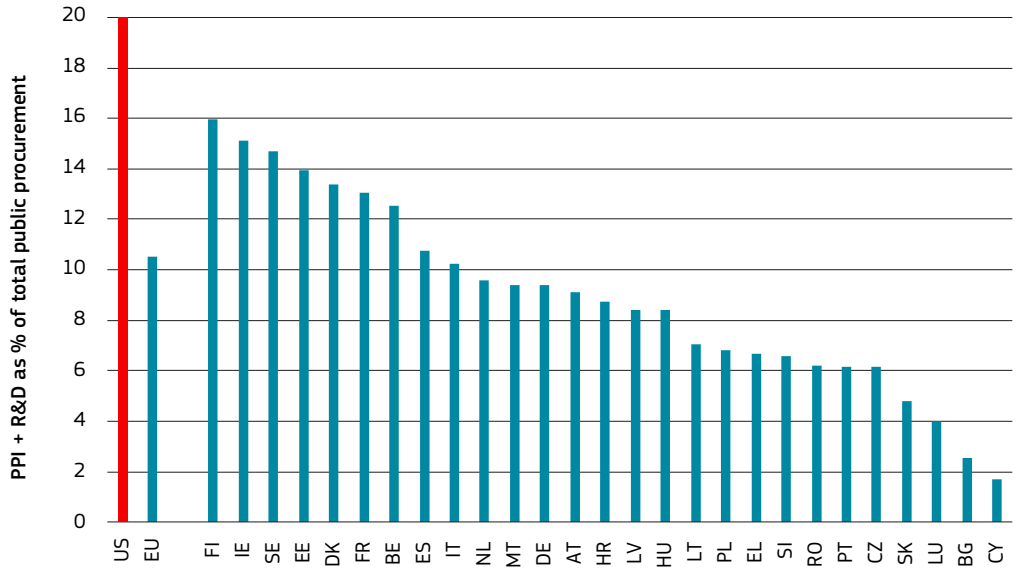
Empirical evidence suggests that innovation-oriented public procurement can have positive effects on firms' innovation performance and growth. Czarnitzki *et al.* (2020), examining a German legislative reform that facilitates innovation-oriented procurement, found that firms winning such contracts experience stronger innovation outcomes than comparable firms without innovation-oriented procurement contracts. Similarly, firm-level evidence from Italian manufacturing shows that companies participating in innovation-related public procurement record, on average, higher turnover from new products and services than similar firms without such contracts (Caravella and Crespi, 2021). Complementary evidence from eight central and eastern European countries also demonstrates that innovation procurement increases the probability of firms introducing both product and process innovations (Stojčić *et al.*, 2020).

The EU lags behind international competitors in leveraging public procurement to support innovation. Estimates suggest that innovation procurement accounts for around 10 % of total public procurement in the EU, significantly below the approximately 20 % observed in the US (European Commission, 2025). This limits scaling opportunities and risks driving EU startups to seek procurement opportunities abroad. On the other hand, the US has a long tradition of innovative procurement, with the Defense Advanced Research Products Agency (DARPA) being a leading example. Rather than buying existing products, DARPA

funds high-risk, high-reward R&D to achieve strategic goals where no market yet exists. Operating outside traditional procurement rules through Other Transaction Authority, it contracts flexibly with startups, universities and consortia. Its approach is outcome oriented, milestone based and mission driven, focusing on creating breakthrough technologies through PCP rather than optimising cost or efficiency in known markets. Many important innovations such as the internet (Advanced Research Projects Agency Network – ARPANET), the Global Positioning System (GPS), stealth technology and autonomous vehicles stemmed from DARPA projects (European Commission, 2024).

EU Member States allocate differing shares of their public procurement to innovation-oriented procurement, with some countries approaching the estimated 20 % level observed in the US, while others lag significantly behind. Figure 5.3-10 shows the share of total public procurement expenditure that goes on innovation procurement (including R&D procurement and PPI) in the EU, the US and EU Member States, while figure 5.3-11 digs deeper, showing the composition of innovation procurement in EU Member States.

Figure 5.3-10 Public procurement of innovation as a percentage of total public procurement, 2022

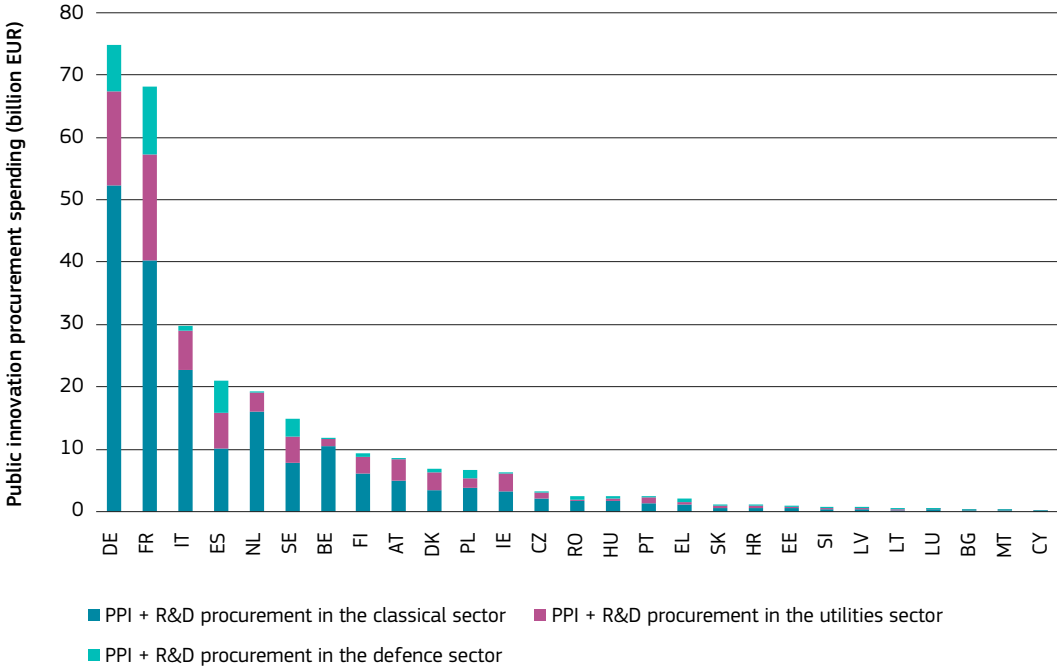


Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on European Commission and PwC (2026).

Note: Classical, utilities and defence sectors are included.

Figure 5.3-11 Public procurement of innovation by type across EU Member States, 2022



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on European Commission and PwC (2026).

Box 5.3-3 Public procurement instruments within and outside the EU procurement directives

Not all public procurement falls under the EU public procurement directives. Whether a procurement procedure is subject to EU rules depends primarily on two factors: whether the contract value exceeds the EU financial thresholds and whether the procurement concerns pre-commercial R&D services.

Two key dimensions are relevant:

- **EU financial thresholds**: The EU public procurement directives apply only to contracts above certain financial thresholds. These thresholds vary depending on the type of contracting authority, the type of contract (works, services or supplies) and the sector (classical or utilities). Contracts below these thresholds are generally governed by national procurement rules.

- **PCP**: As mentioned, PCP refers to the procurement of R&D services aimed at developing solutions that are not yet commercially available. A defining feature of PCP is that the risks and benefits of the R&D are shared between the contracting authority and the suppliers, with intellectual property rights typically remaining with the companies. Because of these characteristics, PCP is excluded from the scope of the EU public procurement directives.

Figure 5.3-12 provides a visual mapping of procurement types based on these two dimensions: EU financial thresholds (vertical axis) and the stage of innovation (horizontal axis). The typology illustrates which types of procurement fall within the scope of the EU public procurement directives and which fall outside.

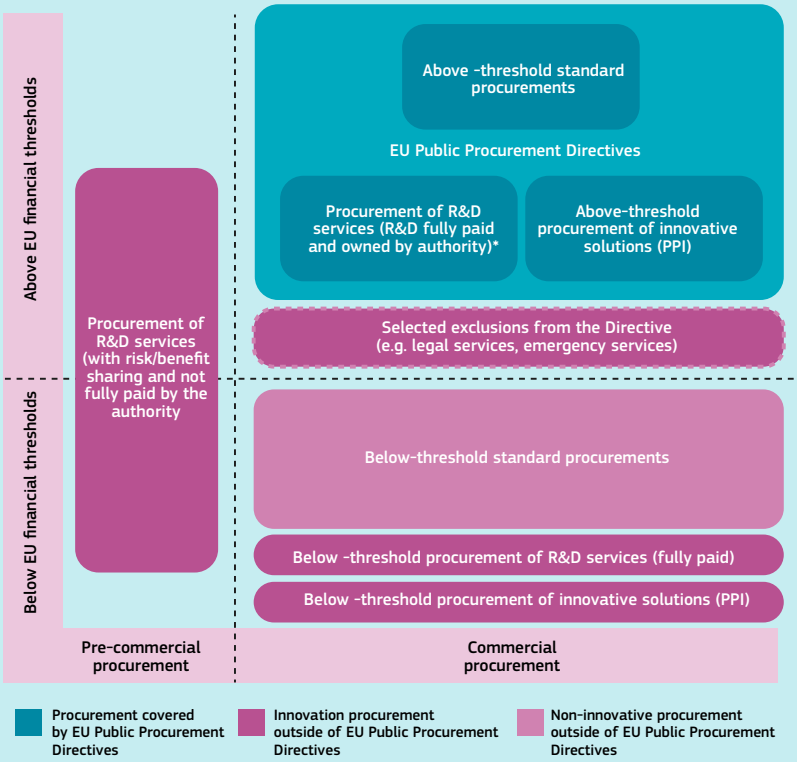
Top-right quadrant (above threshold and commercial stage)
Procurements in this quadrant are generally subject to the EU public procurement directives. This includes both standard procurement procedures and innovation-oriented procurement, such as PPI or procurement of R&D services that do not qualify as PCP. However, some specific categories of services (such as certain legal or emergency services) may be excluded or subject to special regimes.

Bottom-right quadrant (below threshold and commercial stage)
Procurements below the EU financial thresholds are not subject to the EU procurement directives and are primarily governed by national procurement rules. These may include both traditional procurement and smaller-scale innovation-oriented procurements.

Left quadrants (PCP)
Where the procurement concerns pre-commercial R&D services, the procedure falls outside the scope of the EU procurement directives, irrespective of the contract value.

This typology highlights the fact that innovation-oriented procurement can take place both within and outside the scope of the EU public procurement directives. While procurements covered by the EU framework benefit from harmonised rules that support transparency and cross-border competition, procurements outside the scope of the directives (such as smaller contracts or PCP) offer greater flexibility, allowing public authorities to experiment with innovative solutions. However, these more flexible instruments are less harmonised at EU level and may therefore give rise to greater variation in practices across Member States.

Figure 5.3-12 Public procurement typology: financial thresholds and innovation stages



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit.

*At the time of writing, excluded from the scope of the Commission proposal to revise the EU Public Procurement Directives, known as the Public Procurement Act (PPA). However, as the proposal remains subject to the legislative process, its final scope and provisions may differ from those currently proposed.

At the time of writing, the European Commission is preparing a proposal for a European Public Procurement Act, expected by the end of 2026, with the aim of consolidating and modernising the current EU public procurement framework. As the proposal has not yet been adopted by the Commission and its final content remains subject to the ordinary legislative procedure, this chapter describes the existing legal framework established by the 2014 Public Procurement Directives. A relevant change that the Public Procurement Act could introduce compared with the 2014 Public Procurement Directives, and which is worth highlighting, is the exclusion from its scope not only of PCP, but of R&D procurement more generally. Procurement of innovative solutions, as well as procurement involving certain R&D elements that does not qualify as R&D procurement, would remain within its scope.

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CHAPTER 6

GEOGRAPHY OF EU'S SCIENCE, RESEARCH AND INNOVATION

CHAPTER 6.1

THE EUROPEAN R&I DIVIDE

Florence Benoit, Nicola Francesco Dotti

KEY QUESTIONS

- Are there regional disparities in Research and Innovation (R&I) capacity and performance across Europe?
- How have these patterns changed in recent years?
- What economic and innovation-related consequences could these regional disparities have for Europe?

HIGHLIGHTS

- Europe shows a significant R&I divide at the regional level, and between urban and rural areas in terms of both R&I capacity and performance.
- Innovation activity tends to concentrate geographically, forming distinct regional clusters rather than being evenly distributed.
- The causes of the R&I divide can be identified in the self-reinforcing dynamics of R&I capacities and performance leading to path dependence and significant agglomeration effects in favour of the most urbanised areas.
- This divide can lead to sub-optimal use of Europe's R&I potential: valuable capacities in some regions remain underutilised or insufficiently developed, reducing Europe's ability to combine capabilities at scale and enhance its competitiveness.

POLICY INSIGHTS

- R&I policy can benefit from the adoption of a multi-scalar perspective combining EU-wide, country-level and subnational dimensions.
- The R&I divide leads to policy trade-offs to optimise investments, with a need to choose between excellence, cohesion, resilience and reduction of disparities.
- Place-based approaches aimed at strengthening regional R&I capacity, such as investments promoted by Smart Specialisation Strategies (S3), can be successful in addressing a combination of different needs so as to improve R&I capacities and performance in the long term.

Europe's R&I capacities and performance differ across its countries, regions and cities. The cumulative dynamics of the knowledge economy, which tends towards spatial concentration, contribute to widening this 'R&I divide'. These dynamics shape regional development paths, with both positive and negative effects. Advanced regions can build on their knowledge capacity to develop frontier science, effective research and continuous innovation, leading to better economic performance. In contrast, regions lacking these bases risk following downward spirals of declining competitiveness. These disparities shape regional development, affecting productivity, employment, resilience and competitiveness.

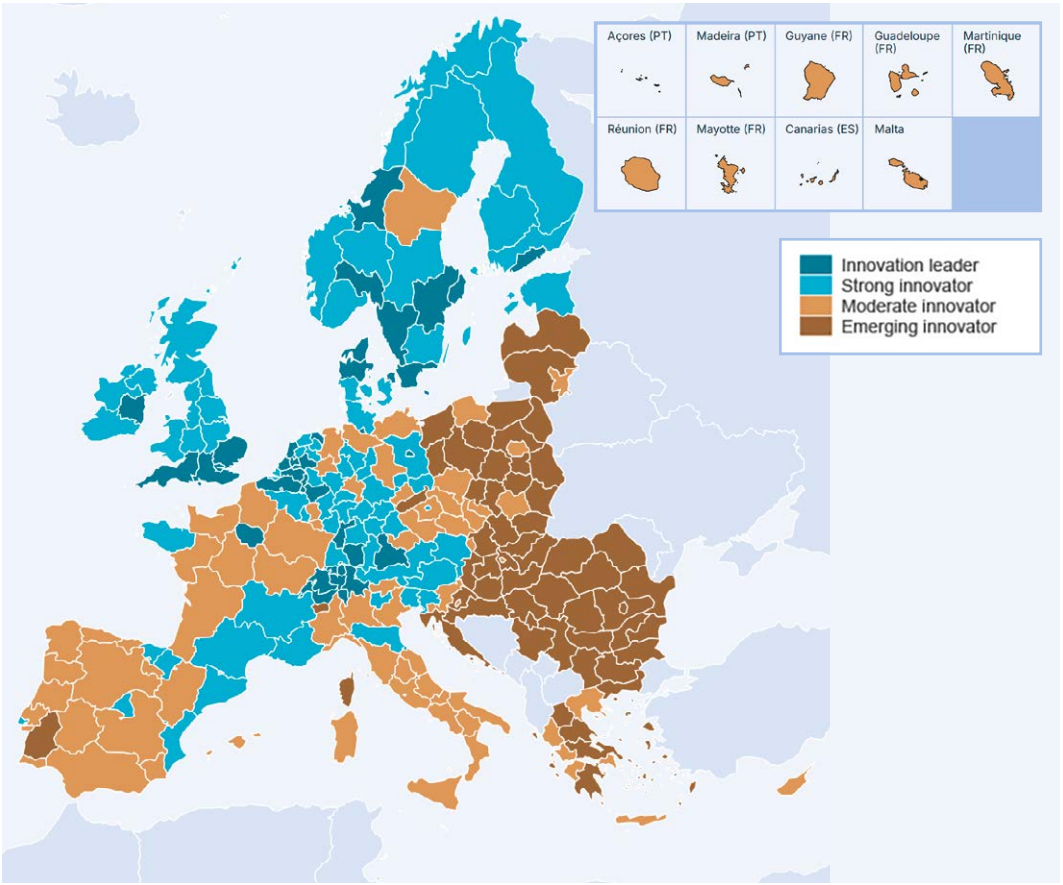
Understanding the geography of the EU's innovation system is essential for shaping policies that balance competitiveness, cohesion and resilience. While urban regions account for a large share of scientific output, patents and entrepreneurial activity, rural and peripheral areas exhibit innovation strengths grounded in local industries, resources and place-specific knowledge (Eder, 2019). However, these capacities are unevenly distributed across space, and their potential is not always fully exploited. Place-based strategies, such as EU's Smart Specialisation Strategy (S3) and Horizon Europe's 'Widening participation and spreading excellence' initiatives, seek to mobilise local capacities and connect less-developed regions to broader knowledge networks to enhance Europe's competitiveness, resilience and sustainability.

1. The R&I divide across European regions

The Regional Innovation Scoreboard (RIS) assesses the innovation performance of European regions, extending the national perspective provided by the European Innovation Scoreboard (European Commission, 2026) **to the regional level.** Despite a more limited set of indicators being available at regional level, the RIS has become a reference for benchmarking of European regions since 2018 (Hollanders, 2023). European regions are classified in four groups: innovation leaders, strong innovators, moderate innovators and emerging innovators. Furthermore, some 'pockets of excellence' are identified. These are regions showing high performance, despite being located in less innovative countries (for more details, see European Commission, 2025b).

Innovation performance across Europe remains highly uneven in spatial terms. At the national level, innovation performance continues to reflect a clear geographical divide: northern and western European countries generally outperform those in central, eastern and southern Europe (European Commission, 2025b). Strongly performing countries also tend to have a higher concentration of regions with above-average innovation activity, reflecting existing territorial imbalances. While variation between regional innovation groups within countries is often limited, disparities at the subnational level remain more pronounced, with innovation frequently concentrated in a small number of leading regions that function as innovation hotspots (Figure 6.1-1).

Figure 6.1-1 Innovation performance groups of European regions, 2025



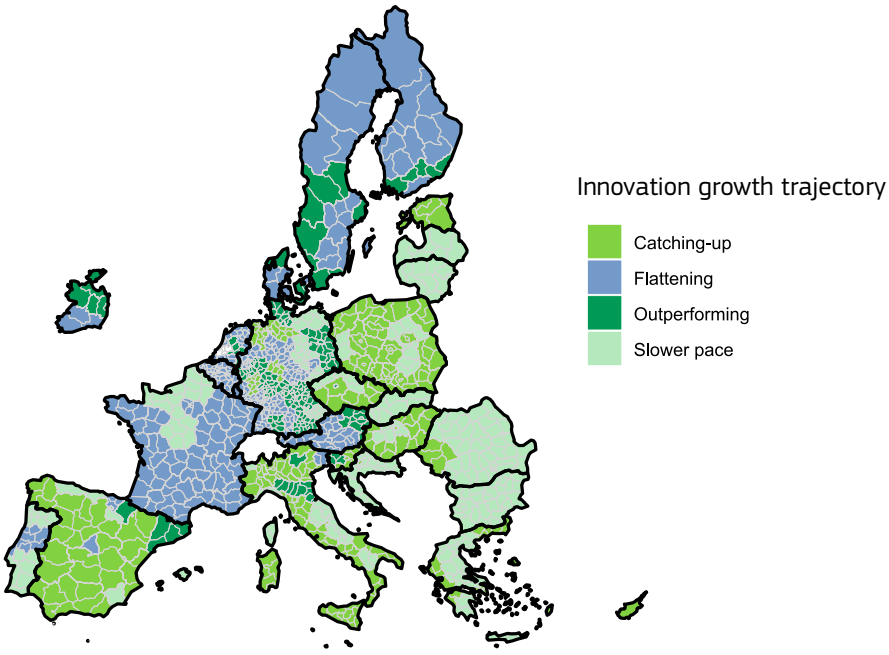
Science, Research and Innovation Performance of the EU 2026

Source: Regional Innovation Scoreboard, European Commission (2025b).

Over time, notable progress has been made in innovation performance across European regions. Between 2018 and 2025, 97% of all regions in Europe managed to increase their innovation performance, with average regional gains of 12.2 percentage points (European Commission, 2025b). Only eight regions in France, Sweden and Switzerland recorded modest declines. Overall, these trends point to a generally positive trajectory for regional innovation across Europe.

Despite this overall progress, the pace of regional innovation growth varies considerably across the EU. Many regions in Czechia, Hungary, Poland and Slovakia, and, to a lesser extent, in Bulgaria and Romania, are catching up, growing faster than the EU average despite lower initial innovation levels. To some extent, this catching-up trend also applies to Spain, Italy and Portugal. Advanced regions in northern and western Europe are experiencing slower growth rates. This 'flattening' is happening in parts of Germany, France, Finland and Sweden, as well as in associated countries like the UK. A smaller set of regions continues to outperform by maintaining high innovation levels and above-average growth, and some regions remain on a slower trajectory, lagging behind the EU average (those regions denoted as 'slower pace' in Figure 6.1-2).

Figure 6.1-2 Innovation growth trajectories of European regions, 2018–2025



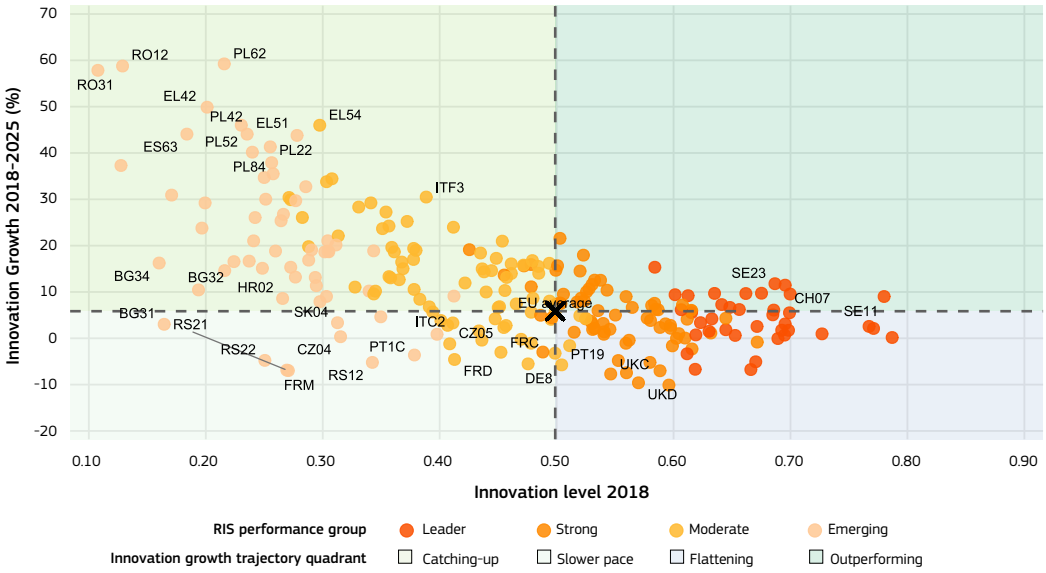
Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on European Commission (2025b).

Note: NUTS 1 or NUTS 2 regions may be presented depending on the country and data availability. The labels describe regions' innovation trajectories relative to the EU average since 2000 as follows: 'catching-up' refers to innovation growth rates that are below average but with faster progress; 'flattening' refers to above-average rates but with slower progress; 'outperforming' refers to above-average rates with faster progress; and 'slower pace' refers to below-average rates with slower progress (see also Figure 6.1-3).

Building on these patterns, the distribution of innovation growth across Europe reveals distinct regional clusters that illustrate how different types of regions are evolving. Figure 6.1-3 places each region according to its initial performance level in 2018 and its progress between 2018 and 2025, highlighting groups of regions that are following similar developmental paths. Within the catching-up cluster (top-left quadrant), regions such as Poland's Warmińsko-mazurskie (NUTS classification PL62), Romania's Centru (RO12) and Sud-Muntenia (RO31) and Greece's Notio Aigaio (EL2) have achieved particularly strong growth. Bulgaria's Severozapaden (BG31) remains closer to the EU average. High-innovation regions also form clusters. Many regions in Finland, France, Germany, Sweden and the UK show high initial innovation levels but below average growth, whereas frontrunner regions in Belgium, Denmark, Ireland and the Netherlands have sustained both high innovation levels and strong growth. Low-innovation, low-growth clusters persist in eastern Spain (Comunitat Valenciana, ES52), southern Italy (Sicilia, ITG1), Latvia (LV00) and Lithuania (Vidurio ir vakarų Lietuvos regionas, LT02), as well as parts of Bulgaria and Romania. Together, these clusters demonstrate that while overall innovation performance across Europe is improving, progress is far from uniform. Regions evolve along distinct trajectories shaped by their starting positions, institutional capacities and innovation ecosystems, resulting in a pattern of differentiated advancement rather than a single common direction.

Figure 6.1-3 Trends of European regional innovation trajectories, 2018–2025



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on European Commission (2025b).

While innovation performance has improved across most regions, the translation of this progress into measurable outputs remains uneven. The regional innovation output indicator shows that innovation outputs are far more spatially concentrated than overall innovation performance (as in the RIS), with a small number of regions obtaining a disproportionate share of results (Bello *et al.*, 2025). This composite indicator encompasses technological and non-technological innovation, as well as contributions to value added in trade, employment and knowledge-intensive sectors. This approach shows that capital regions and major metropolitan areas consistently dominate innovation outputs, reflecting their structural advantages in skills, infrastructure and connectivity. Regions such as Stockholm, Oberbayern, Berlin, Praha and Île-de-France regularly report output levels well above the European average, in sharp contrast to most southern and eastern European regions, where innovation outcomes remain more limited.

2. Exploring the urban and rural perspective

A fundamental dimension of Europe's R&I divide is the urban-rural dichotomy. Urban areas concentrate talents, infrastructures, universities and research centres and facilitate the exchange of tacit knowledge (Huriot and Thisse, 2000; Florida, 2005). On the other hand, rural regions often lack these benefits derived from spatial agglomeration, despite some notable exceptions (Eder and Trippl, 2019). Even though significant data constraints exist (for more details, see Box 6.1-1), this more granular perspective enriches the understanding of Europe's innovation dynamics.

This concentration of R&I performance is evident from scientific publications, in which urban regions dominate knowledge production. Predominantly urban regions accounted for nearly two-thirds of all scientific publications produced between 2000 and 2024, despite being fewer in number than intermediate and rural regions combined (Table 6.1-1). On average, urban regions generate more than five times as many publications per million inhabitants as rural regions, underscoring the importance of these regions as hubs of research activity. They also exhibit a higher share of highly cited publications and a greater incidence of co-publications, reflecting both research excellence and denser knowledge networks. Intermediate regions occupy a middle position.

The same uneven geography is visible for intellectual property outcomes, where various forms of innovation output, from patents to trademarks and industrial designs, are

Box 6.1-1 Understanding science, technology and innovation dynamics of European cities

Cities are the primary engines of science and innovation, acting as vital catalysts for talent attraction, growth, infrastructure, creativity and culture (Florida, 2005). Home to over two-thirds of the European population, cities serve as pivotal nodes within innovation ecosystems. Understanding how cities play this role and their relationship with rural areas are crucial challenges for R&I policy (Bajmócy *et al.*, 2014).

Developing robust city-level indicators is essential for evidence-informed policy, yet significant constraints remain due to data scarcity and spatial consistency. A recent study explored the availability of science, technology and innovation data at subregional level, showing the difficulties in providing exhaustive city-based indicators (Tijssen, 2025). Key challenges include the limited standardisation of city data and conflicting territorial definitions, such as the distinction between statistical and administrative boundaries and functional urban areas.

Investing in improved spatial granularity enables policymakers to design targeted interventions. More granular indicators reveal localised strengths and weaknesses, allowing for more precise resource allocation than regional averages. Such data facilitates benchmarking of cities, helping to identify best practices and foster equitable growth across Europe (e.g., Filippetti and Zinilli, 2023).

concentrated in urban regions. Predominantly urban regions accounted for more than half of all patents registered between 2000 and 2022 and close to 60% of trademarks over a similar period. These regions produce nearly three times as many patents per capita as rural regions. This pattern is not unique to Europe; it mirrors global trends, with 41% of worldwide patent activity concentrated in just 125 large cities that together account for only 15% of the world's population (Belderbos *et al.*, 2022). In part, this concentration reflects differences in overall economic weight. On average, urban regions' total GDP is 4.25 times higher than that of rural regions (EUR 472 billion versus EUR 111 billion). Yet the patent concentration gap is even wider, suggesting that scale alone does not fully explain the observed disparities.

A notable exception emerges in industrial designs, where the urban advantage is weaker and rural regions capture a larger share. This suggests a more geographically dispersed form of innovation, often linked to manufacturing activities, craft-based industries and incremental design improvements (Table 6.1-1). This exception also illustrates the sectoral dimension of innovation. Urban areas often host knowledge-intensive services and high-tech manufacturing, while innovation in rural areas tends to be more incremental or embedded in production. Part of the urban-rural divide therefore reflects the location and type of activities, not just differences in innovative capacity.

Table 6.1-1 **EU urban-rural divide in scientific publications and patents**

	Predominantly urban regions	Intermediate regions	Predominantly rural regions
Number of regions (NUTS 3)	252	535	421
Average GDP (billion EUR), 2024	472	270	111
Scientific publications			
Average number of publications per million inhabitants, 2024	1 750	999	339
Share of total EU publications, 2000–2024	63%	32%	5%
Average share of highly cited publications (top 10%) among total publications, 2000–2024	0.09%	0.07%	0.06%
Average share of co-publications by total publications, 2000–2024	13%	11%	10%
Intellectual property			
Average number of patents per million inhabitants, 2023	123	69	36
Share of total patents, 2000–2023	55%	36%	9%
Share of total trademarks, 2000–2021	59%	31%	10%
Share of total industrial designs, 2000–2021	48%	38%	14%

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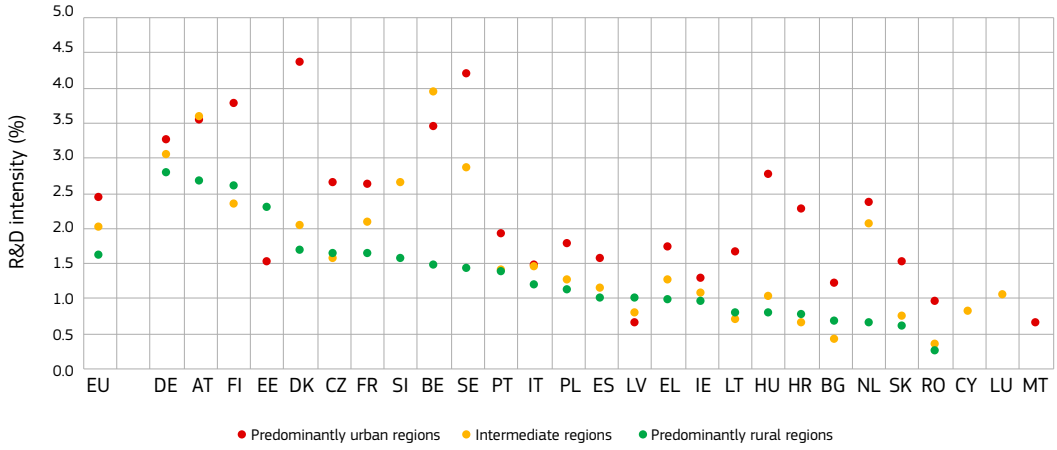
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Fraunhofer ISI, using Scopus.

Note: Patents reflect Patent Cooperation Treaty patent applications at inventor level. Trademarks represent trademark applications filed at the European Union Intellectual Property Office.

The spatial concentration of innovation outputs closely reflects the equally uneven distribution of input. In 2022, R&D investment remained higher in predominantly urban regions, where expenditure averaged 2.4% of GDP, compared with 2% in intermediate regions and just 1.6% in rural areas, both below the EU average of 2.2%. At the same time, aggregate figures conceal significant territorial heterogeneity across Member States' regions (Figure 6.1-4). More than one-fifth of rural regions performed above the EU average in R&D intensity, with notable examples in western Germany, Austria's Oberösterreich region and south-western France, where R&D expenditure surpassed 3% of GDP due to strong local specialisation or the presence of public research institutions supporting innovation capacity (see chapter 2.1 for more details). Rural regions account for only a small share of total EU R&D investment relative to their population size and continue to lag in both public and business R&D (Sasso *et al.*, 2026).

Firms and entrepreneurial dynamism are also predominantly concentrated in urban regions. Enterprises are overwhelmingly located in urban regions, with the highest concentrations found around major agglomerations like Barcelona, Madrid, Lisbon, Paris and Rome (Figure 6.1-5). In 2023, urban areas were home to on average 4.5 times more firms than rural regions. A similar gap is visible as regards business creation rates. While more than 3.5 million firms were established across the EU in 2023, urban regions recorded consistently higher creation rates than rural areas. Still, several rural regions in countries including Estonia, Hungary, Romania and Finland exceeded the EU average, showing that favourable local conditions and capacities can partially offset structural disadvantages and support entrepreneurship beyond major urban centres (Sasso and Perpiña Castillo, 2025).

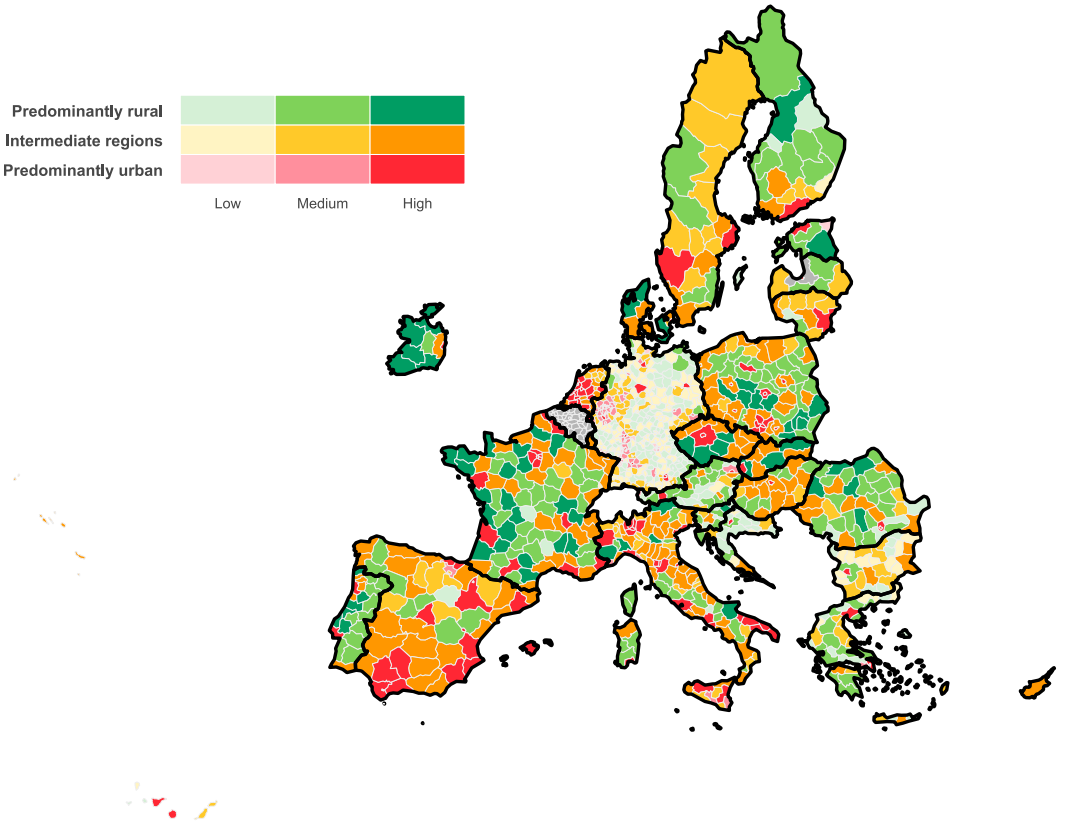
Figure 6.1-4 R&D intensity across EU regions (NUTS 3), 2022



Science, Research and Innovation Performance of the EU 2026

Source: Joint Research Centre, Territorial Development Unit based on projections using JRC ARDECO.

Figure 6.1-5 Enterprise concentration by EU region (NUTS 3), 2023



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Eurostat (DOI link: https://doi.org/10.2908/BD_HGNACE_R).

Note: Concentration level is determined based on the entire sample. Grey indicates missing values.

The urban bias of entrepreneurial dynamics is most pronounced in startup activity. Growth-oriented companies are mostly concentrated in cities, while rural areas specialise in narrower, place-based niches. Across all Member States, startup activity is overwhelmingly urban, with cities hosting on average around 146 startups per 100 000 inhabitants compared to just 19 in predominantly rural regions (Figure 6.1-6, for further details on startups and scaleups, see chapter 5.2). This gap is visible in almost every country, regardless of overall national innovation performance, reflecting persistent urban advantages in access to finance, skills, networks and markets. At the same time, rural startups tend to concentrate in activities such as agrifood, transport and energy and in high-tech sectors that require more space to operate including robotics and semiconductors (Sasso and Perpiña Castillo, 2025). This illustrates their capacity to support specialised forms of innovation rooted in place-based capabilities rather than scale or density (Trippl *et al.*, 2016; Florida *et al.*, 2020).

Figure 6.1-6 Startup rates by EU region (NUTS 3), 2024



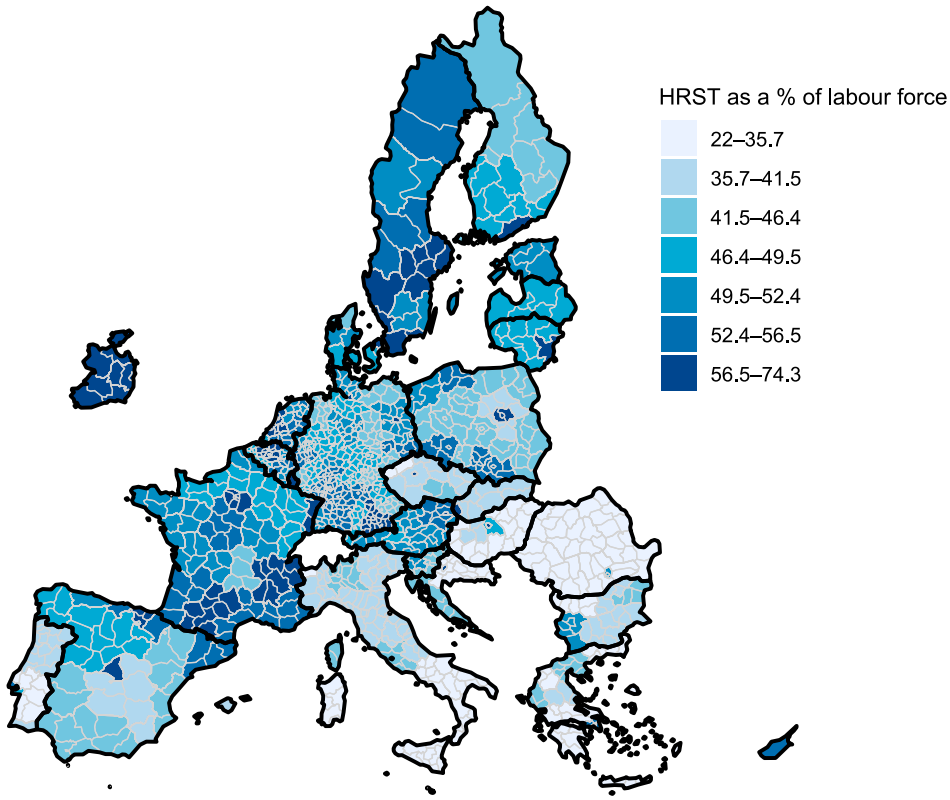
Science, Research and Innovation Performance of the EU 2026

Source: Joint Research Centre, Territorial Development Unit based on Dealroom.

All these territorial imbalances are reflected in differences in human capital endowment. Urban regions tend to concentrate higher levels of human capital due to the presence of universities, research institutions and specialised training facilities. Educational attainment, as a core component of human capital, remains strongly uneven across territories. In 2024, 44.2 % of people aged 25-34 in the EU had completed tertiary education, yet this threshold was reached in only 35 % of NUTS 2 regions. The lowest shares were predominantly found in rural or geographically remote regions, where populations are smaller and the proportion of highly qualified individuals tends to be lower, limiting the availability of highly skilled labour (Eurostat, 2025).

These human capital disparities become even more pronounced when focusing on science- and technology-related employment. In 2024, EU human resources in science and technology (HRST), particularly core HRST, defined as individuals combining tertiary education with employment in science and technology occupations, amounted to 55.4 million people. These workers were heavily concentrated in a small number of regions, including Île-de-France, Rhône-Alpes, Comunidad de Madrid, Cataluña, Andalucía, Lombardia, Oberbayern and Warszawski stołeczny, each with HRST of between 0.8 and 2.4 million. Across Europe, a clear core-periphery pattern emerges: Nordic regions show high HRST shares across almost all territories; in continental and western Europe, capitals and major cities are dominant; HRST in southern Europe is concentrated in urban hubs; and in central and eastern Europe it is mostly limited to capitals and a few advanced metropolitan centres (Figure 6.1-7). A similar concentration is observed in high-technology employment: only 22 NUTS 2 regions employ 100 000 people or more in such sectors, and together, these regions account for nearly 38 % of total EU high-technology employment. In contrast, in many rural regions, only a few thousand people work in high-technology jobs (Eurostat, 2025).

Figure 6.1-7 Human resources in science and technology (HRST) as a percentage of the overall labour force by EU regions (NUTS 2), 2024



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Eurostat (DOI link: https://doi.org/10.2908/TGS00038).

3. Understanding the roots and consequences of Europe's R&I divide

Europe's uneven spatial innovation geography is firstly caused by the high capacity of some regions to attract, retain and concentrate knowledge-intensive activities, creating self-reinforcing advantages. This concentration is largely driven by agglomeration forces. Regions with top universities, leading research institutions, specialised services for firms and advanced infrastructure naturally attract inventors, a highly skilled workforce and innovative firms (Bettencourt *et al.*, 2007). When these actors are located close to one another, ideas can be exchanged easily via informal contacts

and repeated collaboration ensues (Boschma, 2005), while labour can move more efficiently between firms. These dense local networks are called 'Marshallian' externalities and raise both the rate and quality of innovation (Marshall, 1890; Beaudry and Schiffauerova, 2009). As more talent and firms accumulate, local labour pools deepen, networks densify and knowledge spillovers intensify, making these regions even more attractive places in which to invest.

These spatial advantages are further reinforced over time in cumulative processes leading to path dependence. Regions that benefited from early investments in research institutions, industrial clusters and specialised labour markets have been able to build on these initial advantages, attracting further investment and talent and developing new areas of activity, see the seminal contributions by Myrdal (1957) and Merton (1968). These processes are deeply intertwined with agglomeration. Proximity builds the historical foundations that path dependence then entrenches. Conversely, regions lacking such starting points may enter into a mirrored negative cycle, characterised by limited industrial diversity, fewer local innovation opportunities, outward migration of skilled workers and reduced access to public and private innovation funding (MacKinnon *et al.*, 2022).

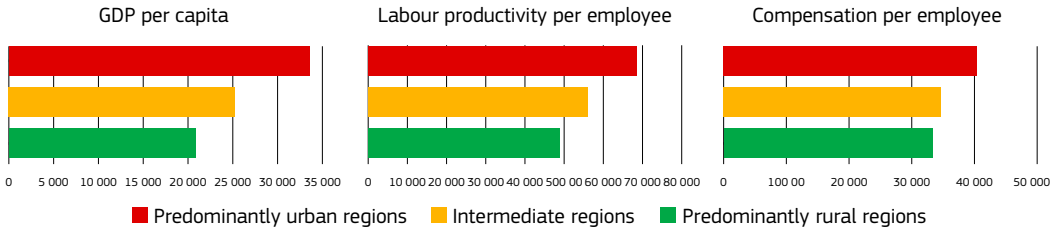
These agglomeration and path-dependent processes shape distinct regional capabilities that guide long-term innovation trajectories (Isaksen and Trippl, 2016). These capabilities refer to the underlying bundles of productive knowledge, skills and institutional capacities that enable regions to produce specific goods, services and technologies (Hausmann and Hidalgo, 2011). They emerge through dense networks, repeated collaboration and cumulative investments embodied in people, institutions and productive activities. Regions that benefit from these self-reinforcing dynamics continuously accumulate capabilities through talent inflows, repeated collaboration and infrastructure upgrades, allowing them to diversify beyond historical specialisations and adapt effectively to new growth opportunities (Neffke *et al.*, 2011). In contrast, regions with thin capability bases face limited diversification opportunities, narrow industrial structures and weak institutions, reinforcing their dependence on a small set of industries and sustaining persistent regional inequalities (Rodríguez-Pose, 2020).

Structural and policy factors can systematically reinforce regional disparities in innovation capacity by shaping who can access resources, networks and investment opportunities. Competitive research funding, cluster programmes and venture capital tend to flow to regions equipped with strong

universities, skilled labour pools and proven innovation track records (Makkonen and Mitze, 2016; Fitjar, 2025). A recent study shows that the Framework Programme's funding tends to concentrate in already economically strong, and research-intensive regions with higher income levels, more patents, a strong presence of knowledge-intensive services and dense urban environments (Marques Santos, 2026). Less-equipped regions struggle to compete for the same resources (Langfeldt *et al.*, 2015; Dotti and Spithoven, 2018; Conte and Marques, 2023). Infrastructure and connectivity amplify these effects as well-endowed regions benefit from superior transport networks, high-speed digital connectivity, access to global markets and strong institutions, while remote regions face higher transaction costs and limited access to knowledge pipelines (Conte and Marques, 2023). These structural conditions help explain why spatial equilibrating mechanisms often fail, and local capacity to attract and retain sources of exogenous opportunities further reinforces these cumulative dynamics. However, targeted policies can help break these negative cycles and build the local capabilities needed for innovation (Dotti *et al.*, 2024).

The combination of agglomeration, path-dependent dynamics, capability accumulation and structural factors produces a self-reinforcing system of regional advantage and disadvantage leading to (measurable) economic divergence. Regions endowed with dense innovation ecosystems, accumulated capabilities and favourable structural conditions tend to capture a disproportionate share of growth opportunities, while others remain structurally constrained (Asheim and Gertler, 2006). These dynamics translate into performance gaps. Over the past decade, predominantly urban regions recorded average GDP per capita of EUR 33 572, labour productivity of EUR 68 520 per employee and labour compensation (i.e., wages) of EUR 40 378. Rural regions show a stark contrast, with corresponding figures of EUR 20 810, EUR 48 970 and EUR 33 295, respectively (Figure 6.1-8). A small set of advanced regions is thus consistently pulling ahead in terms of productivity, employment and living standards, while other regions lag behind, a pattern also observed in non-European contexts (cf. Crescenzi *et al.*, 2007).

Figure 6.1-8 Economic performance indicators by region type



Science, Research and Innovation Performance of the EU 2026
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on JRC ARDECO.

These interregional innovation disparities have deepened during the last few decades because technological disruption and globalisation have uneven regional effects. Since the late 1970s, inter-regional inequality has increased (not only in Europe) as new technologies, global value chains and market integration have disproportionately benefited regions already positioned at the technological frontier (Kemeny and Storper, 2020). The more recent rise of artificial intelligence, automation and other advanced technologies illustrates this pattern clearly. While such technologies can boost productivity and generate new economic opportunities, they also threaten routine and middle-skill occupations that are more prevalent in rural and less-developed regions (e.g., Muro *et al.*, 2019). These dynamics intensify spatial divergence in productivity and employment.

Innovation inequalities shape regions' capacity to cope with economic, technological and environmental shocks. Regions with strong and diversified innovation systems tend to adapt more quickly to changes because they can redeploy skills and capabilities in new activities and sectors (Boschma, 2015). In contrast, regions specialised in a narrow set of activities often lack both the knowledge base and institutional capacity to reorient their economies in response to shocks, making this process slower, more disruptive and more socially costly (e.g., Fritsch and Wyrwich, 2018). Unequal innovation capacities therefore produce divergence with regard to current opportunities and, in the long run, further disparities in terms of the ability to absorb, withstand and recover from future disruptions. For instance, the Regional Resilience Dashboard provides evidence of growing interregional disparities as regards resilience, with peripheral and mountainous regions exhibiting lower capacities and higher vulnerabilities (Heriaud *et al.*, 2025).

Over time, all these interregional disparities tend to translate into social and political tensions. The lack of opportunities and limited economic dynamism in lagging regions have recently been identified as fundamental sources of discontent, as residents perceive themselves as being excluded from innovation-driven growth and from the benefits of European integration more broadly (Rodríguez-Pose *et al.*, 2024). This 'geography of discontent' has been associated with rising support for anti-establishment narratives, Euroscepticism and resistance to policies perceived as favouring successful places (Dijkstra *et al.*, 2020). In this sense, persistent spatial innovation inequalities undermine economic cohesion, leading to the emergence of threats to political and social foundations and long-term stability.

4. Opportunities and challenges linked to the untapped potential of regional innovation peripheries

Many rural and peripheral regions have innovation capacities that are complementary to those of often more advanced urban regions. In these regions, innovation is typically incremental; grounded in local comparative advantages such as natural resources, established industries and place-specific know-how; and characterised by longer development cycles. Innovation often proceeds cumulatively through learning-by-doing, gradual upgrading of processes and products and recombination of existing knowledge, rather than direct engagement with frontier research (Eder, 2019). While slower, this mode of innovation benefits from longer incubation periods and lower pressure to rush to market, enabling experimentation, adaptation to local needs, and development of solutions tailored to specific environmental, social or market contexts (Shearmur, 2011; Doloreux and Porto Gomez, 2017). From a European perspective, this diversity of innovation modes represents a potential strength rather than a weakness.

External linkages are key for capitalising on the untapped potential of peripheral regions. Regions with weaker agglomeration economies can compensate for limited internal capabilities by forging stronger external connections (Bathelt *et al.*, 2004; Bathelt and Turi, 2011; Barzotto *et al.*, 2019). Specifically, peripheral regions can benefit by accessing knowledge from firms, universities, research organisations and other key actors located in other regions through EU Framework Programmes and Cohesion Policy support (see chapter 6.2 for policy options boosting collaboration). These supra-local linkages allow less-developed regions to access specialised knowledge and skills that are not locally available (Meili and Shearmur, 2019). Recent advances in digital connectivity and the spread of remote and hybrid working further strengthen this potential by reducing the need for physical proximity. Improved broadband, co-working spaces and supportive local governance can help attract and retain highly skilled workers, linking local innovation with broader European knowledge networks (Mariotti *et al.*, 2021). Investing in these interregional linkages reinforces the centrality of dense innovation hubs, reducing the risk of saturation, while supporting wider diffusion of innovation capacity.

A central policy challenge is how to tap into latent or underutilised regional innovation potential. In many rural and peripheral regions, innovative ideas do not fail because of poor quality but because supportive framework conditions are missing (Lagendijk and Lorentzen, 2007; Grillitsch and Nilsson, 2015). Weak institutions, poor support infrastructures, limited access to risk finance and weak links to larger markets are among the most common causes of underutilisation of regional innovation potential in peripheral areas (Álvarez *et al.*, 2026). Even when firms engage in continuous process or product improvements, these activities often remain small scale with limited impacts. For policymakers, the challenge is to ensure that these efforts do not end up being statistically invisible due to them falling outside of the R&D- or patent-based metrics that dominate innovation measurement (OECD, 2023). As a result, locally valuable innovations may fail to diffuse, scale or translate into broader productivity gains. The perception of low innovation performance can thus be reinforced despite the presence of real capabilities and potential.

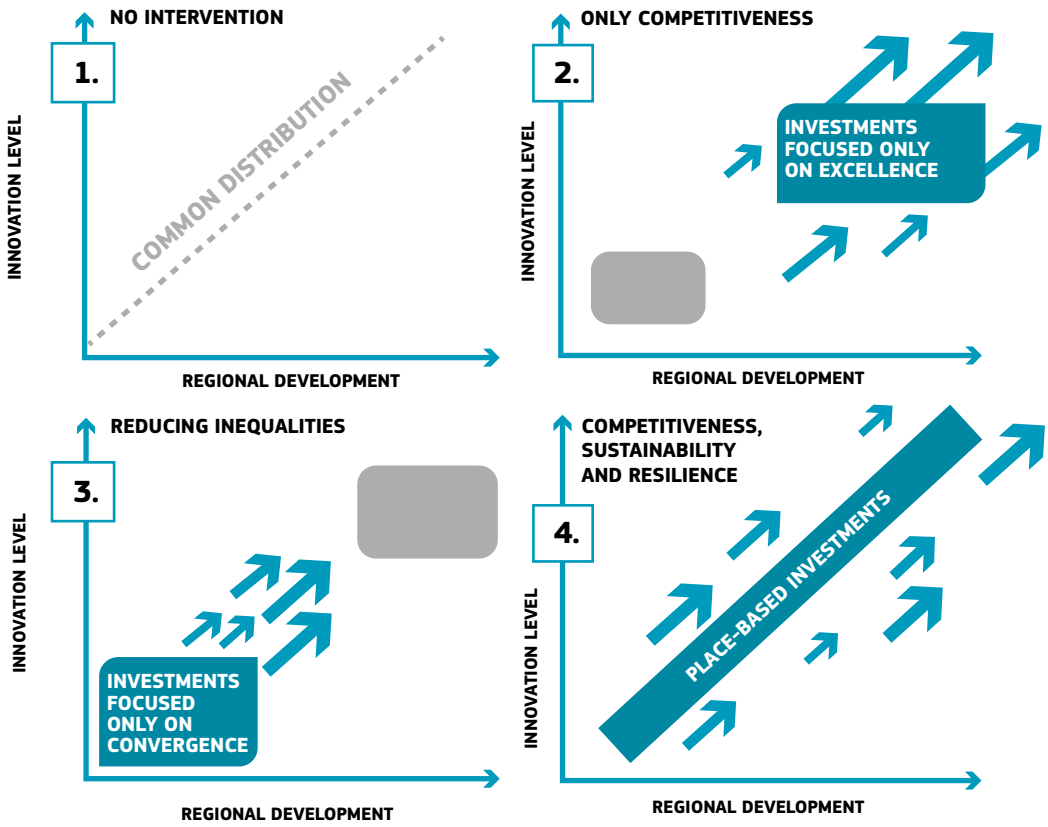
From an EU-wide perspective, mobilising this underutilised regional potential is central to the debate on innovation convergence versus divergence. If innovation capacity remains concentrated in a small number of regions, Europe risks fragmenting its knowledge base, duplicating R&D efforts and leaving substantial talent and domain-specific expertise untapped (Draghi, 2024). In addition, excessive spatial concentration reduces Europe's ability to mobilise sufficient scale and diversity to compete globally. Conversely, enabling more regions to contribute to innovation-driven growth and industrial value chains can strengthen aggregate competitiveness and resilience, especially in a turbulent geopolitical situation. In this perspective, the innovation divide is a double challenge: an equity concern about regions falling behind and an efficiency concern, as underused capabilities represent a loss to the European innovation system as a whole (Barca, 2009).

However, addressing this divide does not mean attempting to replicate the frontier model of dense urban agglomerations everywhere. Most innovative regions benefit from self-reinforcing mechanisms caused by agglomeration economies and path dependence, which cannot be easily engineered in sparsely populated or remote areas. Uniform approaches that aim to achieve excellence everywhere risk wasting resources on mismatched interventions, while diverting attention from region-specific comparative advantages. Instead, differentiated strategies that build on existing strengths can generate sustainable growth while linking more peripheral regions to broader European innovation networks (Richardson *et al.*, 2024).

5. Reconciling competitiveness, convergence, cohesion and resilience

The dynamics of agglomeration, path dependence and cumulative growth place fundamental trade-offs between convergence, cohesion, resilience and competitiveness at the centre of the current EU policy debate. Recent policy discussions, spurred by the Draghi Report; the Ninth Report on Economic, Social and Territorial Cohesion; the *Competitiveness Compass*; and the 2026 European Innovation Council Work Programme, highlight growing tensions between alternative needs (Draghi, 2024; European Commission, 2024, 2025a; European Innovation Council, 2025). On the one hand, there is a call to concentrate resources on a limited set of regional innovation ecosystems to match global competitors, notably China and the US; on the other, it is imperative to reduce territorial disparities and strengthen resilience by investing in the underutilised potential of lagging European regions. In other words, a tension exists between pushing forward the scaling of critical-technology leadership and rapid commercialisation, thereby favouring concentration in a few highly connected innovation hubs, and using public policy instruments to reduce interregional disparities, support less-developed areas and promote a more cohesive, resilient and thus competitive Europe.

Figure 6.1-9 A strategic framework for place-based R&I policy



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit.

Place-based investments are the most suitable policy approach for tapping into regional capacity and innovation potential, providing a way to reconcile the conflicting policy objectives of competitiveness/concentration and convergence/support for lagging regions. The fundamental idea is to combine targeted investments to strengthen existing regional capacities and proactively create interregional linkages promoting Europe's competitiveness and resilience. Figure 6.1-9 provides a schematic, simplified visualisation of possible policy approaches. Frame 1 shows the direct relationship between regional development and innovation levels. Investing in the most innovative and developed regions (Frame 2) would benefit overall competitiveness but could exacerbate inequalities. Alternatively, regional policy solely concentrated on interregional disparities (Frame 3) may be effective in reducing the European R&I divide but is likely to provide little or no support for European competitiveness. Place-based investments (Frame 4) aim to tap into regional capacities and potentials in order to reconcile these dichotomies (Barca, 2009; Bonaccorsi, 2009).

EU's Smart Specialisation Strategy is the most notable example of place-based, R&I-oriented development policy (Foray *et al.*, 2011). Through the European Regional Development Fund (ERDF) and Cohesion Policy in general, the EU aims to narrow the R&I divide by investing in regional research capacity and facilitating innovation diffusion and deployment. S3 policy is designed to encourage regions to identify their competitive advantages – whether in specific technologies, industrial niches or natural assets – and concentrate investments in those areas. The core of S3 is the 'entrepreneurial discovery process', where entrepreneurs, policymakers, citizens and stakeholders work together to identify the most promising areas for their region (Foray, 2014). Combining EU-level guidance with bottom-up engagement, S3 has shaped both academic debate and policy practice and has since been adopted beyond Europe as a model for investing in regional innovation potential (Barroeta *et al.*, 2017; Di Cataldo *et al.*, 2022; Dosso *et al.*, 2022).

Beyond S3, the EU has deployed multiple instruments for investment in place-based R&I development. Recent evidence confirms that S3 has rapidly become the main strategic framework across all European regions (Kramer *et al.*, 2025). As a complementary support, the S3 Thematic Smart Specialisation Platforms foster the development of interregional partnerships around shared industrial priorities, helping regions identify partners, align priorities and translate complementarities into concrete collaboration. Taken together, all these instruments aim to invest in regional R&I capacity and promote interregional linkages, thereby helping address the general challenges discussed in the previous sections.

Horizon Europe's 'Widening participation and spreading excellence' component is another strategic policy instrument designed to reduce R&I disparities across Europe. Targeting 'widening countries' (i.e. Member States and associated countries with lower R&I performance), specific measures have been put in place to upgrade underperforming national systems and increase their success in obtaining competitive EU funding. Key instruments include Teaming and Twinning, which links emerging institutions with international leaders. These measures are associated with other capacity building instruments to support lower-performing countries in accessing and building knowledge linkages across Europe. Supported by capacity building tools like the Research Management Facility, they aim to realise the European Research Area: a single, borderless market for research, innovation and technology.

Mobilising underutilised regional innovation potential has long been a central objective of EU policies. This objective is embedded in the foundational texts of the EU. Based on Article 174 of the Treaty of the Functioning of the European Union, the EU "shall aim at reducing disparities between the levels of development of the various regions and the backwardness of the least favoured regions". This objective combines with that set out in Article 179, which states, paraphrasing, that the EU shall strengthen its "scientific and technological bases" to become more competitive.

Addressing the complex challenges of Europe's R&I divide while balancing potentially conflicting policy objectives in areas like competitiveness, cohesion, resilience and convergence requires collective action at European, national and regional levels, since innovation thrives when multiple actors coordinate as part of a systemic approach. More details on these challenges are given in chapter 9.

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CHAPTER 6.2

THE FRAGMENTATION OF THE EU R&I COLLABORATION SYSTEM

Florence Benoit, Valentina Di Girolamo

KEY QUESTIONS

- What is the structure of R&I collaborations within the EU?
- Why does fragmentation in R&I networks matter for the EU's competitiveness?
- How does EU policy intervene to reduce fragmentation?

HIGHLIGHTS

- Collaborative R&I activities in the EU remain strongly spatially concentrated and tend to cluster in regions located in the most innovative Member States, such as Denmark, Germany, Spain, France, the Netherlands, Finland and Sweden.
- The European R&I collaboration system shows a higher degree of fragmentation than that of the US, especially in terms of co-patenting activities, for which the gap is more pronounced than for co-publications.
- The fragmentation gap between Europe and the US is substantial in most advanced technology and scientific fields, where innovation requires closer, more coordinated and more integrated collaboration.

POLICY INSIGHTS

- Fostering cross-border cooperation in R&I activities is essential to strengthen Europe's strategic autonomy and global standing, and the EU policy framework has designed multiple initiatives and programmes to bridge the gaps created by national disparities and to promote collaboration across Member States.
- The revamp of the European Research Area (ERA) in 2020 signalled a renewed political commitment to building a truly integrated internal market for knowledge in Europe with a focus on fostering R&I collaborations across Member States.
- Horizon Europe plays a central role in encouraging collaborative projects across the EU, and its participation base is wider than that of Horizon 2020, having been expanded to cover collaborative R&I projects.

The exponential increase in the amount of worldwide knowledge has made it harder for individuals and organisations to master the full extent of the expertise required to innovate. With scientific and technological problems becoming increasingly complex and interdisciplinary, collaboration has become indispensable for combining the necessary complementary skills, resources and multidisciplinary perspectives needed for new knowledge creation.

Despite the EU's vast collective talent and resources, research and innovation (R&I) activities and collaboration networks often remain fragmented across Member States. Heterogeneous national rules, standards and strategic priorities tend to reinforce these divides, making cross-border collaboration more difficult, reducing the impact of investments and slowing the scaling of innovations critical for global competitiveness. This fragmentation constitutes a fundamental barrier to achieving the European Research Area's (ERA) vision of a unified, borderless and globally competitive research ecosystem.

1. The collaborative R&I system in Europe remains highly fragmented

Collaborative R&I activities in the EU remain strongly spatially concentrated. The vast majority of collaborative R&I activities are typically conducted between regions located in the same Member State, whereas collaborations between countries remain more limited. This is more pronounced for co-patenting activities, whereas collaborations between researchers in different Member States tend to be more widespread (European Commission, 2024).

Furthermore, collaborative R&I activities in the EU tend to be concentrated in regions located in the most innovative Member States, particularly around key innovation hubs that act as central nodes in national and European networks. The top 10 urban areas in the EU in terms of R&I collaboration activities are located in Denmark, Germany, Spain, France, the Netherlands, Finland and Sweden (Table 6.2-1). Most patent collaborations in these hubs take place within city boundaries, reflecting a strong local bias in technological innovation. By contrast, European and international collaborations on patents remain relatively limited. Collaborations on scientific publications, however, are far more geographically dispersed, with roughly two-thirds of co-publications involving partners from different countries in the EU or beyond (Table 6.2-1). This highlights the more open nature of academic knowledge exchange.

Table 6.2-1 Collaboration patterns of the top 10 EU urban areas

Collaboration on patents 2014–2023				
Urban area	**Country**	**Inter-city**	**EU**	**International**
Paris	France	86.0 %	7.7 %	6.3 %
Munich	Germany	85.6 %	8.8 %	5.6 %
Stuttgart	Germany	88.4 %	8.8 %	2.8 %
Eindhoven	The Netherlands	97.1 %	1.2 %	1.7 %
Stockholm	Sweden	85.5 %	7.7 %	6.8 %
Mannheim	Germany	75.7 %	17.6 %	6.8 %
Frankfurt am Main	Germany	79.0 %	14.4 %	6.6 %
Berlin	Germany	79.8 %	14.6 %	5.6 %
Nurenberg	Germany	86.5 %	10.7 %	2.8 %
Helsinki	Finland	83.1 %	10.3 %	6.6 %
Collaborations on scientific publications 2014–2023				
Urban area	**Country**	**Inter-city**	**EU**	**International**
Paris	France	41.9 %	34.6 %	23.5 %
Rome	Italy	34.3 %	42.2 %	23.5 %
Madrid	Spain	37.6 %	36.0 %	26.4 %
Barcelona	Spain	35.6 %	37.1 %	27.3 %
Milan	Italy	33.2 %	42.6 %	24.2 %
Berlin	Germany	34.6 %	37.9 %	27.5 %
Munich	Germany	35.3 %	36.90%	27.8 %
Stockholm	Sweden	33.3 %	32.3 %	34.4 %
Copenhagen	Denmark	36.4 %	30.6 %	33.0 %
Amsterdam	The Netherlands	32.5 %	36.5 %	31.0 %

Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Balland *et al.* (2025).

Note: Inter-city collaborations are defined as collaborations occurring within the same urban area. European collaborations are collaborations occurring between the urban area and other urban areas located within the EU. International collaborations are those occurring with urban areas outside of the EU.

Innovative activities tend to cluster in specific regions because of agglomeration economies. There exist geographical limits to knowledge spillovers, especially those linked to the transmission of tacit knowledge, the costs of which rise with distance. Industrial and innovation activities typically concentrate in areas where firms, research organisations and skilled workers co-locate. By co-locating, they can benefit from dense networks of interaction, information flows and cumulative learning processes (Audretsch and Fieldman, 1996). Beyond these direct advantages, agglomeration sets off broader regional dynamics that reinforce innovation over time: as firms and skilled workers concentrate, the region becomes more attractive to additional investment, talent and support services.

Geographical proximity thus plays a key role in facilitating and explaining participation in collaborative knowledge production endeavours. Geographical distance negatively affects regional co-patenting and co-publication activities (Hoekman *et al.*, 2009; Lata *et al.*, 2017). This negative influence has traditionally been explained by the need for face-to-face contact in exchanging tacit knowledge. In this context, geographical distance makes direct interaction and trust-building more difficult (e.g., Bathelt *et al.*, 2004; Storper and Venables, 2004), thereby impeding the formation and maintenance of collaborations. Advances in digital communication and transport have made long-distance collaboration easier, but they do not fully replace the benefits of local proximity for exchanging tacit knowledge and building trust (Venturini *et al.*, 2025).

These effects tend to be more pronounced for patent collaborations than scientific collaborations as joint inventions often involve higher coordination costs due to higher levels of confidentiality and trust. In comparison, co-publications can draw on more codified knowledge, which is easier to transfer across distance (e.g., Scherngell and Barber, 2011).

However, proximity is not only spatial. Cognitive, organisational, social and institutional proximity also shape collaborative dynamics within R&I systems (Boschma, 2005). For instance, persistent institutional differences, language barriers, cultural diversity and legal heterogeneity can present significant obstacles to effective R&I collaborations between European regions and countries, even when geographical distance is relatively small (Hoekman *et al.*, 2009; Scherngell and Barber, 2011). These non-spatial barriers help explain why physical closeness does not automatically translate into stronger collaborations (e.g., Cao *et al.*, 2022).

Within Europe, the co-publications network is more interconnected than the co-patents network. In the latter, each urban area collaborates on average with 27 others (Table 6.2-2) and only about one in five possible links materialises (as captured by a network density[1] of 0.20). This suggests that collaboration on technological innovation remains more selective and concentrated within smaller groups. By contrast, the scientific co-publication network is far denser and more connected: each city works with around 129 other regions, and nearly all potential collaborations are realised (network density of 0.93). Both networks exhibit a hub-and-spoke pattern, where large innovation hubs maintain numerous collaborations with smaller innovation partners rather than primarily collaborating

1 Network density is the proportion of actual connections in a network relative to all possible connections. It measures how tightly linked the actors are.

Table 6.2-2 The characteristics of the European R&I collaboration network, urban area level, 2014–2023

Network	Average degree	Density	Assortativity	Average closeness centrality	Average betweenness centrality
Co-patents	27.06	0.20	-0.06	0.003	91.88
Co-publications	128.62	0.93	-0.06	0.002	125.51

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Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Balland *et al.* (2025).

among themselves (negative assortativity[2]). This indicates a relatively open collaboration environment, as knowledge radiates outward from key centres rather than circulating among them.

The European scientific publication network appears to be more resilient than the technological innovation network. The co-publications network is characterised by slightly lower closeness centrality[3] and higher betweenness centrality[4] than the co-patents network (Table 6.2-2). This suggests that while information or collaboration flows may take marginally longer paths, there exist more nodes within the network that serve as bridges between different groups. This structure enhances resilience, as the collaboration network can absorb disruptions without losing overall connectivity. In contrast, the results for the co-patenting network point to the presence of more direct local ties but fewer intermediaries linking separate clusters. This indicates that collaborations in innovation activities are more vulnerable to fragmentation.

Compared to the US, Europe's R&I system is more fragmented (Balland *et al.*, 2025). Although innovation and scientific activities around the globe have increasingly extended across national borders, the European R&I network still faces important integration challenges (Chessa *et al.*, 2013). In contrast, the US benefits from a larger, linguistically and institutionally unified market supported by federal programmes that encourage collaboration and knowledge sharing (e.g. National Science Foundation Regional Innovation Engines). As a result, innovative hubs in the US report a significant degree of both national and international collaboration, positioning themselves as globally connected innovation hotspots (WIPO, 2019).

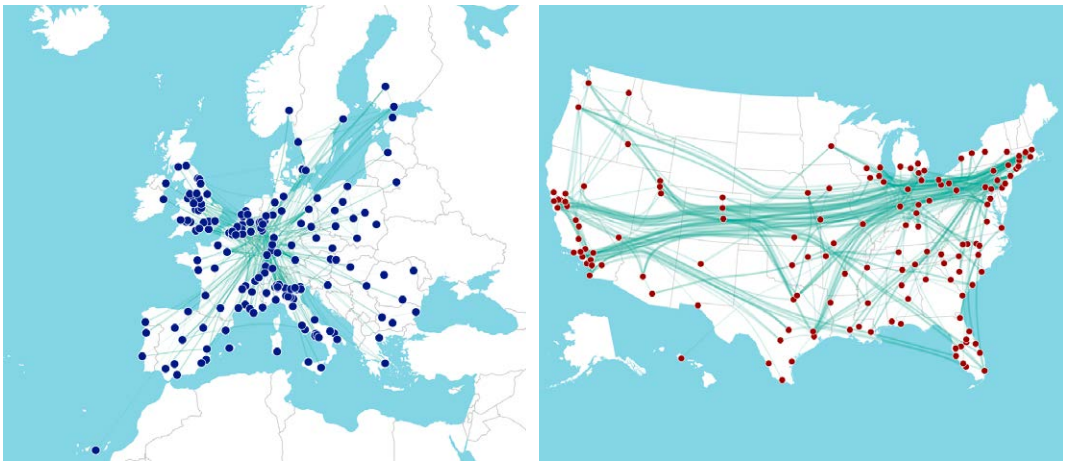
2 Assortativity measures whether nodes in a network tend to connect to other nodes that are similar in degree, where degree simply means the number of connections a node has. Positive assortativity indicates that well-connected nodes link to other well-connected nodes, while negative assortativity indicates that well-connected nodes link mostly to poorly connected ones.

3 This measures how quickly, on average, each node can reach others in the network. High average closeness means that nodes are, on average, close to one another, so information can spread easily within the network. Low average closeness indicates a more fragmented or sparse network, where nodes are farther apart and diffusion is slower.

4 This shows the extent to which, on average, the network relies on intermediaries to connect firms. High average betweenness indicates that information or resources typically have to pass through a few key 'bridge' nodes, pointing to the potential presence of bottlenecks or concentration of influence within the network. Low average betweenness suggests that the network is well connected and decentralised, with many alternative paths between nodes.

The fragmentation gap between Europe and the US is particularly pronounced for co-patenting activities. As mentioned above, the European co-patenting network exhibits distinct clustering within national boundaries, with relatively few long-distance collaborations between major hubs located in different countries (Figure 6.2-1). Conversely, co-patenting activities in the US tend to span across the entire country, without significant border-related clustering and with stronger connections between innovation hubs (Balland *et al.*, 2025).

Figure 6.2-1 **The co-patenting network in Europe and the US**



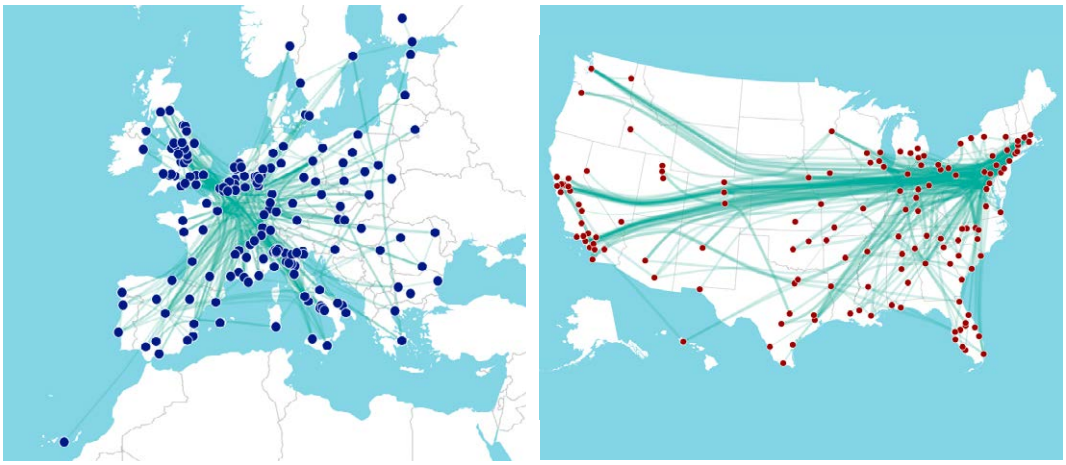
Science, Research and Innovation Performance of the EU 2026

Source: Balland *et al.* (2025).

Note: Nodes represent urban areas, while the links denote co-patenting collaborations. Thicker links imply increased collaboration frequency. Collaborations are grouped based on similar attributes (edge-bundling) to reduce visual clutter. This implies that similar paths are grouped into shared curves, so some individual ties may not be drawn explicitly, even though they exist in the underlying data.

The disparity between Europe and the US is narrower for scientific publications. Although the degree of fragmentation is still higher than in the US, academic research in Europe has achieved greater cross-border integration (Figure 6.3-2), possibly due to stronger structural mechanisms fostering cross-border academic collaboration, such as EU-wide funding frameworks, shared data and open science norms, which have reduced transaction costs in publishing (Balland *et al.*, 2025).

Figure 6.2-2 The co-publication network in Europe and the US



Science, Research and Innovation Performance of the EU 2026

Source: Balland *et al.* (2025).

Note: Nodes represent urban areas, while the links denote scientific collaborations. Thicker links imply increased collaboration frequency. Collaborations are grouped based on similar attributes (edge-bundling) to reduce visual clutter. This implies that similar paths are grouped into shared curves, so some individual ties may not be drawn explicitly, even though they exist in the underlying data.

2. R&I collaborations are critical to strengthening the competitiveness of the EU

Innovation and knowledge creation are inherently interactive processes, as they rely on the continuous exchange of information between actors. Given the place-based nature of R&I activities, the interactions occurring within geographically concentrated innovation environments facilitate these information flows and the creation of positive knowledge spillovers (Bathelt *et al.*, 2004). However, the same forces that underpin local learning advantages can also include lock-in processes. When interactions become overly inward looking or path-dependent, regions risk reinforcing existing technological trajectories, thereby constraining their capacity to explore and integrate new knowledge (e.g., Cano-Kollmann *et al.*, 2016). To avoid this, local knowledge sharing needs to be complemented by wider channels of diffusion that connect regional ecosystems with external and international partners.

The economic impact of knowledge exchange is increased when knowledge circulates beyond local boundaries (Bathelt *et al.*, 2004). International R&I collaborations open up access to scarce and specialised resources, diverse knowledge pools and complementary skills not available domestically. This in turn strengthens local capacities to innovate, improve product quality and increase production efficiency, which are key drivers of competitiveness and growth. At macro level, this knowledge diffusion enhances economies' absorptive capacity, allowing for better adaptation and resource reallocation in response to technological change and ultimately supporting sustained economic growth (Asheim and Coenen, 2006; Balland *et al.*, 2015; Lorenzen *et al.*, 2020).

Fragmentation represents an important challenge for policymakers to address (Letta, 2024; Draghi, 2024). A high degree

of fragmentation weakens the mechanisms through which knowledge circulates and accumulates across the economy, leading to costs along several dimensions. With regard to innovation, when connections between innovation actors are weak or uneven, the flow of knowledge slows down, limiting cooperation and reducing opportunities for new ideas and technologies to emerge. Fragmentation makes it harder to combine complementary expertise or build on existing research. This weakens cumulative learning and slows the diffusion of innovation across sectors and regions. Ultimately, these effects hinder the ability of firms and regions to innovate effectively, with important consequences for economic growth and competitiveness.

In the EU, R&I policies are typically run at national level, while fully pan-European networks struggle to emerge. While the EU provides overarching strategic frameworks and funding mechanisms, innovation policy decisions and priorities are largely shaped by EU Member States at national level. National strategies can often broadly overlap across Member States, reducing the overall scale, diversity and efficiency of Europe's innovation ecosystem (Balland *et al.*, 2025).

Greater coordination across Member States would be particularly important for the development of more sophisticated strategic technologies which are essential for global competitiveness (see chapter 4.1). These types of technology, such as artificial intelligence (AI) or quantum computing, need significant and concentrated investment in order to achieve the necessary scale, i.e. the threshold of resources, talent, infrastructure and market demand needed to support rapid innovation and commercialisation. Without coordination, Member States' investment efforts risk overlapping or running in parallel, causing resources to be spread too thinly and leading to suboptimal investment levels in strategic areas (Balland *et al.*, 2025).

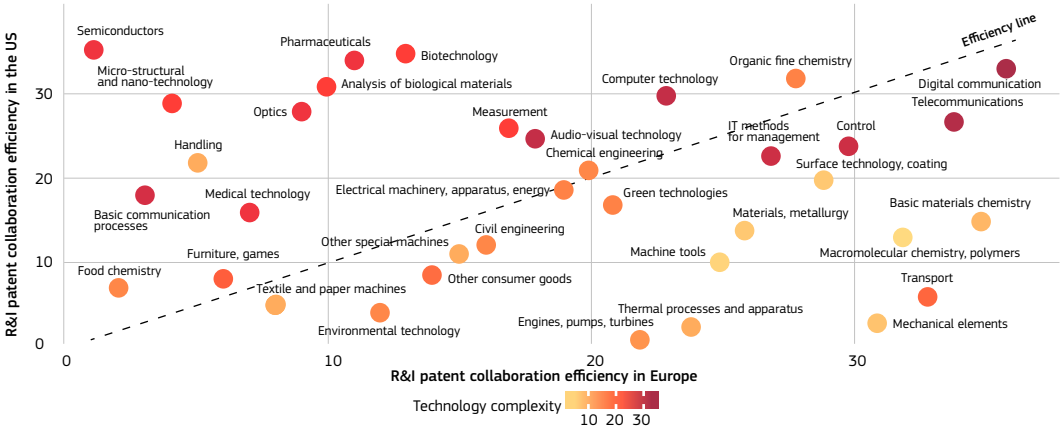
More sophisticated technologies and advanced scientific activities typically require a quite diversified and specialised knowledge base. The geographic distribution of this type of activity tends to differ from the broader patterns of invention and innovation (Esposito, 2023), as the required multidisciplinary expertise is typically sufficiently concentrated only in a few locations with the right mix of talent, infrastructure and institutional support (Hidalgo and Hausmann, 2009; Balland and Rigby, 2017). Because these capabilities are deeply embedded in local ecosystems, they are difficult to transfer or replicate. As accessing expertise beyond a region's core competencies requires building new connections across disciplines and across geographies, it becomes even more important for highly innovative locations to strengthen their participation in international collaboration networks in order to stay at the technological frontier (WIPO, 2019).

Therefore, integration in R&I systems is particularly important for more advanced scientific fields and technologies. There exists a strong positive relationship between the degree of sophistication of a technology and the volume of collaborations across regions and countries (European Commission, 2024). Hence, the existence of strong connectivity between innovation hubs matters most for advanced scientific and technological areas, the ecosystems of which are consequently less fragmented than those is observed for less complex fields (Balland *et al.*, 2025).

Since the innovation gap between Europe and the US is most pronounced in more complex technological fields (see chapter 4.1), **the higher degree of fragmentation within the European collaborative R&I system has a compounding negative effect in these areas.** Recent evidence suggests the existence of a systematic relationship between technological complexity and the efficiency gap between the US and European collaborative

R&I ecosystems (Balland *et al.*, 2025). This gap captures how effectively researchers and firms work together across countries and organisations in Europe compared with the US. As technologies are becoming more complex, this gap is widening (Figure 6.2-3), indicating that Europe faces its largest efficiency losses in advanced fields, where innovation requires closer, more coordinated and more integrated collaboration than is currently in place.

Figure 6.2-3 Technological complexity and R&I collaboration efficiency in Europe and the US, patent data 2019–2023



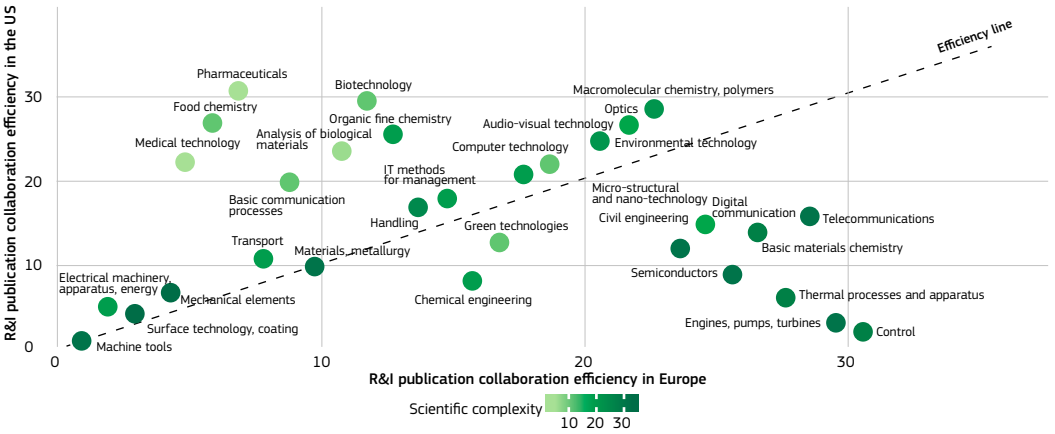
Science, Research and Innovation Performance of the EU 2026

Source: Balland *et al.* (2025).

Note: The axes rank the efficiency estimates per technology area based on their magnitude. The visualisation uses a colour gradient where red represents more complex technologies and yellow indicates less complex technologies, mapped into the 36 WIPO technology classes. The diagonal line can be interpreted as a sort of competitiveness boundary, serving as a reference point for understanding the efficiency gap: technologies above the diagonal show higher collaboration efficiency in the US, while technologies below the diagonal perform relatively better in Europe.

This pattern is not limited to patent activities but extends into scientific publications. As shown in Figure 6.2-4, more advanced research areas are more strongly affected by the efficiency losses associated with fragmentation in the EU R&I system, as this limits the ability of researchers and institutions to form the required cross-border and cross-organisational collaborations. This common effect, observable across both industrial innovation and academic research, confirms that fragmentation remains a structural challenge that affects multiple dimensions of Europe's R&I landscape (Balland *et al.*, 2025).

Figure 6.2-4 The relationship between complexity and R&I collaboration efficiency in Europe and the US, publication data 2019–2023



Science, Research and Innovation Performance of the EU 2026

Source: Balland *et al.* (2025).

Note: The axes rank the efficiency estimates per scientific area based on their magnitude. The visualisation uses a colour gradient where dark green represents more complex scientific fields and light green indicates less complex scientific fields, mapped into the 36 WIPO technology classes. The diagonal line can be interpreted as a sort of competitiveness boundary, serving as a reference point for understanding the efficiency gap: technologies above the diagonal show higher collaboration efficiency in the US, while technologies below the diagonal perform relatively better in Europe.

3. EU policy plays a key role in connecting R&I systems

Reducing political and regulatory fragmentation is high on the EU policy agenda. Internal barriers within the EU act like invisible tariffs hampering innovation and economic integration (Draghi, 2024). The new competitiveness strategy of the EU, the *Competitiveness Compass*, announced in January 2025, calls for the removal of cross-border barriers to enhance competitiveness and strengthen the single market (European Commission, 2025a).

The urgency of addressing this challenge naturally extends to R&I activities, in which the need to encourage cross-border cooperation has become essential to strengthen Europe's strategic autonomy and global standing. In an increasingly complex and competitive global landscape, the continuous strengthening of the traditional four freedoms of the Single Market (the free movement of goods, services, people and capital) risks no longer being sufficient to harness the full potential of the EU economy (Letta, 2024).

In this regard, the establishment of a 'fifth freedom' centred around R&I activities is receiving increasing attention in the policy debate. Many of the challenges the EU is facing, from climate change and an ageing population to digital transformation, are both knowledge intensive and transnational in nature. Therefore, reaching the EU's full potential in the area of global innovation remains essential and necessitates additional efforts to ensure the free movement of research, innovation, knowledge, education and data across the EU (Letta, 2024). This represents a critical step towards the integration of the Single Market beyond goods and services and the reduction of R&I fragmentation across Member States.

EU policy has already made important progress in addressing fragmentation of cross-border R&I collaboration. The EU policy framework has designed multiple initiatives and programmes to bridge the gaps created by national disparities and to promote collaboration across Member States (Table 6.2-3). With these efforts, the EU aims to ensure that researchers, innovators and institutions can work together more seamlessly and leverage their collective expertise and resources.

Table 6.2-3 Overview of EU policy actions and initiatives directly supporting cross-border R&I collaboration

	Scope
Horizon Europe	Explicitly prioritises collaborative projects involving multiple countries. It promotes cross-border partnerships by allocating funds to consortia from different Member States and associated countries, encouraging interdisciplinary and international cooperation.
	This includes the: ▸ Marie Skłodowska-Curie Actions, which supports cross-border researcher mobility; ▸ European Innovation Council, which supports cross-border collaborations by funding projects with transformative potential; ▸ Joint Technology Initiatives and public-private partnerships, which encourage collaboration across sectors and borders by funding joint projects that involve industry and academia from multiple countries.
European Research Area	Aims to create a borderless environment for R&I through policy alignment, reduced fragmentation and enhanced coordination of national research efforts. It supports initiatives that facilitate access to European research infrastructure and networks, promoting collaboration across Europe.
European Regional Development Fund and Cohesion Fund	Supports regional capacity building, research infrastructures and innovation projects with a strong emphasis on interregional and cross-border cooperation to reduce disparities and enhance cohesion.
INTERREG	Specifically targets cross-border, transnational, and interregional cooperation projects aiming to strengthen territorial cohesion through joint actions that address shared challenges and innovation opportunities across borders.
Digital Europe	Supports projects that require cross-border cooperation in areas like AI, cybersecurity, and digital skills, linking different R&I entities across Europe.
European Institute of Innovation and Technology	Supports the building of pan-European innovation ecosystems through Knowledge and Innovation Communities, linking education, business and research.

Science, Research and Innovation Performance of the EU 2026

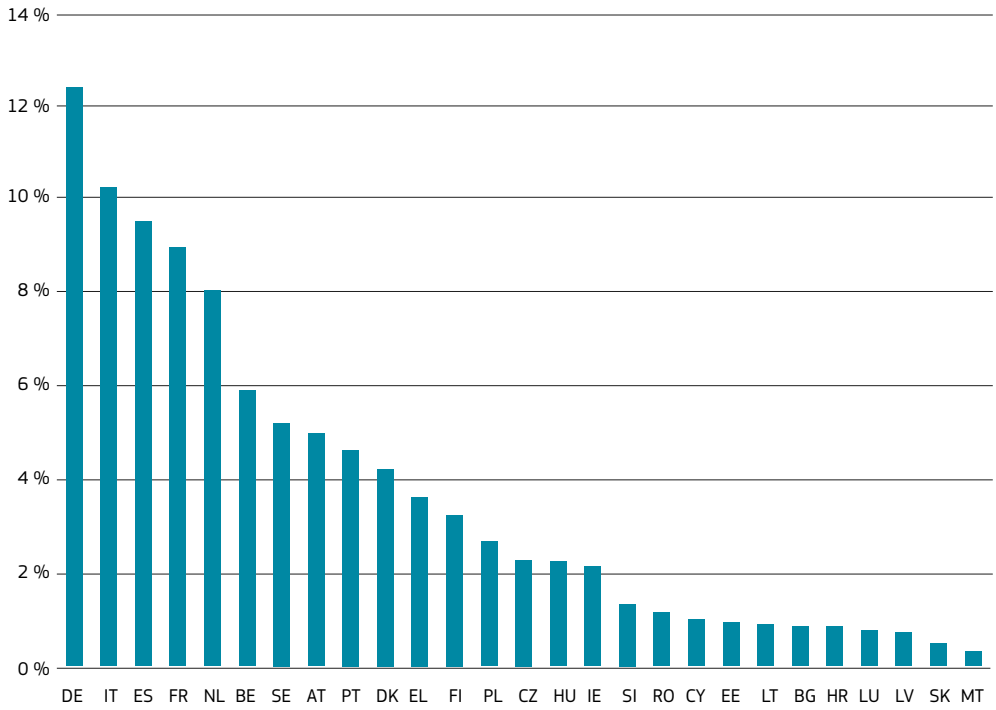
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit.

In particular, the European Framework Programme (FP) for R&I plays a central role in encouraging collaborative projects across the EU. One of the main objectives of the FP is to promote collaborative R&I projects by reducing existing spatial barriers hindering research collaboration. Empirical evidence suggests that European research has become more interconnected thanks to EU support, although the presence of persistent core-periphery patterns indicates that a certain degree of fragmentation within the FP network remains (Balland *et al.*, 2019).

Despite the persistence of some barriers, the FP contribution to the integration of the R&I landscape has continued to deliver important results. Between 2021 and 2024, under Horizon Europe, 15 184 grant agreements were signed with a total value of EUR 43.2 billion, of which 81 % went on funding of collaborative projects (European Commission, 2025c). Compared to projects under Horizon 2020, these collaborative projects have a broader and more diverse participant base, incorporating a greater share of partners from associated and third countries. This expansion highlights Horizon Europe's enhanced role in facilitating international collaboration and integrating a wider range of scientific actors beyond the EU.

Horizon Europe's co-publication collaborations are largely concentrated among the largest EU Member States and a few international partners. The Horizon Europe project reporting cycle is at a relatively early stage: as of November 2025, more than 213 collaborative projects had reported having produced scientific publications, amounting to about 14 500 publications overall. These publications involved authors affiliated to institutions from 173 different countries. Of these co-publication collaborations, 28.33 % occurred between EU Member States, 44.78 % involved partnerships between an EU Member State and a non-EU country, and 26.89 % were collaborations exclusively among non-European partners. Within the EU, almost half of all co-publication links involved just five countries: Germany (12 %), Italy (10 %), Spain (9.6 %), France (9.0 %) and the Netherlands (8.1 %) (see Figure 6.2-5). Among non-EU partners, the UK leads with 16.2 % of EU-non-EU collaborations, followed by the US (13.9 %), Switzerland (8.5 %), China (4.5 %) and Norway (4.2 %). These results highlight the fact that Horizon Europe strengthens EU research networks while consolidating strategic global partnerships.

Figure 6.2-5 The share of intra-EU FP co-publication collaborations, 2021-2025



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on CORDA.

Furthermore, the revamp of the ERA in 2020 signalled a renewed political commitment to building a truly integrated internal market for knowledge in Europe. Anchored in Article 179 of the Treaty on the Functioning of the European Union (TFEU), the ERA aims at ensuring the free circulation of researchers, scientific knowledge and technology across Member States. The actions implemented as part of the ERA revolve around four key priorities: deepening the single market for knowledge; jointly addressing the green and digital transitions; enhancing access to excellence and interconnecting innovation ecosystems; and coordinating R&I investments and reforms (European Commission, 2025b).

The second ERA Policy Agenda (2025-2027), adopted in May 2025, consolidates what has been achieved so far in terms of reducing fragmentation, improving researcher careers, promoting open science and strengthening public trust through citizen engagement (European Commission, 2025b). The new agenda reinforces the role of the ERA as a strategic policy framework for collective action on R&I, balancing continuity in long-term structural policies (such as open science, research infrastructures and careers) with targeted new actions on emerging priorities, e.g. AI in science, research security and science-for-policy (see chapter 3.3).

The forthcoming ERA Act is expected to tackle persistent issues that undermine the efficiency and overall performance of the EU's R&I ecosystem by strengthening the legal and governance framework. Building on the foundations laid by the *Pact for Research and Innovation in Europe*, two ERA policy agendas and the *Choose Europe for Science* initiative, the Act will aim to give the ERA greater coherence and enforceability by setting clearer rules for increasing investment, ensuring alignment and strengthening framework conditions for research and researchers (see chapter 3.2).

All these initiatives show the EU's commitment to reducing fragmentation within its R&I ecosystem. As mentioned in the previous sections, fragmentation remains an issue in the EU, largely due to structural characteristics of the EU system that affect integration in R&I and other areas. These include heterogeneous institutional and regulatory frameworks, language barriers and cultural diversity. These factors vary considerably in nature and call for policy actions able to generate impacts on multiple fronts. Ultimately, addressing fragmentation in the EU R&I ecosystem requires a coordinated and holistic policy approach that goes beyond sector-specific interventions in order to deepen integration across Member States.

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CHAPTER 6.3

EU'S GLOBAL R&I COOPERATION

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KEY QUESTIONS

- What are the main trends and drivers shaping the EU's international research and innovation (R&I) cooperation within and beyond Horizon Europe?
- What are the benefits of association to Horizon Europe for third countries and the EU?
- How does global R&I cooperation help achieve the Sustainable Development Goals (SDGs)?

HIGHLIGHTS

- EU Member States are increasingly engaging in global research collaborations, with the US and the UK as their main scientific partners, followed by China, whose share has increased over the last decade.
- The EU is a key scientific partner for Brazil, Norway, Switzerland and the UK, while China, India, Japan and the US are less reliant on the EU for their international scientific output.
- The EU's international co-patenting activity is highly concentrated with the US, Switzerland, China, the UK and India accounting for around 80% of total collaborations. At Member State level, all 27 countries have at least one non-EU partner that accounts for over 20% of their co-patenting activity, most commonly the US, highlighting the central role of transatlantic innovation linkages.
- Within Horizon Europe, internationalisation is well established and continues to grow. At the same time, restricted calls are used when needed, notably in space, quantum, raw materials and artificial intelligence (AI).
- Association of non-EU countries to Horizon Europe is mutually beneficial, as third countries bring complementary expertise and scientific excellence, while association facilitates their integration into Horizon Europe. At the same time, reciprocity provisions expand opportunities for EU participation in global R&I programmes.
- Through Horizon Europe, the EU contributes to the progress towards the SDGs. In terms of scientific specialisation related to the different SDGs, the EU maintains a balanced portfolio, with strengths in peace, justice and strong institutions, responsible consumption and production, and gender equality.

POLICY INSIGHTS

- While the EU's global scientific cooperation is relatively diversified, its international patenting activity is more concentrated, predominantly with the US. This could present vulnerabilities if cooperation is disrupted.
- Following association, non-EU countries become more integrated into Horizon Europe, requiring a strategic EU approach that balances cooperation with research security considerations.
- Global cooperation between the EU and third countries is an important lever to help achieve the SGDs that the EU has committed to.

International research and innovation (R&I) cooperation plays an essential role in addressing global challenges by facilitating coordinated and transnational interventions. Cross-border collaboration allows countries to pool resources and knowledge, thereby enhancing outcomes and maximising spillover effects (Mitra *et al.*, 2024). This type of cooperation can also mitigate negative forms of path dependence and lock-in by exposing EU actors to diverse knowledge bases, alternative technological trajectories and new institutional settings. Cooperation is particularly important for global challenges related to health, climate change and human rights, as reflected in the Sustainable Development Goals (SDGs). The EU provides a prominent example of institutionalised R&I cooperation, notably through the development of the European Research Area (ERA) and its long-standing framework programme for R&I. This integration has strengthened intra-European collaboration while positioning international engagement as a strategic instrument for competitiveness. Indeed, 79% of EU stakeholders report that increased collaboration with like-minded non-EU partners has a positive impact on EU competitiveness (European Commission, 2025a).

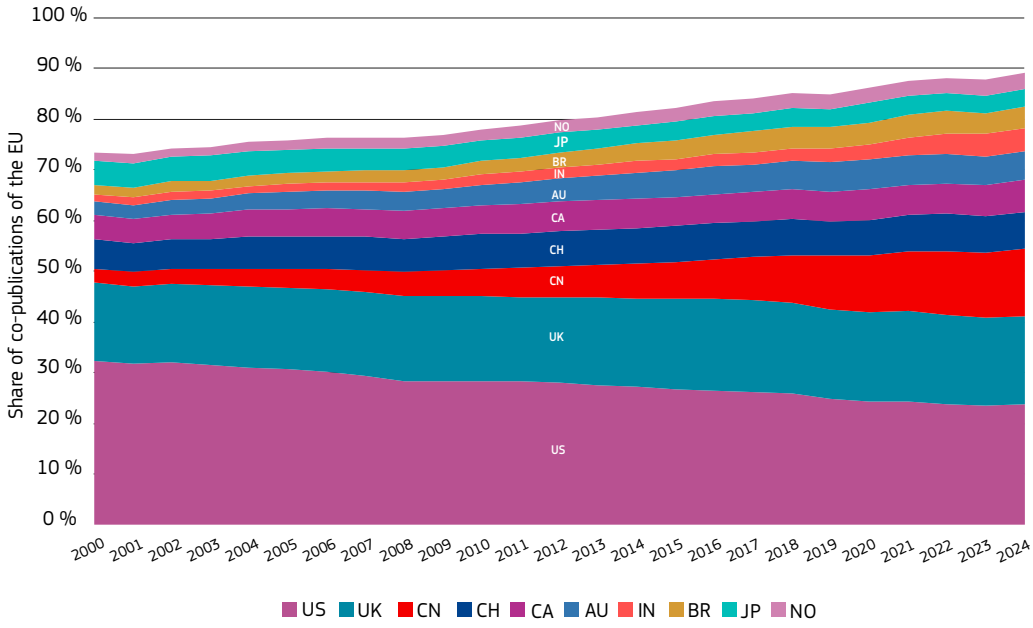
Internationalisation can enhance R&I excellence and impact. Beyond addressing shared challenges and maximising spillovers, cooperation facilitates the mobility and interconnection of talent, knowledge and capital. Evidence shows that international scientific collaboration is associated with higher citation impact and broader global reach than domestic collaboration (Wang *et al.*, 2024). This advantage is explained by the combination of more diverse and less overlapping knowledge bases, which may improve research quality, and increased visibility through engagement across multiple countries. However, part of this citation premium may be due more to structural network effects and 'home country' biases than quality alone. Spatial and institutional analyses show that international collaborations often achieve higher impact because they connect researchers from different countries and institutions (Frenken *et al.*, 2010). These cross-border partnerships bring together diverse knowledge and expertise, which can improve the quality and influence of research.

1. Proximity and innovation performance drive the EU's global R&I partnerships

International scientific collaborations have intensified over the last decade, and EU Member States are increasingly engaging in global research collaborations. As shown in chapter 3.1, over the past decade all EU Member States have expanded their cross-border cooperation. Some Member States rely more heavily on intra-EU collaborations, while others – including those with stronger research systems, such as Denmark, Germany, Ireland, France and Sweden – are more actively engaged in international (non-EU) collaboration networks. The share of total scientific publications co-published by researchers from the EU and peers from non-EU countries increased from 21% in 2000 to 38% in 2024. The increase has slowed in recent years but has continued despite global frictions.

The main scientific partners of EU Member States are the US, the UK and China, with China's share increasing over the last decade. In 2024, the US, the UK and China were the EU's top three scientific partners, accounting for 24%, 17% and 13%, respectively, of total international co-publications involving EU researchers. These countries have large economies and are strong innovators, and most have close ties to the EU historically. Beyond this group of countries, Switzerland (7%), Canada (6%), Australia (6%), India (5%), Brazil (4%), Japan (4%) and Norway (3%) make up the rest of the EU's top 10 partners. These 10 countries account for 90% of the EU's international co-publications (Figure 6.3-1). Since 2000, the EU has seen an increase in its scientific collaboration with China, India

Figure 6.3-1 Top 10 scientific partners of the EU, 2000–2024



Science, Research and Innovation Performance of the EU 2026

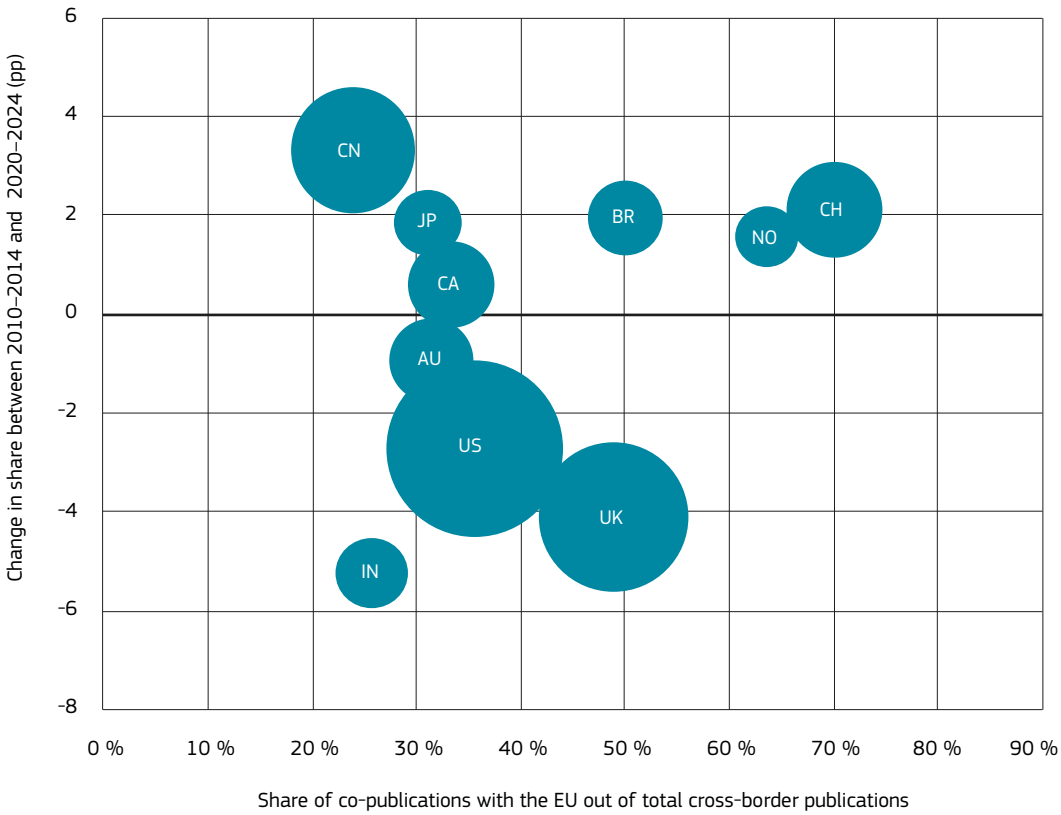
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

Note: Partner collaborations are measured by the share of international co-publication with an EU Member State.

and Australia, with their shares increasing by 11, 3 and 3 percentage points (pp), respectively. Over the same period, collaboration with the US and Japan has decreased by 8 and 1 pp, respectively.

The EU is a key scientific partner for Brazil, Norway, Switzerland and the UK, while China, India, Japan and the US are less reliant on the EU for their international scientific output. Of the EU's top 10 scientific partners, the results indicate that collaborative ties are particularly strong with Switzerland, Norway and the UK. Co-publications with EU Member States account for 70%, 64% and 49%, respectively, of their total cross-border scientific output (Figure 6.3-2). These findings highlight the EU's role as a primary and often dominant scientific partner for these countries. On the other hand, the relative importance of the EU is lower for China, India, Japan and the US, for which co-publications with the EU constitute 24%, 26%, 31% and 35%, respectively, of their total cross-border scientific production. Over the last decade, the shares have increased for China (+3 pp), Switzerland (+2 pp), Brazil (+2 pp) and Japan (+2 pp), showing that these countries have intensified their scientific cooperation with the EU. Conversely, they have decreased for India (-5 pp), the UK (-4 pp), the US (-3 pp) and Australia (-1 pp).

Figure 6.3-2 The EU's shares of international co-publications involving its top 10 partner countries, 2020–2024

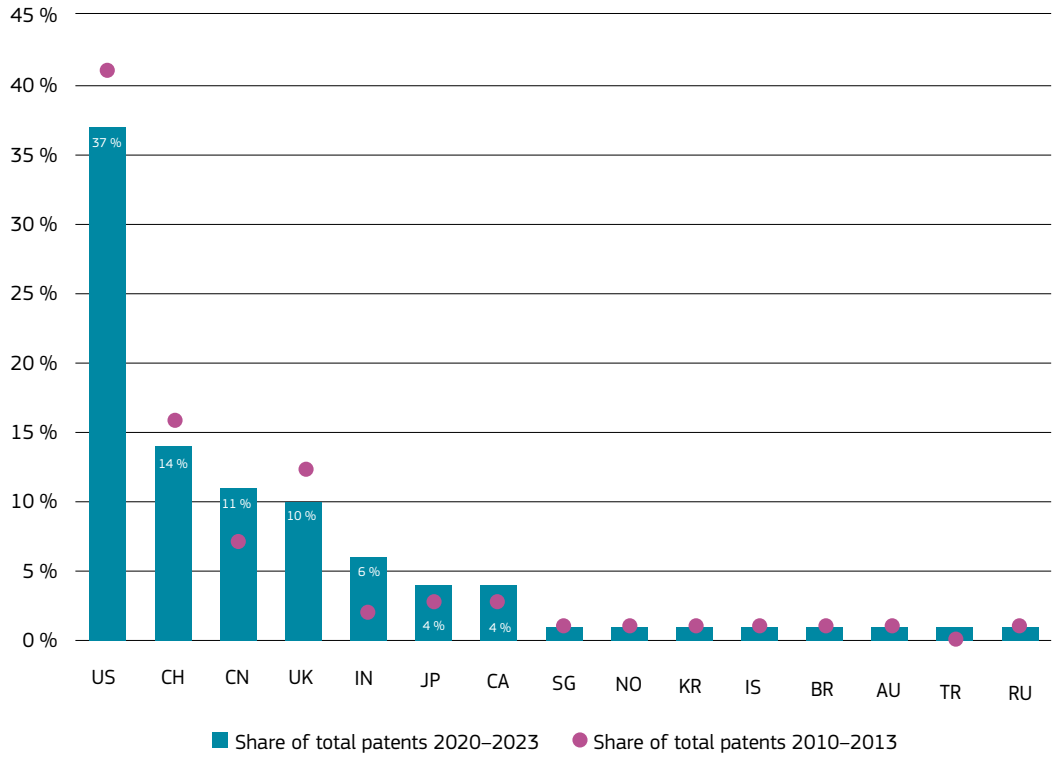


Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

Note: The size of the bubble represents the total number of co-publications with the EU in the 2020–2024 period.

Figure 6.3-3 The EU's top 15 international co-patenting partners, 2020–2023 and 2010–2013



Science, Research and Innovation Performance of the EU 2026

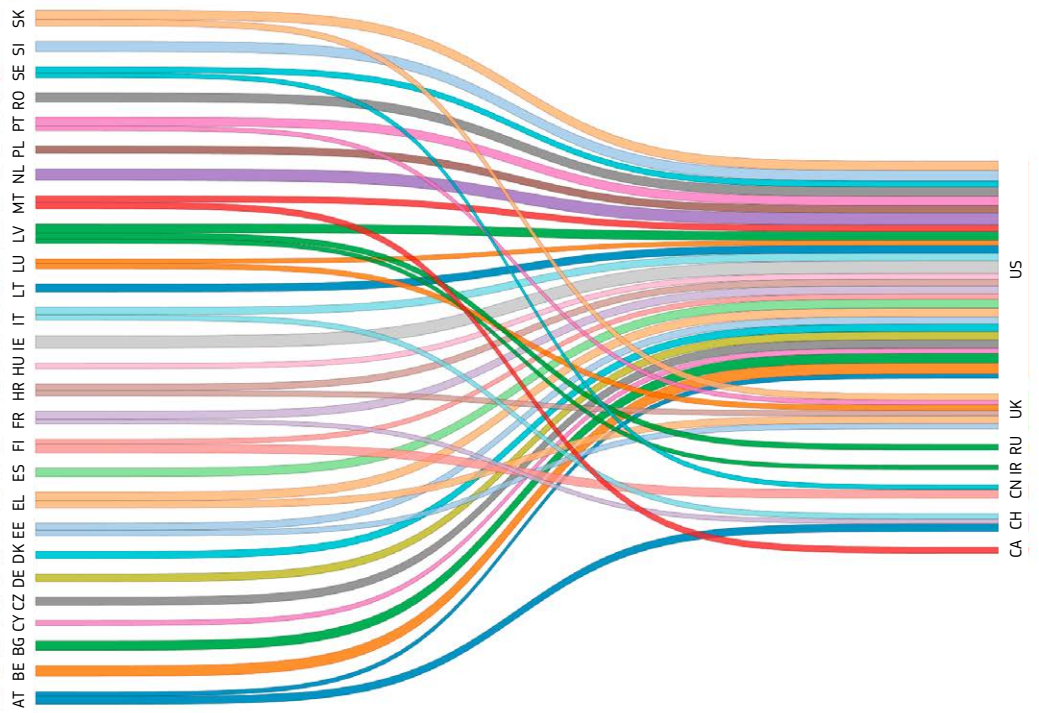
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on PATSTAT.

Note: The figure shows total global patenting output between EU Member States and their international partners, measured by inventor location using fractional counting to reflect proportional contributions to joint inventions. The share is calculated the number of patents the EU has with a given non-EU country over the total number of the EU's international co-patents.

The EU's primary international partners in patenting activities are the US, Switzerland, China, the UK and India, which together account for approximately 80% of the EU's global co-patenting activity. The US is the EU's leading partner, with 37% (2611) of co-patents recorded over the 2020-2023 period. It is followed by Switzerland with 14% (994), China with 11% (802), the UK with 10% (703) and India with 6% (386) (Figure 6.3-3). The main partners have remained largely stable over the last decade, though China (+4 pp) and India (+3 pp) have seen an increase, while the US (-4 pp), Switzerland (-2 pp) and the UK (-2 pp) have seen their shares decline. This distribution suggests that the EU's international innovation collaboration, as captured through co-patenting, is highly concentrated among a limited number of key partners. Beyond the top five, Japan (4%), Canada (4%), Singapore (1%), Norway (1%) and South Korea (1%) round out the top 10, demonstrating notable but lower levels of collaboration with EU Member States.

All EU Member States engage in co-patenting activity with the US, which accounts for at least 20% of their international co-patenting partnerships. This highlights the importance of transatlantic innovation linkages. Over the 2020–2023 period, these connections were particularly pronounced in Belgium, Ireland and the Netherlands, where more than half of all co-patenting activity with third countries involved partners based in the US (Figure 6.3-4). Beyond the US, several other countries, including Canada, Switzerland and the UK, are significant collaboration partners, each accounting for shares of above 20% in more than one Member State.

Figure 6.3-4 Shares of co-patents between EU Member States and third countries, by top partner countries (shares above 20%), 2020–2023



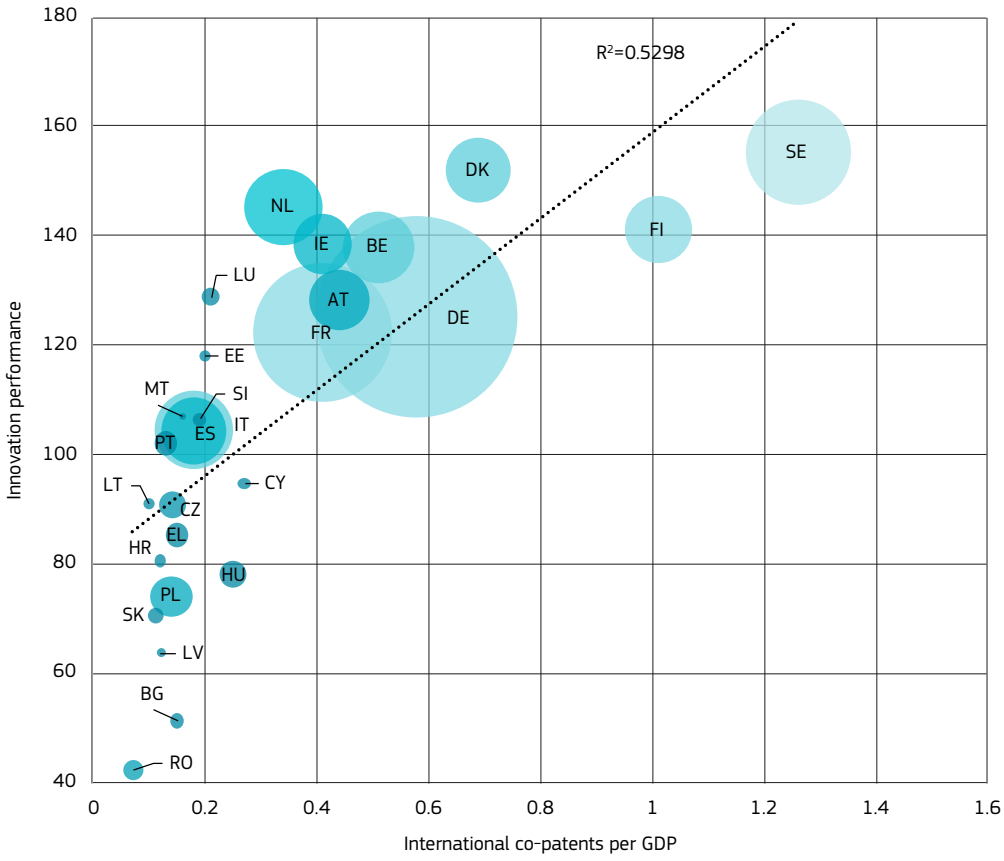
Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on PATSTAT.

Note: For each Member State, the figure illustrates the share of collaborations with the non-EU countries shown on the right-hand side. This share is calculated as the number of patents a Member State holds with a given third country divided by the total number of that Member State's international co-patents. Patent counts reflect fractional counts and locations refer to inventor location. The figure only shows third countries with shares exceeding 20%.

International co-patenting activity across EU Member States is uneven, with collaboration with global partners concentrated in a relatively limited number of EU countries, largely determined by innovation capacity and economic size. When aggregating all international co-patents originating from EU Member States, Germany and France together account for slightly more than half of total co-patenting activity, reflecting their large economies. Sweden, Italy, the Netherlands and Belgium follow in absolute terms (Figure 6.3-5, bubble size). Relative to economic size, Sweden and Finland stand out as the Member States with the highest numbers of international co-patents, followed by Denmark, Germany and Belgium (Figure 6.3-5, x-axis). Furthermore, international co-patenting is correlated with the innovation capacity of EU Member States, as measured by the European Innovation Scoreboard (EIS) (Figure 6.3-5). These results suggest that international co-patenting intensity is guided by wider national innovation capacity. This is in line with evidence showing that stronger innovation output in the EU is linked to higher investment in research and development (R&D), higher income levels and sustained economic growth, among other factors (Bello *et al.*, 2026).

Figure 6.3-5 International co-patenting of EU Member States, 2020–2023



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on PATSTAT.
Note: The size of the bubble represents the number of international co-patents, with reported counts reflecting fractional counts. Location refers to inventor location. GDP is measured in current (market) prices, billion EUR, for 2023. Innovation performance is measured by the 2025 EIS.

2. Strategic openness in Horizon Europe strengthens research excellence and creates mutual benefits

To enhance and align R&I cooperation, the EU has concluded bilateral science and technology agreements with countries around the world. Currently, the EU has such agreements with 20 countries. These agreements are based on common interests and priorities and are aimed at increasing cooperation in R&I activities. Some were signed decades ago: for example, with Switzerland in 1987, the US and China in 1998 and India in 2001, underlining a long-standing common understanding that cooperation in R&I is essential to progress towards shared goals[1].

Horizon Europe, the EU's framework programme for R&I, has become a flagship for cooperation with non-EU countries worldwide. It is a unique programme that facilitates international cooperation by offering R&I funding opportunities to entities all over the world (Steeman *et al.*, 2025). Association to Horizon Europe represents the closest form of cooperation with the EU for non-EU countries, allowing them to participate in (parts of) the programme on equal terms, although restrictions may be applied when necessary. Non-associated countries can also participate but sometimes without or with only limited EU contributions. Since the start of Horizon Europe, many new countries have become associated and have been granted access on equal terms. The programme is now global in scope, with associated countries including Canada, Egypt, South Korea, Japan, Australia and New Zealand, along with neighbouring countries such as Norway, Switzerland, Ukraine and the UK[2]. Furthermore, Horizon Europe facilitates close cooperation beyond the association process, with most countries worldwide eligible for EU funding, including those with low- and middle-income country status (Figure 6.3-6).

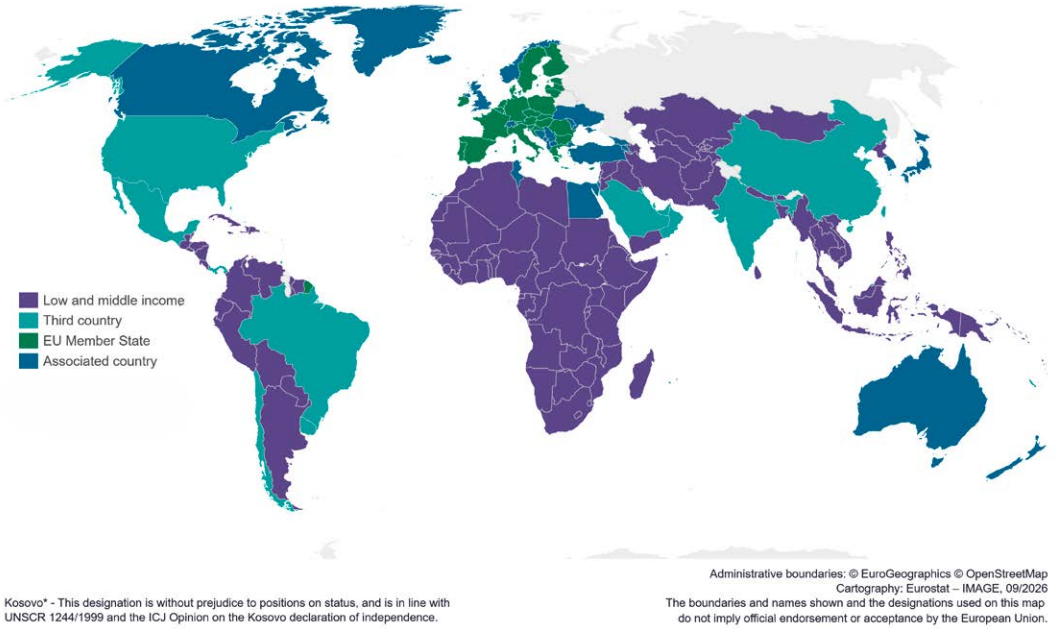
Horizon Europe functions not only as an R&I funding programme but also as an EU science policy instrument, translating the EU's strategic priorities into research agendas, governance arrangements and funding mechanisms. This role extends beyond the EU itself, as the programme also shapes scientific collaboration, policy alignment and innovation trajectories in ways that involve third countries. In fact, Horizon Europe exerts a structuring effect on global R&I systems. Through its scale, rules of participation and conditionalities such as open science requirements, ethical standards and data governance, the programme shapes institutional behaviour and policy frameworks within and outside the EU. This reinforces policy convergence, capacity building and strategic alignment, while serving broader EU science diplomacy and international cooperation objectives.

Association of third countries to Horizon Europe provides substantial additional financial input to the programme's R&I activities, as well access for EU entities to equivalent third country programmes. The combined annual financial contribution from associated countries is close to EUR 3 billion. With the reciprocity clause, access to national R&I programmes of associated countries seen as equivalent to Horizon Europe

1 https://research-and-innovation.ec.europa.eu/strategy/strategy-research-and-innovation/europe-world/international-cooperation/bilateral-cooperation-science-and-technology-agreements-non-eu-countries_en#ongoing-dialogues-and-other-current-agreements-with-international-partners

2 As of July 2026 Japan and Australia have concluded negotiations yet the association agreement has to be signed, see the latest details on associated countries via the following link: https://research-and-innovation.ec.europa.eu/strategy/strategy-research-and-innovation/europe-world/international-cooperation/association-horizon-europe_en#countries-associated-to-horizon-europe

Figure 6.3-6 EU global cooperation via Horizon Europe



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Horizon Europe Dashboard.

Note: Canada, South Korea, Japan, Australia and New Zealand are associated to Pillar II of Horizon Europe: 'Global Challenges and European Industrial Competitiveness'. Association includes countries formally associated with Horizon Europe as well as EU Overseas Countries and Territories (OCTs), which are eligible to participate in Horizon Europe under specific provisions.

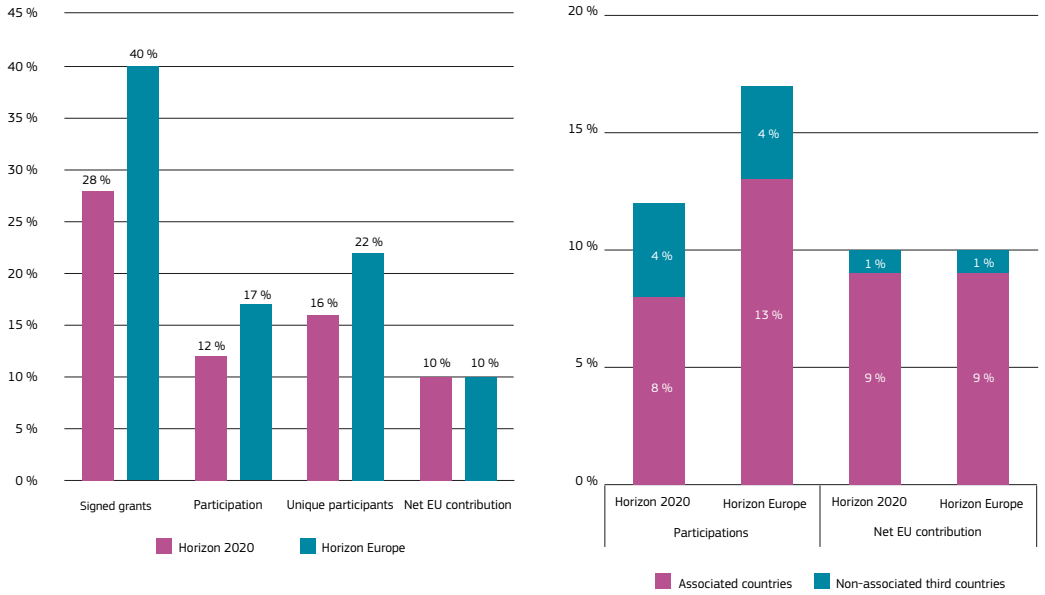
has been established. As of February 2026, the clause gives EU-based entities access to 107 programmes in some of the associated countries.

International cooperation with non-EU countries within EU framework programmes is well established. Third countries are well integrated in Horizon Europe, with 40% of all grants allocated to projects involving third countries – up from 28% under the previous programme, Horizon 2020. The participations and unique participants metrics also show substantial increases, while the net EU contribution has remained stable, with circa 10% of the budget going to third countries (Figure 6.3-7, left). Overall, these results indicate increased internationalisation of Horizon Europe.

Most third country engagement comes from associated countries, which account for 13% of participations and 9% of the net EU contribution (Figure 6.3-7, right)[3]. Further analysis shows that Horizon Europe is highly internationalised throughout, with the highest levels of international engagement (participation and funding) in the fields of scientific excellence and research mobility (Pillar I) and collaborative projects (Pillar II), while in relative terms, as regards shares of total funding per pillar, the picture is more balanced across the programme. Horizon Europe and its predecessors have also made a substantial contribution to the R&I activities of international organisations, with 1,061 Horizon Europe projects involving IOs already funded, totalling EUR 441 million (see Box 6.3-1).

3 The data on the grouping of associated countries in Figure 6.3-7 should be treated with caution. If a non-associated country becomes associated during the lifespan of Horizon Europe, then its grouping changes to associated for the entirety of the programme. This leads to the number on the engagement of associated countries to be overrepresented.

Figure 6.3-7 Third country engagement in Horizon Europe and Horizon 2020



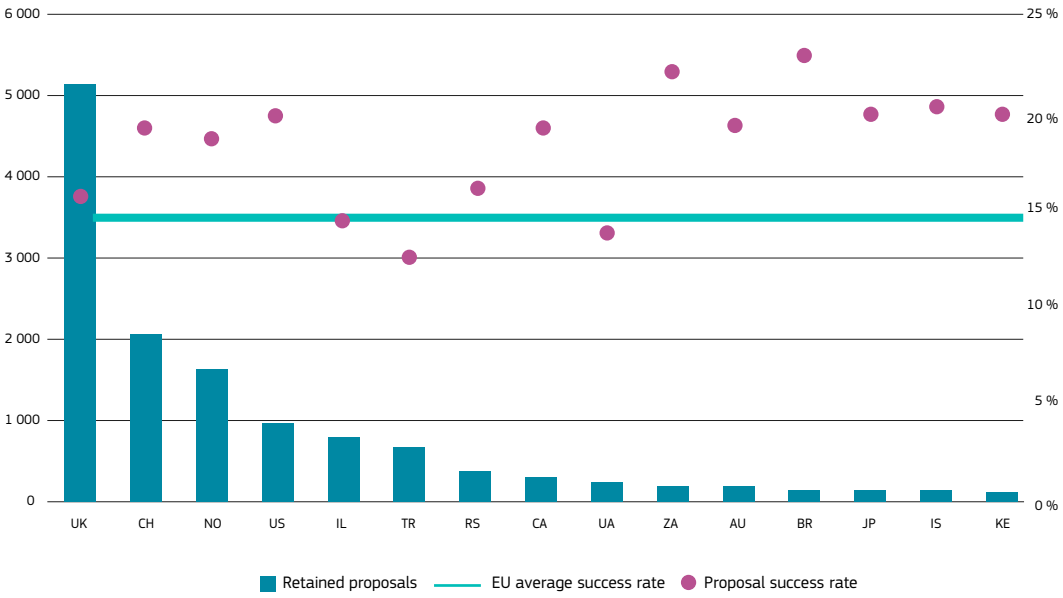
Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Horizon Europe Dashboard (cut-off: 5 January 2026).

Of non-EU countries, the main participants in Horizon Europe are the UK, Switzerland, Norway and the US, while Norway, the UK, Israel and Türkiye receive the largest shares of funding. Further analysis based on Horizon Europe Dashboard data shows that neighbouring third countries with strong innovation capacity participate the most in Horizon Europe, with associated countries the UK, Switzerland and Norway first (5.1%), second (2.4%) and third (2.2%), respectively, based on their shares of total participations, while the US, a non-associated third country, also shows strong engagement in fourth place (1.1%). Results based on the net EU contribution show Norway leading, having received 3% of total funding, followed by the UK (2.5%), Israel (1.8%) and Türkiye (0.7%).

Third countries participating in Horizon Europe bring excellence to project proposals, strengthening the overall quality of the programme. The UK, Switzerland, Norway, the US and Israel are the third countries with the most retained proposals (Figure 6.3-8). Proposal success rates from the 15 most successful third countries are almost all above the EU average (14.4%). This is exemplified by the four third countries with the highest participation rates, which all have higher success rates: 16.0% for the UK, 18.8% for Switzerland, 18.3% for Norway and 19.7% for the US. This indicates that a proposal that includes third country participation is often assessed as (more) valuable, potentially because often it incorporates complementary knowledge and/or capabilities.

Figure 6.3-8 Success rates of third countries in Horizon Europe

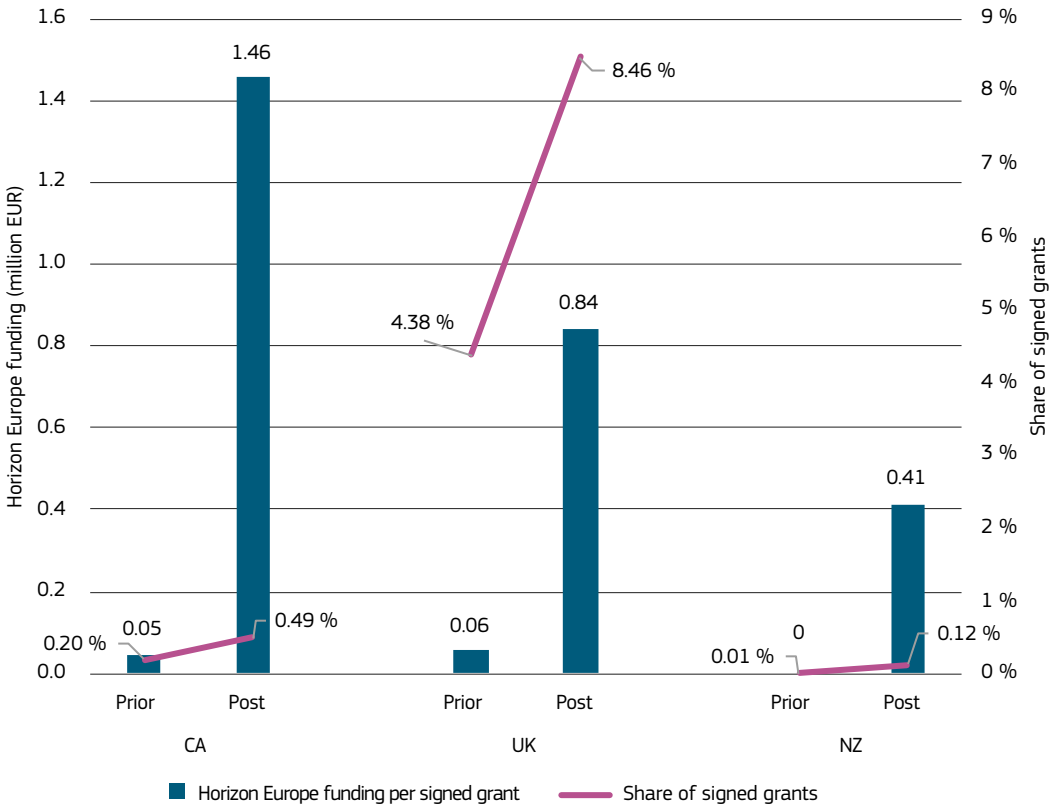


Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Horizon Europe Dashboard (cut-off: 5 January 2026).

Since they have been associated to Horizon Europe, Canada, New Zealand and the UK have become more integrated into the programme, as evidenced by substantial rises in the numbers of projects in which they participate and increases in the funding they receive. Focusing on Pillar II, New Zealand was involved in only 0.01% of all signed grants prior to its association, since which its share has risen to 0.12% – an increase by a factor of 23. A similar trend has been observed for Canada. Before association, Canada was a recipient of 0.2% of all Pillar II grants signed during the period under consideration, whereas after association this share more than doubled, rising to 0.49%. For the UK, which is associated to almost the entire programme, similar impacts have been observed, with a share of 4.38% of signed grants prior to association almost doubling to 8.46% after association. Net EU contributions to organisations in these countries have also increased substantially. Prior to association, the UK and Canadian organisations received approximately EUR 57 000 and EUR 46 000 respectively per grant signed, while the New Zealand one did not receive any contributions. Since association, these amounts have risen to over EUR 840 000 for the UK, EUR 1 460 000 for Canada and over EUR 410 000 for New Zealand. Overall, these figures indicate that these countries have become more integrated into Horizon Europe, thereby strengthening international R&I cooperation (Figure 6.3-9).

Figure 6.3-9 Pre- and post-association results for Canada, the UK and New Zealand



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Horizon Europe Dashboard (cut-off: 5 January 2026).

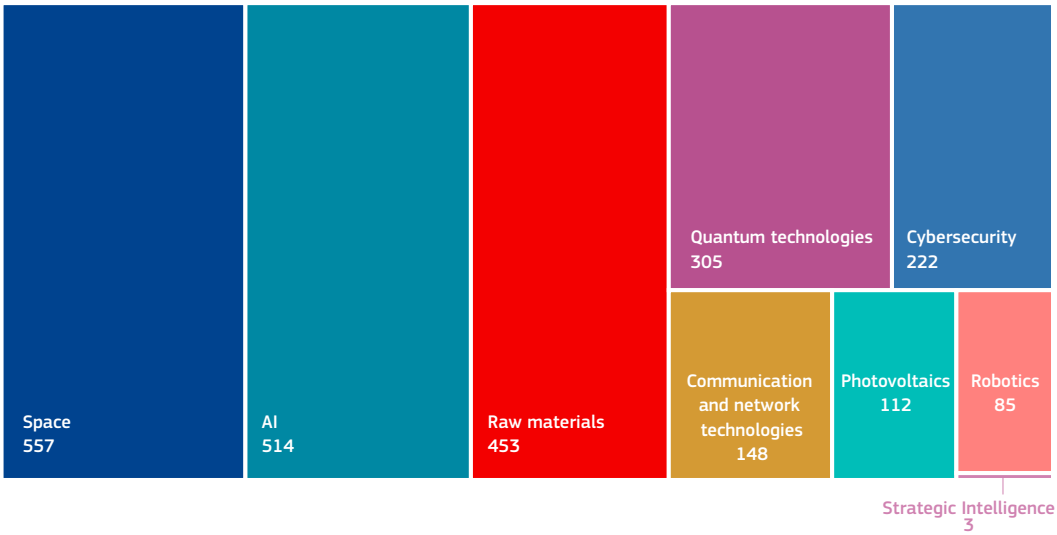
Note: Association dates are based on the retroactive application dates: Canada, 1 January 2024; New Zealand, 1 January 2023; UK, 1 January 2024. For Canada and New Zealand, only Pillar II is considered; for the UK, the full programme is considered, excluding the European Innovation Council (EIC) Accelerator. The share of signed grants is calculated as the total number of grants signed by the associated country divided by the total number of grants signed under Horizon period in the same considered period.

While widespread international participation in Horizon Europe demonstrates openness, the programme includes safeguards which are applied when necessary. Article 22(5) and (6) of Regulation (EU) 2021/695 establishing Horizon Europe restricts participation in specific calls when required to protect EU assets, interests, autonomy or security (European Commission, 2021). These restrictions apply mainly in areas involving sensitive technologies or potential risks of foreign interference. They are complemented by guidelines on foreign interference, a code of practice for the management of intellectual assets, guiding principles on knowledge valorisation and a code of practice on standardisation, all of which enhance resilience and responsible research practices across the EU.

Restricted calls within Horizon Europe are mostly seen in the areas of space, Artificial Intelligence (AI), raw materials and quantum. So far (cut-off date: December 2026), there have been 136 calls, totalling close to EUR 2.4 billion, restricted via article 22.5, with most restricted calls in the areas space, AI, raw

materials and quantum. Decisions to impose restrictions are made on a case-by-case basis, and in most cases, restricted calls are open to third countries such as associated countries or Organisation for Economic Co-operation and Development (OECD) member countries. Four calls have been restricted to EU Member States only. The total budget of the restricted calls amounts to approximately 4.6 % of the total budget allocated through Horizon Europe in the same period (from the beginning of Horizon Europe until the cut-off date).

Figure 6.3-10 Closed calls in Horizon Europe by topic area and budget, million EUR



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Horizon Europe data (cut-off: 11 December 2025).

Box 6.3-1 Multilateralism: the EU's contribution to International Organisations

Horizon Europe and its predecessors have made a substantial contribution to the projects of international organisations (IOs), supporting multilateral institutions in their R&I endeavours. Various IOs have been supported, for example the European Space Agency, NATO, the OECD, various United Nations (UN) bodies such as UNESCO, international and European research centres and laboratories and the World Health Organization (Figure 6.3-11). The projects are numerous, including collaborative research projects and direct cooperation with, for instance, the OECD on the STIP (science, technology and innovation policy) Compass. Through Horizon 2020, 995 projects with IOs were funded, with the net EU contribution totalling EUR 509 million. For Horizon Europe already 1061 projects involving IO's have been funded, totalling EUR 441 million. The IOs are mostly active in programmes related to the European Research Council; food, bioeconomy, natural resources, agriculture and environment; and research infrastructures, through which EUR 90 million, EUR 79 million and EUR 77 million, respectively, have been allocated to IO projects.

Figure 6.3-11 Horizon Europe funding for International Organisations, million EUR



Science, Research and Innovation Performance of the EU 2026

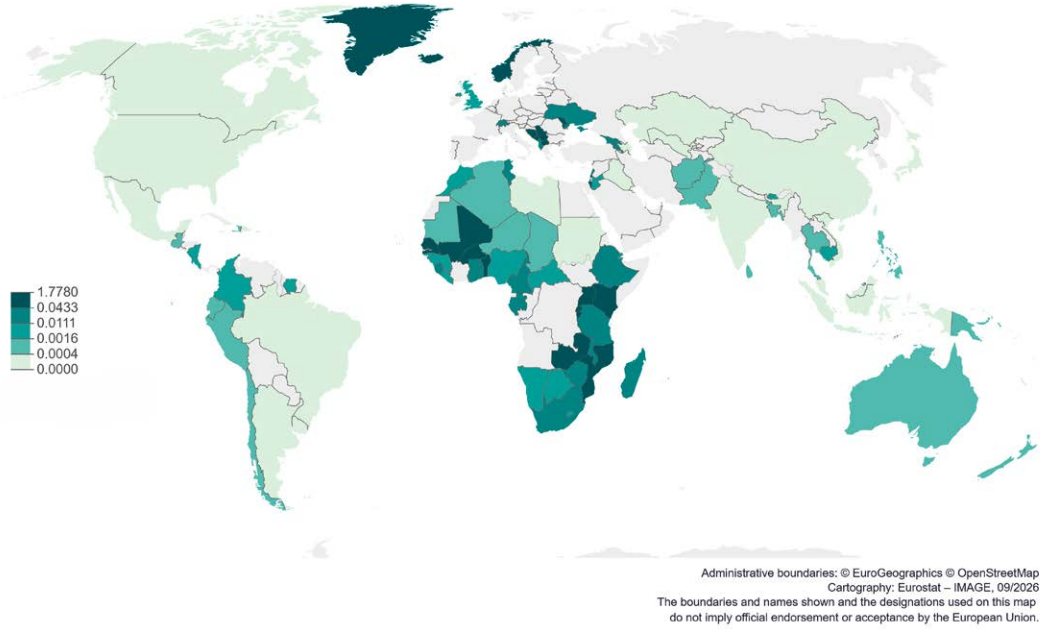
Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on CORDA (cut-off: May 2026).

3. The EU's global cooperation supports progress towards the SDGs

The EU advocates for inclusivity in scientific development to bridge knowledge gaps and foster global partnerships in order to address health crises, climate change and economic instability. This advocacy is demonstrated though Horizon Europe's openness to low- and middle-income countries[4] regardless of whether they are associated to the programme. In fact, some of the highest EU financial contributions relative to recipient country GDP are in Sub-Saharan Africa (Figure 6.3-12).

The EU's global R&I cooperation also supports progress towards the SDGs. The SDGs are key objectives that guide the EU's internal and external policies. The UN 2030 Agenda for Sustainable Development[5] includes 17 SDGs related to universal public goods such as equality, a clean and affordable planet, zero poverty and innovation. These 17 goals are fundamental to the 2030 Agenda, which was adopted by all UN members in 2015. Progress towards the SDGs is embedded in the objectives of Horizon Europe. According to Article 3 of Regulation (EU) 2021/695, the general objective of Horizon Europe is to generate scientific, technological, economic and societal impact through EU investments in R&I (European Commission, 2021). These investments are aimed at strengthening the EU's knowledge base and competitiveness, while contributing to its strategic priorities and the achievement of its objectives. The regulation explicitly highlights the role of R&I in tackling global challenges, including those highlighted in the SDGs, in line with the principles of the 2030 Agenda and the Paris Agreement.

Figure 6.3-12 **EU financial contributions to non-EU countries relative to their GDP**



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Horizon Europe Dashboard and World Bank.

4 Countries listed as low and middle income by the World Bank are eligible to receive EU funding under Horizon Europe even without being associated to the programme.

5 https://sustainabledevelopment.un.org/post2015/transformingourworld

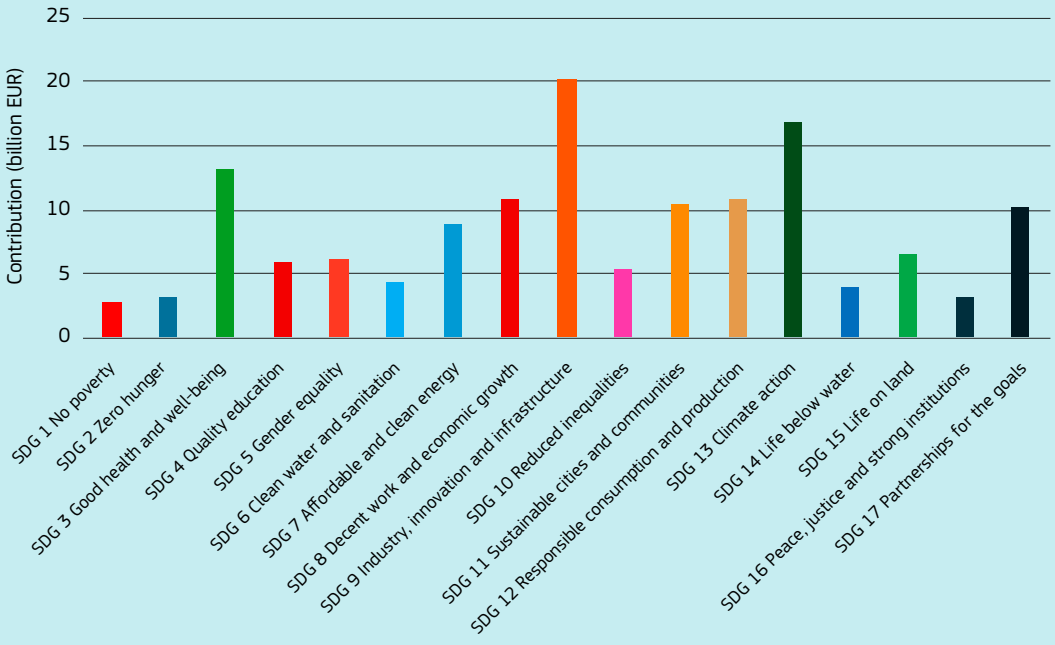
Box 6.3-2 Horizon Europe and support for the SDGs

Veera Natunen (European Commission, DG Research & Innovation)

The European Commission monitors Horizon Europe contributions through the programme's performance framework. This framework tracks the results of affiliated projects, such as scientific publications, innovations and patents relevant to the SDGs. Expectations regarding SDG contributions are set at the start of projects and updated over the course of their implementation. When funding topics are designed, they are tagged for their expected contribution to specific SDGs. This information is then updated using reports provided by project participants during the project or at its end.

As of 2026, at least EUR 31.2 billion has been mobilised through Horizon Europe to help achieve the SDGs. Data obtained in January 2026 highlights significant financial contributions, including an estimated EUR 20 billion to industry, innovation and infrastructure (SDG 9), EUR 17 billion to climate action (SDG 13) and EUR 13 billion to good health and well-being (SDG 3) (Figure 6.3-13).

Figure 6.3-13 Horizon Europe contribution to SDGs, billion EUR



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on CORDA (cut-off: January 2026).

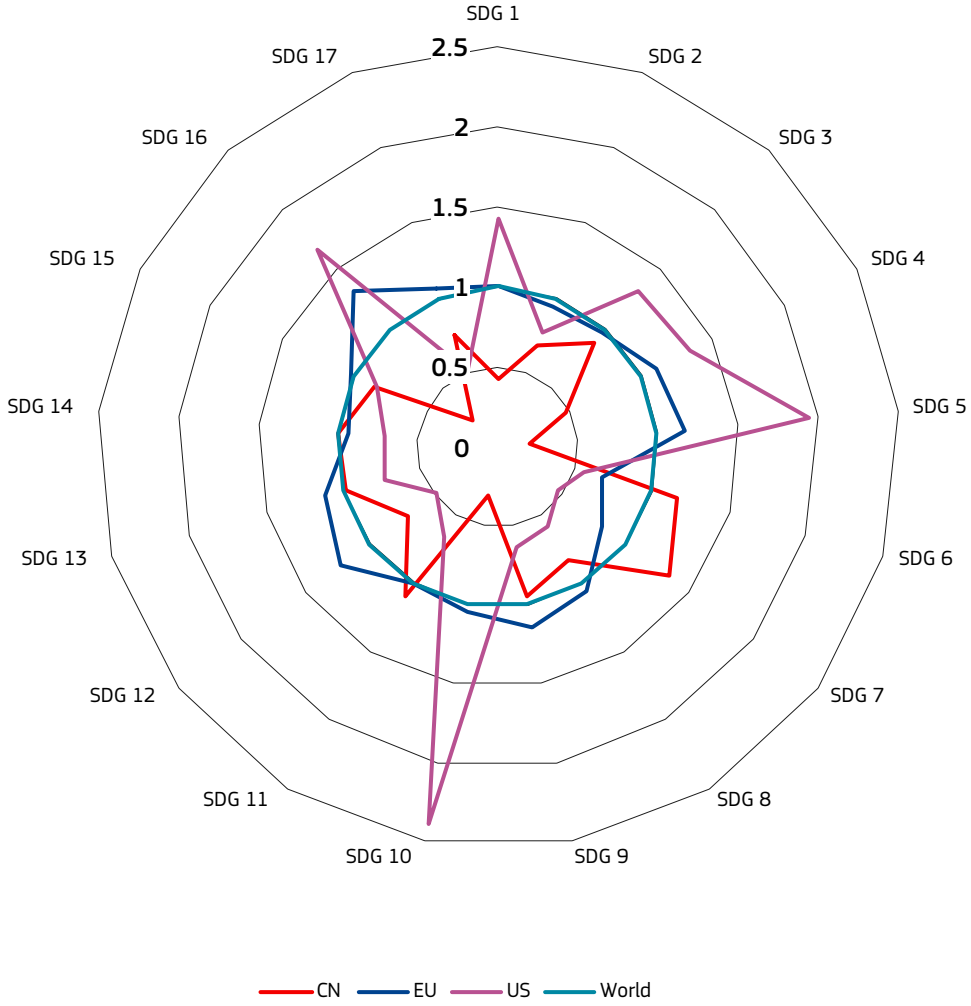
The commitment to the SDGs is further reinforced through international partnerships under Horizon Europe. Several Horizon Europe partnerships require international participation to achieve their objectives and are explicitly aligned with SDG priorities. For example, the Afri-FOOD-Links[6] project connects 15 African and five European cities to help transform urban food systems. To date, the project has produced 15 city-level food system reports, launched intercity and stakeholder exchange mechanisms and developed proposals for real-world socio-technical experiments. Similarly, the CarbFix2[7] project shows how EU research is helping achieve SDG 13 on climate action by developing CO_2 mineralisation technology that permanently stores captured CO_2 in volcanic rock. The technology was piloted at the Hellisheiði geothermal power plant in Iceland and is now being scaled up for wider use. These projects reflect the EU's commitment to using R&I cooperation as a means of supporting sustainable development beyond its borders.

Through its different calls, Horizon Europe provides funding in areas that helps achieve the SDGS, with most funding steered towards innovation, industry, climate, and health. As of 2026, a minimum of EUR 31.2 billion is mobilized through Horizon Europe towards achieving the SDGs (box 6.3-2). The EU also monitors these contributions through a dedicated framework (box 6.3-2).

In terms of scientific specialisation in the different SDGs, the EU provides a balanced portfolio with specialisations in peace, justice and strong institutions; responsible consumption and production; and gender equality. The US exhibits a more concentrated pattern of specialisation, particularly in reduced inequalities; gender equality; and peace, justice and strong institutions. China demonstrates a narrower specialisation profile, with some emphasis on affordable and clean energy, and clean water and sanitation, while scoring low on gender equality; peace, justice and strong institutions; and reduced inequalities (Figure 6.3-14).

6 https://cordis.europa.eu/project/id/764760

Figure 6.3-14 Specialisation index (SI) for each SDG, EU, US, China and World, 2024



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Science-Metrix using Scopus (Elsevier).

Note: An SI above 1 indicates that the entity produces a greater share of its research output in that area than the world average (i.e. it is specialised). Conversely, an SI below 1 indicates a smaller share than the world average (i.e. it is not specialised). SDG 1 – no poverty; SDG 2 – zero hunger; SDG 3 – good health and well-being; SDG 4 –quality education; SDG 5 – gender equality; SDG 6 – clean water and sanitation; SDG 7 – affordable and clean energy; SDG 8 – decent work and economic growth; SDG 9 – industry, innovation and infrastructure; SDG 10 – reduced inequalities; SDG 11 – sustainable cities and communities; SDG 12 – responsible consumption and production; SDG 13 – climate action; SDG 14 – life below water; SDG 15 – life on land; SDG 16 – peace, justice and strong institutions; SDG 17 – partnerships for the goals.

4. The EU's approach to global cooperation respects openness while safeguarding security

The EU's policy approach to international R&I cooperation balances openness and reciprocity with safeguarding of EU strategic interests. As evidenced by this chapter, the EU is well established in international R&I collaboration and promotes this via various instruments. The EU's Global Approach to Research and Innovation provides an overarching framework for its international R&I cooperation in which openness and reciprocity are balanced with safeguarding of the EU's strategic interests. Recently, the focus of EU R&I collaboration has shifted towards strengthening cooperation with like-minded partners, reciprocity requirements and research security provisions in order to ensure a level playing field and safeguard sensitive knowledge, thereby ensuring that openness remains aligned with European principles and strategic priorities (European Commission, 2026). This includes the introduction of research security measures that allow for the restriction of participation in specific calls where this is necessary to protect EU assets, interests and autonomy. These measures are complemented by guidelines on foreign interference, codes of practice on intellectual asset management and standardisation and broader efforts to ensure responsible knowledge sharing. This new stance is aligned with the *European Economic Security Strategy* through a 'promote, protect and partner' approach (European Commission, 2023).

Science diplomacy further reinforces this balanced approach by positioning R&I as a tool for international engagement and trust building. Through bilateral and multilateral cooperation, the EU seeks to strengthen global knowledge networks, support capacity building and contribute to solutions to global challenges, particularly in regions where R&I cooperation can have a strong developmental impact (European Commission, 2025b). This approach also underpins the Multilateral Dialogue on Principles and Values for International Cooperation in Research & Innovation. The first phase of the dialogue concluded in 2024 with the Brussels Statement, endorsed by an international ministerial conference in February 2024.

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CHAPTER 7

ARTIFICIAL INTELLIGENCE, RESEARCH AND INNOVATION

Valentina Di Girolamo, Julien Ravet

KEY QUESTIONS

- How is the diffusion of artificial intelligence (AI) impacting economic growth and the nature of work?
- Where does the EU stand in the global AI landscape, and what does the evolving ecosystem reveal about EU strengths and gaps?
- What role is AI playing in transforming scientific discovery?
- How is the European policy framework responding to the rise of AI?

HIGHLIGHTS

- AI adoption can deliver significant firm-level productivity gains, but economy-wide impacts remain more modest and uneven.
- Europe currently accounts for only around 5% of global AI compute capacity and 90% of global data centres are outside EU jurisdiction. This leaves Europe heavily dependent on foreign infrastructures and proprietary systems, posing important challenges to its economic security.
- The global AI ecosystem is strongly dominated by the US which accounted for around 80% of global AI investment in 2025, compared with the EU's 5%. AI private investment accounts for around 73% of total AI spending in the EU and is mostly allocated to skills development (41%) and data and equipment (37%).
- The US and China together account for the most of global patent filings in the field, while the EU's patent application share reported a steady decline over the last decades, from around 20% in 2000 to 12% in 2022.
- Nevertheless, the EU's position remains strong in terms of scientific output related to the development of AI technologies, with important European cities reporting performance levels comparable to those of their Asian and US peers.
- The use of AI in scientific research has surged in recent decades, with China emerging as a clear leader. The EU trails but remains on a par with the US.
- The integration of AI into science has important implications for the novelty and impact of scientific research, although its benefits remain unevenly distributed across geographic areas and dependent on both the topology of the knowledge space underpinning a field and the degree of AI penetration within it.

POLICY INSIGHTS

- Given its ubiquitous nature and growing impact on productivity, scientific discovery, innovation performance and long-term competitiveness, AI has become a key strategic priority for EU policy.
- The EU's AI policy framework has entered a more operational phase, centred on three main functional building blocks: the AI Act to support trust and legal certainty, the AI Continent Action Plan to strengthen AI capabilities, and the Apply AI Strategy to scale uptake across industry and the public sector.
- R&I investment, anchored in Horizon Europe is central to advancing core AI capabilities and embedding AI across scientific and industrial domains. Furthermore, The European AI in Science Strategy strengthens the responsible integration of AI into research through dedicated governance and capacity-building actions, such as RAISE (Resource for AI Science in Europe).

Artificial intelligence (AI) has rapidly emerged as a transformative, general-purpose technology with the potential to reshape economic systems, scientific progress and innovation. From a macroeconomic perspective, AI can produce economic impact either by increasing the rate at which goods and services are produced, or by increasing the ability to generate new ideas, thereby accelerating innovation. Since 2022, AI systems have experienced important advances that have enhanced the capabilities of these tools, further deepening their role in knowledge creation, and triggering a profound transformation in employment dynamics, task structures, skill premia, and the organisation of work. At the micro level, AI reshapes, among other things, individual productivity, task allocation, and skill accumulation.

At the same time, AI's pervasive nature raises critical questions about economic security, geopolitical dependencies and Europe's ability to shape the direction of AI's technological progress. The global AI ecosystem is increasingly characterised by asymmetries in compute capacity, data availability, talent attraction and private investment. Despite its world-class scientific capabilities and strong research ecosystem, Europe grapples with persistent structural weaknesses that risk exacerbating its dependencies on foreign technologies.

1. AI is set to have profound economic and social impacts

AI systems boast unique capabilities that enable them to perform complex tasks and to accelerate innovation. An important distinction can be made between generative and non-generative AI models. The latter are models that analyse large amounts of data to identify patterns, make predictions and support decision-making through recommendations (Filippucci *et al.*, 2024). Machine learning used to be mainly characterised by algorithms such as neural networks that analyse large amounts of data to identify patterns, make predictions and provide recommendations through expert systems. On the other hand, generative AI (GenAI) models, including large language models (LLMs) such as ChatGPT, are designed to produce content of different forms, from text, images and audio to computer codes. This type of AI is also characterised by iterative learning and positive feedback loops that allow for refinement of its performance over time, enabling it to automate tasks, but also to augment and accelerate creative and knowledge-intensive activities (Filippucci *et al.*, 2024). Furthermore, recent advances have enabled the development of AI agents, i.e. systems that can independently make decisions and take actions (European Commission, 2025c). Unlike GenAI, which stops after producing an output, AI agents use tools, call application programming interfaces (APIs), iterate, and stop when a goal is achieved.

AI is seen as a general-purpose technology, given its ubiquitous nature and its potential to transform multiple sectors of the economy simultaneously. Akin to the introduction of electricity, the invention of the steam engine, or the arrival of computers and the internet, AI holds the potential to significantly boost economic growth (Misch *et al.*, 2025). In particular, generative AI exhibits defining characteristics of general-purpose technologies, including a marked degree of pervasiveness across a broad set of areas (from life and medical sciences to banking and finance), the ability to improve over time thanks to continuous advances in compute and model capabilities, increased access to data, and the capacity to foster further innovations, either within the same technological domain or across different sectors (Calvino *et al.*, 2025b). Beyond its direct applications, AI has also been characterised as a general-purpose 'method of invention' (Cockburn *et al.*, 2018) and a 'method of discovery' (Bianchini *et al.*, 2022)[1].

However, whether AI can ultimately deliver the productivity gains many anticipate remains a topical question in the policy debate in Europe and worldwide. Since the early 2000s, global productivity has been experiencing a significant slowdown across multiple countries and industries (see chapters 5.1 and 11). This deceleration in the pace of productivity growth has occurred despite the progress in information and communication technologies (ICTs), anticipated to become key drivers of economic development (Brynjolfsson *et al.*, 2018), but which have not been able to reverse the sluggish global productivity trend (Goldin *et al.*, 2024).

AI can deliver important short-term productivity and performance gains at micro-level. Recent evidence shows that AI adoption across OECD countries is associated with improvement in labour productivity at firm level of up to 11% (Filippucci *et al.*, 2024).

1 Given its pervasive nature and its multifaceted applications, AI has the potential to not only improve productivity or automate tasks, but also to fundamentally change how innovation itself happens. Additionally, AI tools are increasingly adopted by researchers to carry out scientific activities. In this sense, AI can be seen as a method of invention, i.e. a general-purpose research tool that changes the process of discovering new ideas and technologies across many fields, and a method of discovery as it provides tools that help scientists find patterns in or gain insights from existing data or knowledge.

Furthermore, experiments with GenAI show even larger effects, pointing to customer-service workers resolving more cases, professionals writing faster and better, software developers producing code more quickly and with fewer errors (Filippucci *et al.*, 2024), and households being more productive (Blank *et al.*, 2026).

The productivity gains from adopting GenAI strongly depends on the complexity of the task undertaken. Recent evidence suggests that less experienced users tend to benefit more from the structured guidance and error-correction assistance provided by AI systems (Calvino *et al.*, 2025a). Nevertheless, recent advances are also set to expand the productivity gains from AI adoption to other categories of workers, notably experienced workers for whom AI coding agents appear to be particularly complementary (Sarkar, 2025; Daniotti *et al.* 2026).

Nevertheless, these micro-level gains do not automatically translate into economy-wide productivity growth. AI-based productivity gains can come from different channels, including task automation, enhanced complementarity and the creation of new tasks (Acemoglu, 2025). Furthermore, AI has the potential to generate productivity gains across sectors such as healthcare, manufacturing, transport, energy, agriculture and public administration through improved efficiency, innovation and cost reductions (European Commission, 2025c). Concerning automation[2], only a subset of tasks across the economy can be concretely automated with current AI systems, and automation is also subject to ethical and consumer safety requirements that guarantee human oversight. This creates a ceiling and raises ethical and regulatory questions regarding the productivity gains that can be achieved from pure automation (Acemoglu, 2025).

Additionally, achieving economy-wide impacts requires substantial complementary investments, in terms of organisational change, data infrastructure, intangible capital and workforce skilling and upskilling. These typically take time to be deployed and translated into productivity improvements, limiting the economic impact achievable through augmentation (Aghion and Bunel, 2024).

When these constraints are accounted for, macroeconomic simulations of the aggregate impact of AI adoption tend to produce more modest estimates than micro-level data. In Europe, projected gains of around 1.1% (against the 0.8% of the baseline scenario) in total factor productivity (TFP) over five years occur only under the assumption of rapid AI diffusion across sectors, high adoption intensity among firms, sufficient investment in complementary capabilities, and regulatory environments that do not significantly restrict deployment (Misch *et al.*, 2025). Significantly smaller long-run effects are observed in case of smaller diffusion and limited automation potential (Acemoglu, 2025).

Furthermore, significant heterogeneity exists across European countries with regards to expected productivity gains from AI. High income countries are projected to experience the largest medium-term TFP gains, mainly because they face higher labour costs, have a higher concentration of AI-exposed sectors, and can rely on stronger digital infrastructures (Misch *et al.*, 2025). This suggests that Europe's AI-driven productivity trajectory will likely be highly uneven, posing challenges for the economic convergence process within Europe.

2 Automation is defined as the expansion of the set of tasks performed by capital (e.g., machines, algorithms, or AI systems) rather than by labor within the production process (Acemoglu, 2025).

The economic impact of AI will also depend on the speed and breadth of adoption by businesses. From 2021 to 2023, AI adoption by European firms was roughly stable, but has more than doubled since 2023 (Bick *et al.*, 2026). This has important implications for productivity growth. Since 2019, AI adoption has accounted for about 12% of European companies' total productivity growth (EIB, 2026). Firms adopting big data analytics and AI report significant productivity gains, reflecting more efficient use of inputs and improved decision-making. Specifically, companies investing in only one GenAI application area boast better performance (showing approximately 25% higher TFP than firms that do not invest in generative AI), whereas firms deploying GenAI across two or more areas achieve nearly 30% higher TFP (EIB, 2026).

However, adoption varies significantly by firm size. Large firms are typically better placed to adopt advanced technologies, thereby benefitting from larger productivity gains. Conversely, smaller companies report substantially lower adoption rates (EIB, 2026). This risks slowing down Europe's overall digital transformation and could potentially exacerbate the gap with the US. In this regard, AI adoption is currently higher in the US than in Europe, with both US workers and companies using AI for a larger fraction of their work week and for production, respectively (Bick *et al.*, 2026).

Even if aggregate productivity gains materialise at a different pace, the AI's contribution to economic growth is still expected to be significant. Although automation alone is expected to deliver only limited macroeconomic benefits, AI's ability to enhance human performance, reduce costs and deliver impact, mostly in knowledge-intensive sectors, suggests that its long-term contribution to economic growth can be structurally significant[3]. In general, the macroeconomic impact of AI will likely hinge on the coexistence of different factors, from technological capability, adoption and workforce adaptation to the development of complementary technologies. Upon these conditions, AI holds the potential to lead to significant long-run economic growth, although uncertainty remains on both the timing and the distribution of such economic gains (White House Council of Economic Advisers, 2026).

Doubts remain on whether AI's potential to increase overall productivity will also translate into increased shared prosperity. In particular important concerns exist about the distributional effects of AI adoption and the risk of exacerbating income, social disparities (Filippucci *et al.*, 2024) and intergenerational and gender inequality (Pal *et al.*, 2024). At the same time, there is growing evidence that AI can contribute to the achievement of several Sustainable Development Goals (SDGs), while potentially hindering that of others; however, its overall effects appear to be more enabling than inhibiting (Vinuesa *et al.*, 2020; Gohr *et al.* 2025).

This is particularly relevant for labour market dynamics. Technological progress has historically affected tasks, occupations and, more generally, employment in heterogeneous ways, depending on whether it led to the automation, augmentation or transformation of work (Brynjolfsson *et al.*, 2025). Each major technological shift, from mechanisation to computerisation, has been accompanied by fears of job displacement due to the risk of machines replacing workers (Mokyr *et al.*, 2015; Johnson and Acemoglu, 2023). Technological progress tends to favour highly skilled workers, while replacing tasks performed by low-skilled workers, thereby widening wage inequality between the two groups (Minniti *et al.*, 2025). Furthermore, a significant drop in the labour share of national income has been observed since the mid-20th century across most industrialised economies

3 https://www.ft.com/content/4b51d0b4-bbfe-4f05-b50a-1d485d419dc5

(Karabarbounis, 2023). This has contributed to rising income inequality and has been accompanied by an increase in the skewness of income distribution towards the richest individuals (Johnson and Acemoglu, 2023).

Recent evidence on GenAI suggests a partially distinct pattern. Around 20% of workers are estimated to have more than half of their tasks exposed to GenAI, particularly in occupations combining cognitive, communicative, and creative tasks. This exposure is not concentrated among low-wage workers, but rather affects workers located in the middle-to-upper segments of the wage distribution, raising new questions about how recent waves of AI could reshape inequality dynamics relative to earlier episodes of technological change (Eloundou *et al.*, 2024).

Negative effects on labour dynamics can be attributed to technological progress prioritising automation over human complementarity (Johnson and Acemoglu, 2023). Workers are affected by technological advances in different ways, depending on their exposure to a given technology and the extent to which that technology will automate or augment their work tasks (Autor *et al.*, 2024). As an example, the use of industrial robots produces negative effects on wages in those occupations most exposed to robotisation (Acemoglu and Restrepo, 2020). On the other hand, technological progress through augmentation innovations can spur the creation of new jobs, raising occupational labour demand through both substitution and scale effects (Autor *et al.*, 2024).

AI adds a new layer of complexity to how technological change affects labour demand by introducing, alongside traditional skill-biased and routine-biased mechanisms, a dimension of seniority-biased technological change. Because AI systems can perform both routine and increasingly complex cognitive tasks, there is a risk of creating displacement effects in those occupations in which workers' skills can be more easily substituted by AI adoption. Recent evidence suggests that occupations where AI is mostly used to automate tasks exhibit significant declines in early-career employment, whereas those in which AI is primarily used to augment tasks report no decline or increase (Brynjolfsson *et al.*, 2025). Furthermore, the adoption of GenAI by firms appears to disproportionately reduce junior employment where work is more routine and codifiable, whereas senior employment remains largely unaffected, presumably because the tasks of senior employees rely more on tacit knowledge, contextual judgment and complex problem-solving (Lichtinger and Hosseini Maasoum, 2025). It is worth mentioning that these findings are based on early evidence and may thus not fully generalise across sectors or to the aggregate economy.

Beyond its implications for labour market dynamics, AI adoption is also accompanied by a set of non-economic risks that could ultimately undermine its economic outcomes. These include the concentration of technological power in the hands of a few global AI developers (European Commission, 2025a), cybersecurity risks, the spread of misinformation and disinformation though specific types of AI systems, as well as hybrid threats such as influence operations, privacy breaches and algorithmic bias (Filippucci *et al.*, 2025). Although these risks fall outside traditional economic domains, they can have direct economic consequences, eroding public trust in digital systems, and slowing down adoption by firms and households (Filippucci *et al.*, 2025).

For these reasons, AI has also become central to discussions around Europe's economic security and strategic autonomy (see chapter 4.1). Being a foundational technology underpinning economic competitiveness and critical infrastructures, and one which can also impact the functioning of democratic societies,

AI is set to play a pivotal role in determining Europe's ability to safeguard its strategic autonomy. Control over the core parts of AI value chains and the ability to shape their future development trajectories is currently concentrated outside Europe, notably in the US and China (European Commission, 2025a). Europe currently accounts for only around 5% of global AI compute capacity, leaving it heavily dependent on foreign infrastructures and proprietary systems (Dealroom, 2025). Furthermore, as of April 2025, the US accounts for roughly 75% of global AI supercomputing power, followed by China at around 15%. Industry dominance is also accelerating, with AI supercomputers in the private sector now outpacing those in academia and government (Pilz *et al.*, 2025).

In addition, 90% of global data centres are outside EU jurisdiction, further limiting Europe's ability to develop sovereign AI systems (European Commission, 2025a). This raises significant concerns about the risk of increasing structural dependencies on external providers, which limits Europe's ability to influence how AI technologies are designed, governed and deployed (European Commission, 2025a).

2. Despite its strengths, Europe lags behind in the global AI landscape

The global AI ecosystem

Investments[4] in AI have accelerated substantially since the early 2010s and experienced a major surge from 2020 onwards. Global private investments in AI started to increase significantly after 2014, with a marked acceleration between 2017 and 2018 (Figure 7-1). After a moderate decline in 2022, investments directed to AI companies[5] continued to climb, exceeding USD 190 billion in 2025. Furthermore, private AI investment accounts for around 73% of total AI spending in the EU and is mostly allocated to skills development (about 41%), followed by data and equipment (37%). R&D represents only around 13% and other intellectual property products less than 10% (Fonteneau *et al.*, 2025)[6].

This global trend is overwhelmingly driven by the US. Between 2010 and 2025, the US accounted for the largest share of global investment in AI startups, which corresponded to around 80% of global AI investment in 2025[7]. Other important players such as the EU, China, and the UK experienced flat private investment trajectories and minor fluctuations over the same period (Figure 7-1). In particular, AI investment

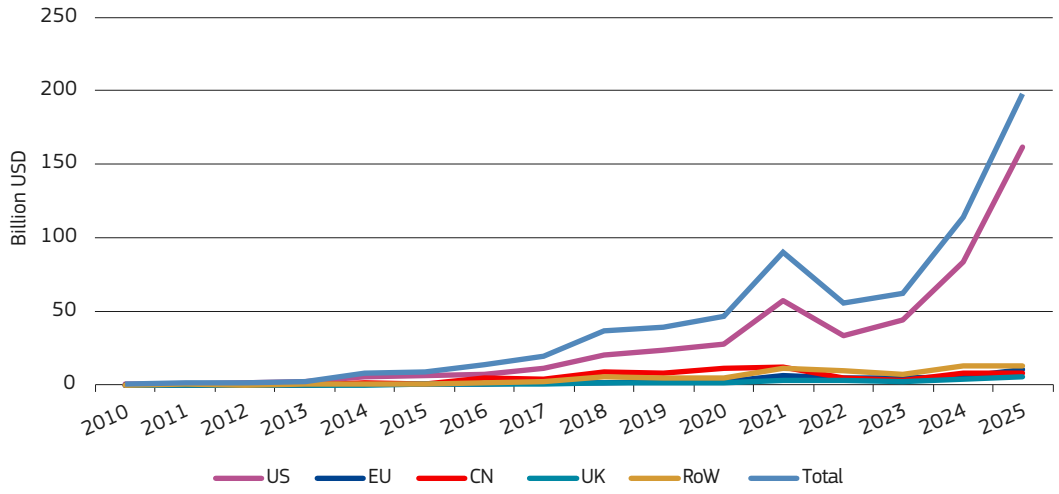
4 Data on investments is calculated considering the following rounds: pre-seed, seed, angel, Series A, equity crowdfunding, Series B, Series C, corporate round, Series D, Series E, Series F, Series G, Series H, Series I and Series J. Additionally, grants and convertible notes for companies were also factored in if, at the time of announcement, the companies did not exit through initial public offering.

5 Companies that operate in industries related to 'Artificial Intelligence', 'Generative AI', 'Intelligent Systems', 'Machine Learning' and 'Natural Language Processing' according to the Crunchbase database.

6 The estimates are based on a top-down macroeconomic approach that combines aggregate investment data from sources such as Eurostat and EUKLEMS with 'AI intensity coefficients' derived from proxies like patent data, education statistics, and AI-related academic programmes. These coefficients are used as multipliers to estimate the share of total investment attributable to AI, allowing for an approximation of AI-specific investment in the absence of direct firm-level data (Fonteneau *et al.*, 2025).

7 CEPS and AI World (https://aiworld.eu/) based on Crunchbase as of 1 January 2026.

Figure 7-1 Global trend in private investment in AI, by geographic region, 2010–2025



Science, Research and Innovation Performance of the EU 2026

Source: CEPS and AI World (https://aiworld.eu/) based on Crunchbase (2026; as of 1 January).

Note: Companies are geo-localised based on headquarter locations.

in the EU amounted to around USD 10 billion in 2025, around 5% of global AI investment[8].

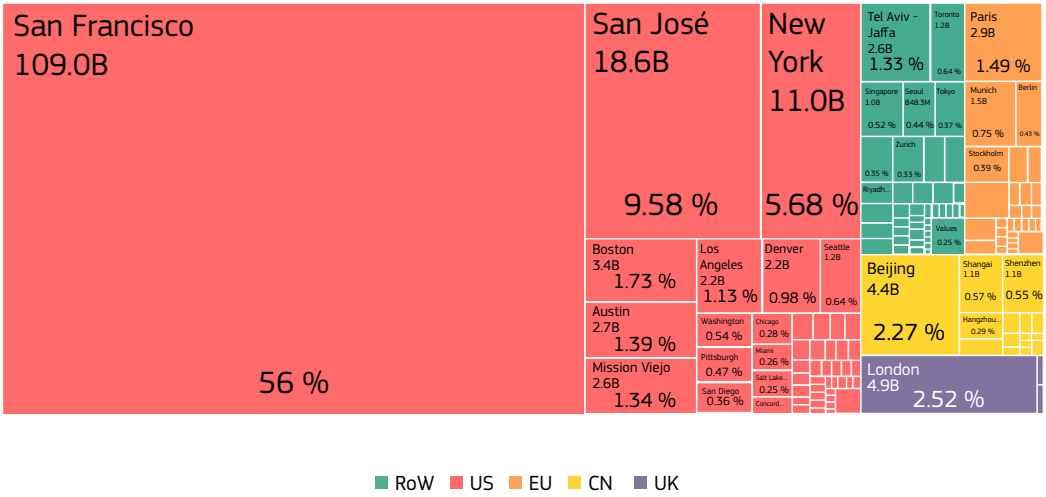
AI technologies require substantial capital injection to sustain the high computational costs of training large models, the need for specialised talent and the demands of scaling infrastructure. This translates into venture capital (VC) activities increasingly characterised by so-called mega rounds, i.e. funding rounds exceeding EUR 100 million. This further strengthens the US lead, whose VC market can easily accommodate rounds of such a size. On the contrary, China remains active, albeit with more moderate deal sizes[9], while the EU exhibits fewer such transactions and smaller average amounts (StepUp StartUps, 2025).

Private AI funding is heavily concentrated in a small number of US metropolitan areas. San Francisco reported investments of over USD 100 billion in 2025, accounting for 56% of all global AI investment (Figure 7-2). San Jose added another USD 18.6 billion (9.6%), further confirming Silicon Valley's status as the world's central hub for AI capital. Outside the US, leading hubs, such as London, Paris, Berlin, Tel Aviv–Jaffa, and Beijing attract significantly smaller investment volumes, capturing relatively modest shares (typically below 3%) (Figure 7-2).

8 CEPS and AI World (https://aiworld.eu/) based on Crunchbase as of 1 January 2026.

9 Although looking at just private investment figures likely understates China's total AI spending, given its government guidance funds (AI Index report, 2026).

Figure 7-2 Top 50 AI hubs in terms of private investments, 2025



Science, Research and Innovation Performance of the EU 2026

Source: CEPS and AI World (https://aiworld.eu/) based on Crunchbase (2026; as of 1 January).

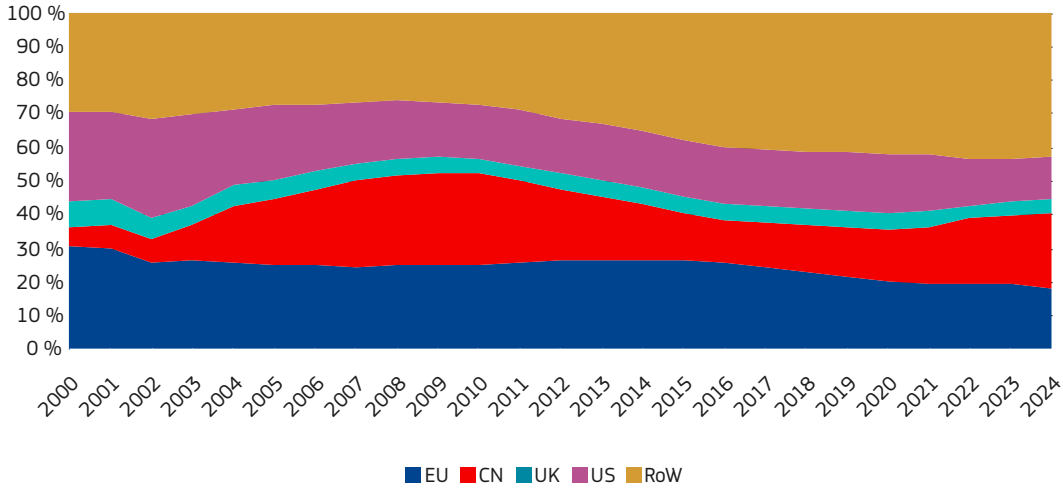
Note: The tree map illustrates the geographic distribution of private AI investment both in absolute and relative terms. The larger the rectangles, the greater the volume of capital attracted by the corresponding urban area. Companies are geo-localised based on headquarter location.

Despite lagging significantly behind the US, the potential of the European AI ecosystem is improving rapidly. In the EU, there are more than 4 100 venture capital-backed startups operating in the sectors covered by the *Apply AI Strategy* (see section 4). These companies account for around 6 % of all VC-backed companies across the EU, and their enterprise value has experienced a 16-fold increase over the past decade, reaching EUR 161 billion (Dealroom, 2025).

Furthermore, the EU's position remains strong in terms of scientific output related to the development of AI technologies (see chapter 3.1). Between 2000 and 2024, the EU's share of scientific publications in the field of AI development experienced a moderate decline, although remaining comparable with and even higher than that of the US (Figure 7-3). On the other hand, China exhibited a sharp increase starting from the mid-2000s, ranking first in 2024 with a share of 23 %, against the 18 % and 13 % of the EU and the US, respectively.

A closer look at the top 50 global scientific hubs further confirms that Europe remains on a par with its major competitors in the AI research domain. East Asia, particularly China and Japan, is home to the largest AI scientific hubs in terms of total publication output. Nevertheless, important European cities report performance comparable to that of their Asian and US peers, with Paris standing out as one of the strongest research hubs globally, second only to Beijing (Figure 7-4). This highlights that although the EU is struggling to match the private investment performance of its main competitors, its AI scientific system remains globally competitive.

Figure 7-3 Global share of scientific publications in AI, 2000–2024

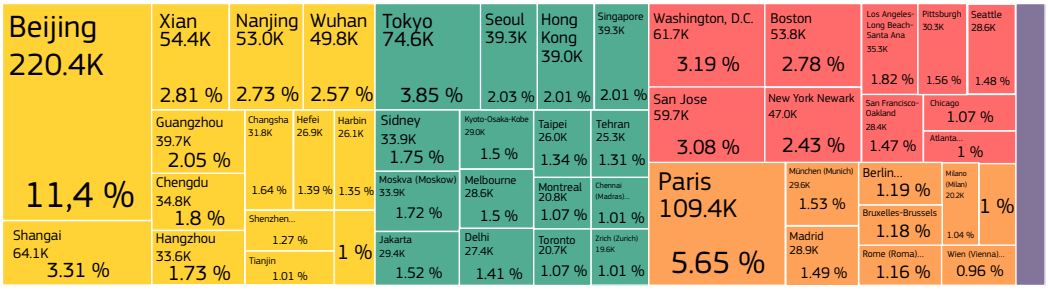


Science, Research and Innovation Performance of the EU 2026

Source: CEPS and AI World (https://aiworld.eu/) based on OpenAlex (2025; as of May).

Note: Full counting method. Publication metadata in OpenAlex are subject to indexing delays, and it may take until the middle of the following year to fully capture a given year's publications. As a result, data for the most recent year may be incomplete.

Figure 7-4 Top 50 global scientific hubs, 2000–2025



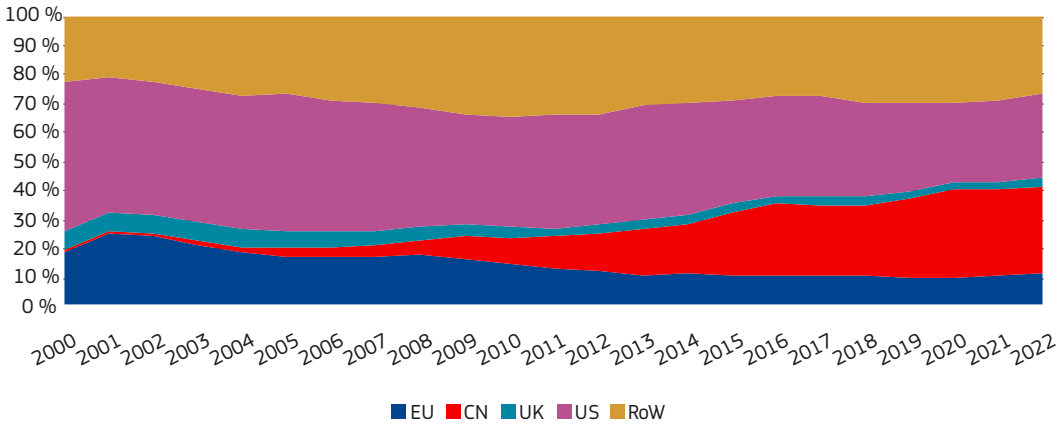
Science, Research and Innovation Performance of the EU 2026

Source: CEPS and AI World (https://aiworld.eu/) based on OpenAlex (2025; as of May).

Note: Absolute numbers refer to scientific publications. The percentages refer to each city's share of the total of the top 50 hubs only.

However, Europe continues to struggle to translate its scientific knowledge into innovation (see chapter 4.2). When looking at patent activity in AI, there exists a persistent gap between the EU and its global peers, with the US and China together accounting for the vast majority of global patent filings in the field (Figure 7-5). China, in particular, experienced a rapid increase in AI patent applications from the mid-2000s onwards and accounted for about 30% of global patent activity in 2022. This increase occurred mostly at the expense of the US, whose share decreased from more than 50% in 2000 to around 29% in 2022. The EU's share declined steadily from around 20% of global patent applications in 2000 to 12% in 2022 (Figure 7-5).

Figure 7-5 Global share of AI patent applications filed under PCT, 2000–2022



Science, Research and Innovation Performance of the EU 2026

Source: CEPS and AI World (https://aiworld.eu/) based on OECD REGPAT (May 2025 release).

Note: Patent Cooperation Treaty (PCT) patents, full counting method, inventor's country of residence and priority date used.

How AI models are developing

AI model development is evolving at an unprecedented pace and is increasingly industry-driven. Until 2014, academia led the way as regards the release of machine learning models. Since then, AI models originating from industry have taken the lead, steadily increasing over the past decade. In 2024, industry produced around 90% of the most influential models within the AI/machine learning ecosystem. In this regard, US Big Techs hold leading positions in terms of capabilities, with Google, OpenAI and Anthropic being close to each other in terms of performance[10]. In addition, model training compute, dataset size, and parameter scale continue to expand (Maslej *et al.*, 2025).

Against this backdrop of increasing industry dominance, the fast growth of open-source AI models deserves attention. AI models are released under various access types, each with varying levels of openness and usability. Understanding how open models perform relative to closed models (whose details remain proprietary) is crucial, as openness makes the software free and creates competitive pressure[11] within the market, thereby contributing to lowering

10 https://artificialanalysis.ai/evaluations/artificial-analysis-intelligence-index

11 https://newsletter.semianalysis.com/p/google-we-have-no-moat-and-neither

inference prices, reducing market concentration, and enhancing access to AI capabilities (Nagle and Yue, 2025).

Open-source LLMs are experiencing an extraordinary boom[12]. In this area, NVIDIA has emerged as the leader, topping open-source AI repository contributions in 2025[13]. China has also shown significantly high performance, with Chinese-developed models accounting for over 45 % of total downloads in 2025[14]. Conversely, only a few European firms are gaining traction in the open-source space. These include Mistral AI, with its open models like Magistral, and Stability AI, with its image generating models[15].

In the AI open-model ecosystem models, developers, and countries compete for adoption and influence. Over the last few years, the open AI ecosystem has experienced a non-linear evolution, alternating phases of democratisation and consolidation. Between 2021 and 2024, the dominant position of big US tech firms (Google, Meta, OpenAI) declined, while unaffiliated developers and online communities began to play an ever-increasing role in the AI development landscape. When models become widely available, innovation shifts from centralised labs to distributed communities, making core capabilities more accessible and enabling a broader set of actors to build on top of them (Longpre *et al.*, 2025).

Furthermore, during 2024 and 2025, AI development has become increasingly distributed across multiple linguistic communities. English still dominates in overall model presence, followed by Chinese, French, Spanish, and German. However, these widely used languages are expanding at slower rates than several emerging ones; the fastest year-over-year growth is occurring in Ukrainian, Swedish, Arabic and Turkish. This contributes to a more diverse multilingual open-source AI ecosystem and reflects broader global participation in model creation and training[16].

Nevertheless, commoditisation does not eliminate concentration. Signs of re-concentration began to reemerge by 2025, led by new actors, particularly Chinese companies like DeepSeek and Qwen. Furthermore, participation is still constrained by compute and expertise, indicating while commoditisation can expand access, it does not eliminate inequality (Longpre *et al.*, 2025).

Although openness can generate substantial benefits, risks remain. These largely stem from users being able to tweak (and manipulate) model weights and instructions more easily, and are linked to malicious use (e.g. cyberattacks, deepfakes, harmful content), privacy breaches, intellectual property violations, as well as difficulties in monitoring or retracting models once released. The existence of these competing effects calls for context-specific, marginal risk-benefit assessments that compare different degrees of openness, while avoiding the adoption of a one-size-fits-all approach (OECD, 2025).

12 https://aiworld.eu/story/hugging-faces-two-million-models-and-counting

13 https://aiworld.eu/story/nvidia-leads-open-source-ai-momentum-as-chinese-labs-close-in

14 https://aiworld.eu/story/chinese-developers-account-for-over-45-of-top-open-model-public-downloads

15 https://aiworld.eu/story/nvidia-leads-open-source-ai-momentum-as-chinese-labs-close-in

16 https://aiworld.eu/story/the-growing-number-of-non-english-models

EU innovation capacity in AI

Innovation capacity in the field of AI in Europe is concentrated in only a few regions. These are Inner London, Île-the-France (region of Paris), Noord-Brabant (region of Eindhoven) and Oberbayern (region of Munich), which together accounted for more than 25 % of total AI patent applications in the EU by 2024 (European Commission, 2025a).

These hubs remain poorly connected across borders, thereby limiting the EU's ability to generate the large-scale AI innovations that are needed to be globally competitive. Most AI patent collaborations in the EU occur within the same country, and existing hubs tend to collaborate more with neighbouring domestic regions than with other leading European centres (European Commission, 2025a). Although cross-border linkages are present, they are still quite limited. This fragmentation reflects a broader pattern in the European R&I ecosystem (see chapter 6.2), where innovation policies are still largely determined at national level. This calls for increasing efforts to strengthen inter-hub connectivity within the EU and to translate the EU's scientific strength into competitive, world-class AI innovations (European Commission, 2025a).

The EU can also count on a highly educated workforce and top AI researchers, but it continues to experience significant brain drain. At undergraduate level, Europe's performance is on a par with that of the US, but around 14 % of European-trained students in the field of AI move to the US to continue their studies after obtaining their bachelor's degrees (European Commission, 2025a). This trend becomes even more pronounced when researchers enter the job market, as European AI researchers are more likely to remain in the US than to return to Europe[17]. This makes the US a primary beneficiary of global AI talent. More in detail, the US is home to around 60 % of the world's leading AI institutions and continues to be the most attractive destination for the top 2 % of global AI talent[18].

Talent mobility is not limited to cross-border flows but extends to cross-sector transition. AI research has traditionally taken place across both academia and industry. Nevertheless, its influence on the latter has surged, and there has been a significant movement of top-class AI researchers from academia to industry over the last decade, particularly towards major technology firms, with potential implications for the direction and nature of frontier research (Jurowetzki *et al.*, 2025).

The brain drain problem is further exacerbated by the difficulties Europe experiences in preparing its workers for AI-driven transformations within the economy. The rapid and pervasive diffusion of AI is reshaping the labour market, which is increasingly characterised by a rising demand for analytical, social, and domain-specific skills (European Commission, 2025a). This calls for increased efforts to modernise Europe's education and training systems by leveraging digital tools, AI-enabled personalised learning and technologies like augmented reality, virtual reality and gamification. These technologies can play a central role in better aligning European education systems with the demands of a fast-changing labour market, thereby helping build a more adaptive, AI-ready skills ecosystem (European Commission, 2025a).

17 The Global AI Tracker 2.0.

18 https://archivemacropolo.org/interactive/digital-projects/the-global-ai-talent-tracker/

3. The diffusion and adoption of AI in science have important implications for knowledge creation

Over the past century, scientific advances have been a key engine for economic growth and societal well-being. Scientific innovation continues to play a key role in addressing global challenges and fostering economic growth and social progress (European Commission, 2024). The discovery of new ideas, whether in the form of improved production techniques, innovative products, or more efficient organisational methods, increases and improves the ways in which existing physical resources can be combined into more valuable goods and services, thereby enhancing economies and societies' growth potential (Romer, 1993).

However, the lower productivity growth rates observed in recent decades have also been accompanied by a considerable slowdown in the pace of transformative scientific discoveries and technological breakthroughs. The ICT revolution contributed to making knowledge more accessible and automatable (King *et al.*, 2009). Automation in science makes it possible to increase efficiency, reduce errors and open new areas of research that were previously out of reach because they were too large or complex for scientists to address on their own (Waltz and Buchanan, 2009). The diffusion of digital tools has enhanced scientists' ability to process and analyse increasing amounts of data (European Commission, 2024). Nevertheless, despite these advances, the productivity of scientific research has been decreasing over time (Aghion *et al.*, 2021), while new scientific and technological ideas are becoming less disruptive (Park *et al.*, 2023).

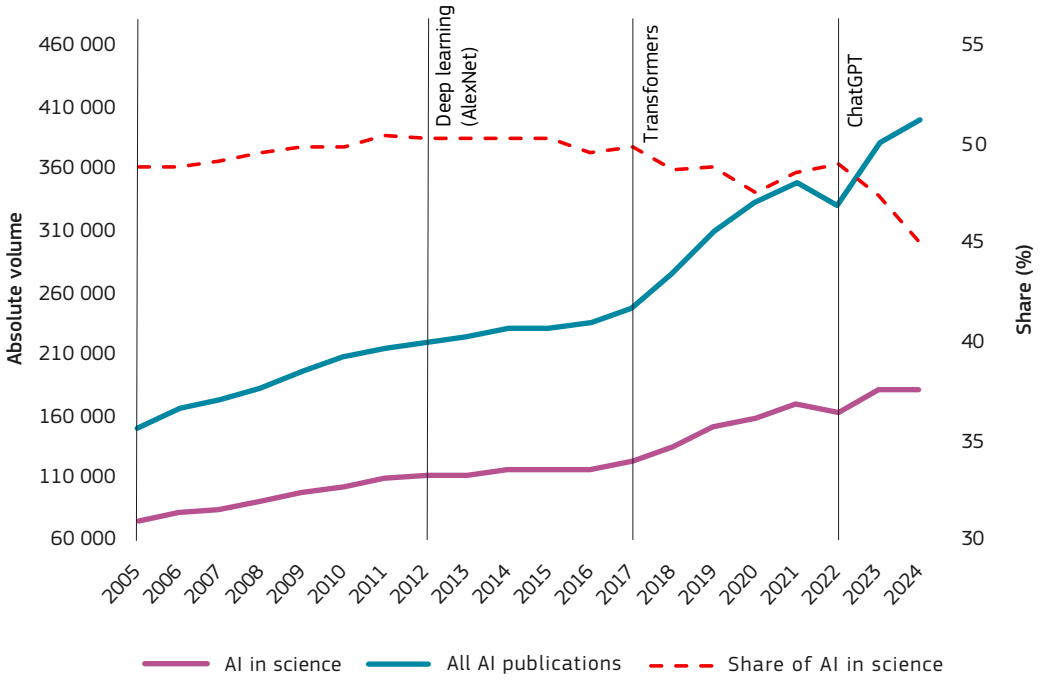
The fast and widespread penetration of AI tools in scientific activities is pushing back the frontiers of the digital revolution and reshaping the way research is conducted. AI systems, especially those powered by machine learning and large-scale data processing, are important tools that enable machines to perform cognitive functions such as learning, reasoning, and even creativity (Bianchini *et al.*, 2026). In this regard, AI represents an extremely powerful and versatile research tool with great potential for discovery as it can act as a new 'general method of invention' (Bianchini *et al.*, 2022) that can influence knowledge creation in several ways, from increasing analysis capabilities and helping identify unexpected regularities in experiments or scientific literature, to supporting scientific activities through task automation and enhanced efficiency (Bianchini *et al.*, 2026).

The number of scientific publications adopting AI tools[19] has significantly increased over recent decades. It went from more than 70 000 in 2005 to almost 180 000 in 2024 (Figure 7-6). The growth was gradual until 2012, when deep neural networks began outperforming machine learning methods, leading to an initial acceleration in the volume of both total AI scientific output and AI-related scientific papers. This increase was then followed by a further rise after the introduction of transformers in 2017 and an additional significant acceleration from 2022, the year of the release of ChatGPT (Figure 7-6). By 2024, scientific activities applying AI technologies accounted for 45 % of total AI publications[20].

19 A paper is considered to be employing/adopting AI when it is co-classified under a specific application domain (e.g., cancer research) and at least one of AI OpenAlex concepts. For example, an article tagged both as Oncology and Machine Learning counts as AI adoption in cancer research.

20 DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on OpenAlex as of November 2025.

Figure 7-6 Trends in the adoption of AI in science, 2005–2024



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on OpenAlex (2025; as of November).

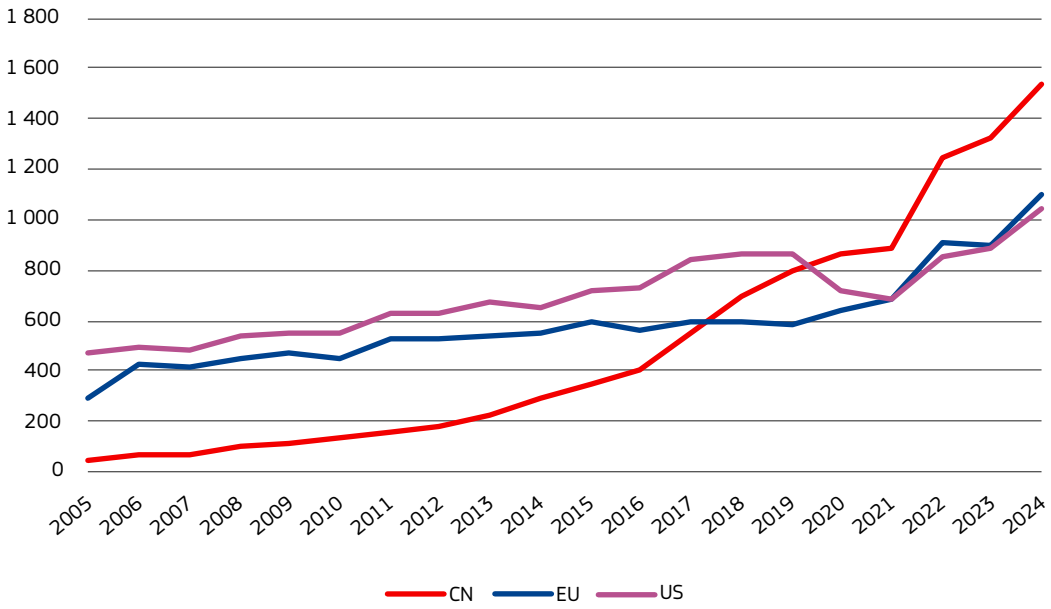
Note: The solid blue and purple lines (left axis) measure all AI scientific publications and the volume of scientific publications applying AI tools, respectively, whereas the red dashed line (right axis) captures the relative share of AI-related papers in total AI publications. Furthermore, publication metadata in OpenAlex are subject to indexing delays, and it may take until the middle of the following year to fully capture a given year's publications. As a result, data for the most recent year may be incomplete.

At geographical level, China is the standout performance over the last decade. After a decline between 2010 and 2016, the number of Chinese scientific publications using AI tools accelerated considerably, positioning China ahead of both the EU and the US. The EU reported a continuously steady upward trend between 2005 and 2024, maintaining its position ahead of the US over most of the period, though all regions have experienced a small decline in the last few years[21].

China also leads with regard to the quality of publications. The distribution of the top 1% most-cited AI-related publications reveals a marked shift in research leadership among major regions. While both the EU and the US saw a steady increase over the period 2005-2024, China experienced a sharp and significant acceleration in the production of high-quality AI-related scientific output after 2013 (Figure 7-7). The country was thus able to overtake both the EU and the US between 2017 and 2019, remaining in the lead thereafter.

21 OpenAlex as of November 2025. Please note that publication metadata in OpenAlex are subject to indexing delays, and it may take until the middle of the following year to fully capture a given year's publications. As a result, data for the most recent year may be incomplete.

Figure 7-7 Volume of top 1 % most-cited AI-using scientific publications in the EU, the US and China, 2005–2024



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on OpenAlex (2025; as of November).

Note: Publication metadata in OpenAlex are subject to indexing delays, and it may take until the middle of the following year to fully capture a given year's publications. As a result, data for the most recent year may be incomplete.

The integration of AI into science has important implications for the novelty of scientific research. Scientific output applying AI tools tends to be semantically more distant[22] from prior work, and therefore conceptually more original (Figure 7-8, Panel A). However, when novelty is measured through linguistic innovation (as measured by indicators capturing the introduction of new words[23], new word combinations[24], or new phrases[25]), the effects are mixed (Bianchini *et al.*, 2026).

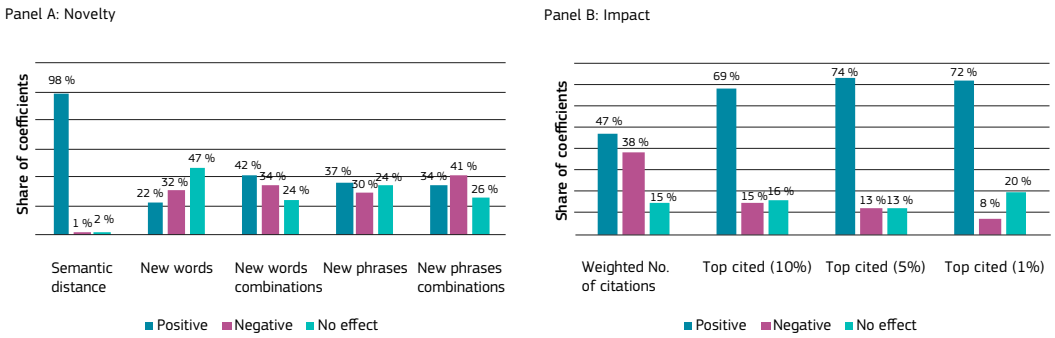
22 Semantic distance is calculated as 1 minus the maximum cosine similarity between the focal paper and all papers published in the previous five years, providing a measure of how semantically different the focal paper is from prior work (Bianchini *et al.*, 2026).

23 Measured by a binary variable equal to 1 if the focal paper introduces at least one new unigram (single word) in its title or abstract, and that word is subsequently reused in at least one other paper (Bianchini *et al.*, 2026).

24 Measured by a binary variable equal to 1 if the focal paper introduces at least one novel pair of words (used together), and that pair is reused in at least one subsequent paper. The individual words themselves do not need to be new.

25 Proxied by a binary variable equal to 1 if the focal paper introduces at least one new noun phrase in its title or abstract, and that phrase is subsequently reused in at least one other paper. Noun phrases consist of one or more words with a noun as their head (e.g., 'polymerase chain reaction') (Bianchini *et al.*, 2026).

Figure 7-8 The relationship between AI and scientific novelty and impact



Science, Research and Innovation Performance of the EU 2026

Source: Bianchini *et al.* (2026).

Note: Panel A shows the share of positive, negative and non-significant coefficients for novelty indicators. Panel B shows the corresponding shares for impact indicators.

A clearer pattern emerges when focusing on scientific impact. A clear positive association is observed between the use of AI and the production of highly influential work, with AI-related papers being substantially more likely to appear among the most-cited publications, particularly within the top 5% and top 1% (Figure 7-8, Panel B).

However, the benefits of AI for scientific creativity are not evenly distributed across geographical areas. The contribution of AI to scientific outcome appears strongest in China, while the EU and the US exhibit similar trends (Bianchini *et al.*, 2025a). This evidence suggests that China's massive investments in AI research and large-scale AI infrastructures have enabled the country not only to catch up in terms of scientific production but also to position itself as a global leader in terms of AI driven novelty and impact (Bianchini *et al.*, 2025a).

In addition, AI technologies powered by high-performance computing (HPC) are up to five times more likely to become highly cited, and much more likely to introduce genuinely new ideas (Bianchini *et al.*, 2025b). AI requires extremely powerful computers to analyse increasingly large amounts of data, and HPC systems provide the type of computational power required for training, testing, and running large-scale simulations. Therefore, combining AI with HPC is rapidly becoming one of the most powerful engines of modern scientific discovery, allowing scientists to make remarkable progress in several scientific disciplines, such as biology, materials science, and energy (Bianchini *et al.*, 2025b).

Nevertheless, access to these technologies and infrastructures is increasingly unequal. Supercomputing capacity and AI-specific computing infrastructures are highly concentrated, with both the US and China dominating the global landscape (Bianchini *et al.*, 2025b). This unequal distribution has important implications for scientific discovery as both AI and HPC are becoming key drivers of breakthrough science. As a result, the future of scientific innovation will likely depend not only on developing better quality algorithms and more powerful computers, but also on ensuring broader and fair access to these technologies (Bianchini *et al.*, 2025b).

The creative potential of AI in science also hinges on the breadth and depth of its adoption within each field. Scientific disciplines characterised by higher levels of AI penetration tend to generate more novel research outputs, suggesting that the key role of AI as a catalyst for scientific creativity is enhanced when AI-usage reaches a critical mass within a discipline (Bianchini *et al.*, 2026).

Furthermore, the strength of AI's contribution to scientific novelty and impact varies with both the topology of the knowledge space underpinning a field and the degree of AI penetration within it. Specifically, the effect is particularly pronounced in fields characterised by a more complex and fragmented knowledge structure, i.e. research disciplines relying on different areas of expertise. This suggests that AI holds the potential to act as a tool for cognitive integration, helping scientists and researchers integrate diverse information sources and identify patterns across vast sets of research areas, thereby uncovering novel insights. Also, the greater the extent of AI exposure (how deeply AI has become embedded in research practices), the stronger its association with novelty and impact (Bianchini *et al.*, 2026).

Notwithstanding the important benefits from the uptake of AI in science, several concerns remain. AI models, especially deep neural networks, continue to suffer from an opacity problem that makes the interpretability and reliability of their outputs more challenging (Rudin, 2019). This issue is further compounded by the risk of training data being incomplete and biased, which can lead to the generation of misleading or distorted scientific inferences (Budach *et al.*, 2022).

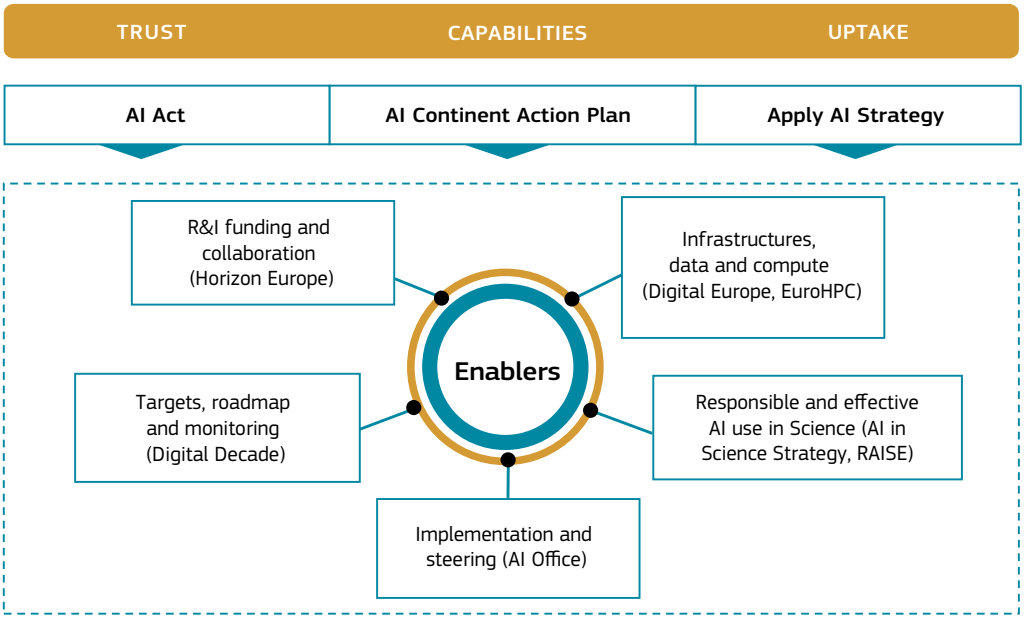
Questions also remain about the scientific validity and acceptance of AI-generated results. AI-generated scientific results are often regarded as lacking theoretical grounding and relying on correlations rather than causal explanations (Bianchini *et al.*, 2026). Furthermore, the emergence of LLMs and GenAI introduces further risks, including artificial hallucinations, factual inaccuracies, bias, plagiarism, and declining research rigour (Athalauri *et al.*, 2023; Beutel *et al.*, 2023). Beyond issues of accuracy and integrity, there are also deeper epistemic concerns: AI systems may produce predictions or classifications that are operationally useful yet opaque to researchers, potentially weakening scientific understanding (Messeri and Crockett, 2024). Taken together, these concerns cast doubt on and lead to scepticism about the ultimate impact that the adoption of AI tools can have on the creativity and quality of the scientific process they are called to support. This indicates that while AI can bring clear benefits to the scientific process by enhancing efficiency and analytical capacity, its adoption and deployment need to prioritise transparency and rigorous adherence to scientific principles[26].

26 https://research-and-innovation.ec.europa.eu/document/2b6cf7e5-36ac-41cb-aab5-0d32050143dc_en

4. Ensuring trust, capabilities and uptake for EU AI and R&I

AI's growing impact on productivity, scientific discovery and the innovation landscape has made it a key strategic priority for EU policy. The EU seeks to shape how AI contributes to scientific excellence, innovation performance and long-term competitiveness, while safeguarding fundamental rights. Its approach combines capabilities, trust and uptake, reflecting the need to mobilise a coherent policy mix that spans regulation, infrastructure, R&I support, capability building, skills, diffusion and deployment. EU policymaking for AI has evolved through three phases: exploration, transition and maturation (Rodriguez Müller *et al.*, 2026). The exploration and transition phases laid the foundations for the EU's current AI policy framework. They defined the principles of trustworthy and human-centric AI, strengthened coordination with Member States, and progressively translated policy ambitions into regulatory and support measures. This prepared the ground for the maturation phase, in which the EU approach has become more consolidated and operational, centred on the *AI Act*[27], the *AI Continent Action Plan* and the *Apply AI Strategy* (Figure 7-9).

Figure 7-9 AI, R&I and main EU policy building blocks



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit.

27 Regulation (EU) 2024/1689.

Trust is the starting point for responsible AI development and adoption. The *AI Act* provides legal certainty for the development and use of AI, in a context where uncertainty regarding acceptable uses, responsibilities and risks associated with AI can slow experimentation and uptake, particularly where transparency and credibility are central. From an R&I policy perspective, governance frameworks therefore play a critical role in providing predictable conditions for the responsible development and use of AI. Within the EU policy mix, the *AI Act* establishes a risk-based legal framework that differentiates obligations according to the level and nature of risk posed by AI systems, thereby providing greater legal clarity and predictability for developers and users across use cases[28]. Provisions on transparency, documentation and human oversight for high-risk AI systems are particularly relevant in R&I contexts where AI outputs may influence scientific results or inform consequential decisions. The *AI Act* also helps reduce regulatory fragmentation and supports the emergence of a single market for AI systems and general-purpose AI models (Rodriguez Müller *et al.*, 2026).

Building on this foundation of trust, the EU approach also focuses on strengthening the capabilities needed for AI excellence. The *AI Continent Action Plan*[29] articulates a coordinated ambition to strengthen the EU's position in AI across the full AI value chain, including regulation and simplification, large-scale computing infrastructure, access to high-quality data, support for AI innovation and adoption in strategic sectors[30], and AI skills and talent. This is particularly important for R&I because access to advanced compute, high-quality data and experimentation environments increasingly shapes who can develop, test and apply frontier AI systems. The Plan supports this through initiatives such as AI Factories and Gigafactories, Data Labs, the AI Skills Academy, and the transformation of European Digital Innovation Hubs into Experience Centres for AI. Programmes such as Digital Europe[31] and EuroHPC[32] help operationalise these capabilities by supporting AI infrastructures, common data spaces, testing and experimentation facilities, and high-performance and AI-optimised computing. It is also closely linked to dedicated efforts to support AI adoption and AI in science, which are addressed respectively through the *Apply AI Strategy* and the *European Strategy for AI in Science*.

These capabilities need to translate into wider uptake if AI is to support productivity and competitiveness. The *Apply AI Strategy* seeks to accelerate the uptake of AI across industry and the public sector, reinforcing an 'AI first' mindset that spans economic and scientific domains[33]. From an R&I perspective this is key, as the economic and scientific benefits of AI depend not only on frontier capabilities, but also on their diffusion across firms, sectors and public institutions. The *Apply AI Strategy* also introduces governance and monitoring mechanisms, such as the AI Observatory, the Apply AI Alliance and coordination through the AI Board, to track uptake, identify emerging use cases and support implementation across Member States and sectors. The implementation of the *AI Continent Action Plan* and the Apply *AI Strategy* is led by the EU AI Office, the centre of AI expertise across the European Commission and the EU, which promotes the development and deployment of AI solutions that benefit society and the economy[34].

28 https://digital-strategy.ec.europa.eu/en/policies/regulatory-framework-ai
29 https://digital-strategy.ec.europa.eu/en/library/ai-continent-action-plan
30 These include health and life sciences, technology and digital, environment and sustainability, education and culture, manufacturing and engineering, etc.
31 Regulation EU 2021/694.
32 Council Regulation EU 2021/1173.
33 https://digital-strategy.ec.europa.eu/en/policies/apply-ai
34 https://digital-strategy.ec.europa.eu/en/policies/ai-office

Box 7-1 The need for future-oriented AI policy[35]

AI is a field experiencing incredibly fast growth, making it challenging to monitor and assess the emerging instruments and adoption. This fast-moving field calls for forward-looking approaches to anticipate possible futures. The foresight study '*Futures of AI: Implications for Europe's R&I Ecosystem and EU Policy*' explores plausible trajectories of AI development and assesses their implications for Europe's R&I ecosystem.

AI development is characterised by uncertainty, path dependencies and competing trajectories rather than a single predictable pathway. Future adoption trajectories diverge across sectoral profiles, ranging from deep integration in innovation-led sectors to incremental optimisation in operational sectors. Market fragmentation, the dominance of SMEs with limited resources, insufficient access to high-quality and interoperable data, and shortages of skilled professionals are identified as today's barriers, while investment levels remain fragmented and comparatively modest.

Three overarching areas for promoting a future-oriented, anticipatory governance in the EU can be identified:

- **Strengthening anticipatory governance capacities to navigate persistent uncertainty.** By embedding technology monitoring and foresight tools in policymaking, the EU can develop a flexible institutional mechanism capable of responding to rapid technological change.
- **Enhancing European competitiveness through broader and deeper AI adoption across sectors.** This requires strengthening digital, data and computing infrastructures as foundational enablers. Promoting sector-specific AI solutions tailored to European industrial strengths can accelerate responsible, AI-led innovation.
- **Shaping a distinct European pathway for AI that builds on trust, sustainability and public interest.** This includes investing in education and humanistic competencies, aligning AI with environmental goals, fostering innovation ecosystems and cultural engagement, strengthening technology diplomacy and supporting public-private collaboration within a European AI ecosystem across all Member States.

These areas emphasise the need to actively shape AI policy as a socio-technical field, adopting a future-oriented approach.

35 Based on Mehnert *et al.* (2026).

Delivering this policy mix also requires coordination across the wider digital transformation agenda. The *Digital Decade Policy Programme 2030* establishes a governance framework with common targets, national strategic roadmaps and an annual monitoring cycle to support coordination across Member States and EU institutions in areas relevant to AI-enabled R&I, including digital skills, infrastructure and technology uptake[36]. By providing a common set of targets and indicators, the *Digital Decade* enhances transparency and comparability across Member States in areas that underpin AI-related R&I capabilities.

Within this broader policy mix, Horizon Europe is a central lever for shaping both AI development and its use across R&I activities. It supports the full spectrum of AI-related R&I, from the advancement of core AI methods and capabilities to their application in scientific R&I-oriented projects across a wide range of domains. Through its support for collaborative research, research infrastructures, skills development and innovation-oriented actions, Horizon Europe enables AI to be addressed both as a research field and as an enabling technology for R&I in areas such as health, energy, mobility, manufacturing and public services. In doing so, the programme plays a key role in shaping the direction, scale and integration of AI-related R&I efforts in the EU, while providing a structured framework for translating research advances into broader innovation outcomes. Additionally, funding for AI deployment is mainstreamed across other programmes, such as the European Defence Fund and the Digital Europe Programme.

The integration of AI into scientific research raises specific challenges related to research practices, integrity and skills that require dedicated R&I policy steering. To address these issues, the *European AI in Science Strategy* sets out a coordinated approach to support the responsible and effective use of AI in science, taking into account scientific practice, skills and research culture (see box 7-2). At the heart of the strategy is RAISE, the Resource for AI Science in Europe, a virtual institute designed to pool and coordinate AI resources for science, including talent, compute, data and funding, and to strengthen Europe's capacity to develop AI and apply it to scientific research (European Commission, 2025b). In this way, AI-in-science actions aim to strengthen trust in AI-enabled scientific outputs by supporting robust methods, skills and responsible research practices.

36 https://digital-strategy.ec.europa.eu/en/policies/digital-decade-policy-programme

Box 7-2 A European strategy for AI in science

David Arranz (European Commission, DG Research & Innovation)

To maintain its leadership in science and benefit from the associated prosperity, the EU must capitalise on AI's potential to expedite discoveries and productivity gains. AI is changing the way in which science is done and opening up new opportunities to tackle complex problems (Purificato *et al.*, 2025). Europe can leverage its strengths, such as excellent scientific talent and research institutions, world-class research facilities, and its commitment to trustworthy AI that to develop superior scientific models.

In October 2025, the European Commission adopted the European Strategy for AI in Science[37], the main goal of which is to facilitate the adoption of AI in Europe as a tool in all different scientific disciplines. This will increase European scientists' productivity, accelerate scientific breakthroughs and contribute to the development of a more dynamic European AI ecosystem. It was adopted alongside the *Apply AI Strategy*, which focuses on deploying AI in key sectors. These efforts complement each other and contribute to the *AI Continent Action Plan*, all of which will help position the EU as a global leader in AI.

The private sector, and particularly AI leaders such as Google DeepMind, Microsoft, OpenAI and Mistral AI, is devoting significant resources to applying AI to scientific problems. Different countries are working on similar initiatives. In November 2025, the UK published its AI for Science Strategy[38] and the US launched the Genesis Mission[39], which is framed as a modern-day 'Manhattan project' for AI in science.

The European AI in Science Strategy targets four key areas with flagship actions designed to foster AI adoption among scientists:

- **excellence and talent**: measures to encourage global scientific talent to 'choose Europe', including EUR 58 million under the RAISE pilot for Networks of Excellence and Doctoral Networks.
- **compute**: EUR 600 million from Horizon Europe to enhance and expand access to computational power for science, including AI Gigafactories for EU researchers and startups.
- **research funding**: doubling Horizon Europe's annual investments in AI to over EUR 3 billion, with increased funding for AI in science.
- **data**: support for scientists in identifying strategic data gaps and integrating necessary datasets for AI research.

37 https://research-and-innovation.ec.europa.eu/strategy/strategy-research-and-innovation/our-digital-future/european-ai-science-strategy_en

38 https://www.gov.uk/government/publications/ai-for-science-strategy/ai-for-science-strategy

39 https://www.whitehouse.gov/presidential-actions/2025/11/launching-the-genesis-mission/

These areas are supported by collaboration across three dimensions: work with the private sector, coordination with Member States and R&I stakeholders under European Research Area activities, and engagement in international cooperation on AI in science.

A key instrument of the strategy is RAISE (Resource for AI Science in Europe), a 'Virtual Institute' designed to pool resources in talent, compute, data, and funding. RAISE aims to create a critical mass of European capabilities exceeding the reach of any single country. It will comprise two interconnected and mutually reinforcing dimensions: the development of AI and its applications in science. The scientific community will play a strong role in RAISE, which will be a talent magnet for global experts in AI and science.

The implementation of the strategy has begun. The 2025 AI in Science Summit[40], held as part of the Danish Presidency, served as the kick-off for various actions presented in the strategy, in particular the RAISE pilot activities. In 2026 and 2027, many of the actions announced in the strategy will be implemented and launched, paving the way to the next Framework Programme for R&I that will start in 2028.

40 https://ais25.eu/

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PART 2

CHAPTER 8

GOVERNMENT-FUNDED INNOVATION AND ECONOMIC GROWTH: EVIDENCE AND MEASUREMENT

Florence Benoit (European Commission), Paolo Surico (London Business School and the Centre for Economic Policy Research)

Innovation policy is increasingly expected to deliver more than scientific progress alone. It is now central to Europe's ambitions for stronger productivity growth, competitiveness, resilience, decarbonisation, health and security. Yet debates on innovation policy often swing between two misleading views: one sees innovation as mainly a private sector activity in which government plays only a limited supporting role; the other treats a small number of celebrated mission successes as evidence that the state is the principal driver of transformative innovation. The more useful question lies between these positions: when governments support innovation, which institutional arrangements are most likely to generate broad and lasting economic gains?

A central message of this chapter is that, in innovation policy, composition may matter as much as scale. The effects of public support depend not only on how much governments spend on R&D but also on where that support is directed, which institutions perform the research, how knowledge is owned and diffused and whether public investment stimulates further private innovation rather than displacing it. Public support for innovation is therefore not simply a budgetary input. It is a policy design choice that helps shape the wider innovation ecosystem and, through it, the long-term path of productivity and growth.

A useful starting point is the institutional blueprint that shaped the post-war US innovation system. At the end of the Second World War, President Franklin D. Roosevelt asked his science adviser, Vannevar Bush, to reflect on how the extraordinary wartime mobilisation of science could be translated into a peacetime research strategy for long-term national prosperity and security. In Science, the *Endless Frontier*, Bush (1945) argued that basic research is the pacemaker of technological progress and that its natural homes are universities, colleges and research institutes. He also set out a division of roles that remains highly relevant today: government should support fundamental research with uncertain private returns, while firms should translate knowledge into products, processes and commercial applications at scale.

Europe now faces its own strategic moment. As highlighted in the Draghi Report on the Future of European Competitiveness, closing the innovation gap relative to global leaders will require not only more investment but also more effective institutional arrangements for turning research strength into productivity growth and strategic capacity. The relevance of the US experience is therefore not that Europe should copy it mechanically; institutional settings differ, and the organisation of public research, finance and commercial scale-up varies across the EU and the UK. The value of the comparison lies instead in identifying mechanisms and design principles, i.e. how public funding, institutional capacity and private commercialisation interact and how those interactions shape the economic returns for innovation.

1. Funding and ownership as policy design choices

Public support to innovation is often discussed as a question of scale, but institutional design can be just as important. Two design dimensions are especially relevant for policy and are measurable in administrative data. The first is funding source: whether an invention was developed with government support or with private funding. The second is ownership: whether the resulting patent is privately owned or government owned. Ownership governs licensing, access and the practical ease with which other firms and sectors can build on an invention.

Combining funding source and ownership yields three categories of innovation that are useful for policy analysis. The first is government-funded but privately owned innovation, which often arises through grants and contracts funding research performed by universities, research institutes and firms, with intellectual property (IP) assigned to a non-federal entity. The second is privately funded and privately owned innovation. The third is government-funded and government-owned innovation, in which the government retains title.

The reason for separating these categories is not legal formalism. Diffusion and spillovers depend on who holds the rights to use and commercialise knowledge and on the incentives on offer to the organisations best positioned to turn discoveries into widely adopted technologies.

2. Evidence from the post-war US: the public origins of American innovation

Measurement and descriptive statistics

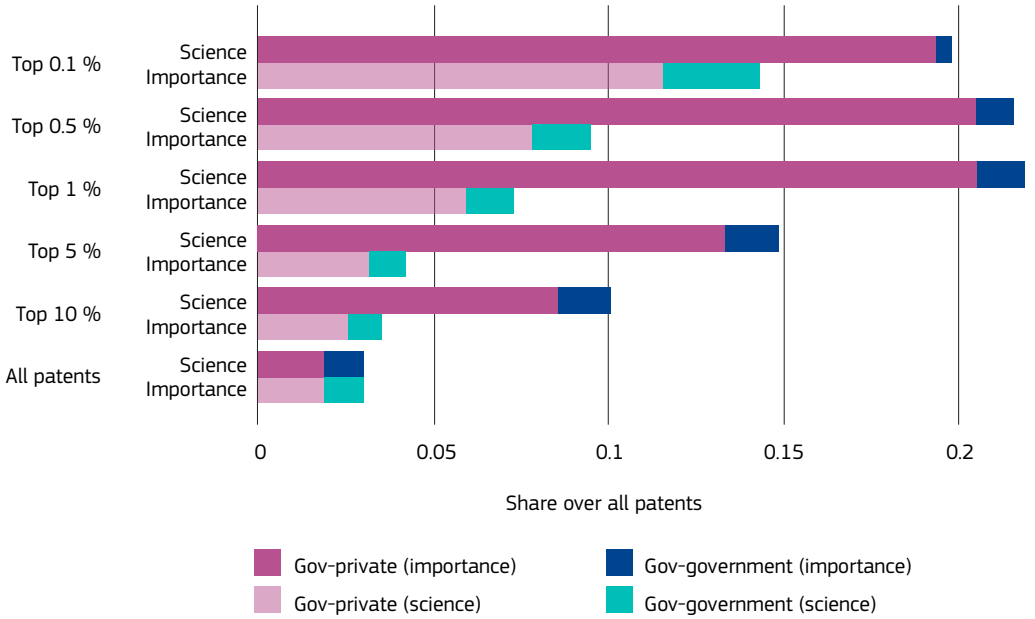
A recurring problem in evaluating public innovation policy is that inputs are easier to observe than outputs. Governments report R&D spending, programme budgets and procurement volumes, but it is harder to track, in the long term, which concrete inventions were supported, how they were owned and whether they were sufficiently widely diffused to affect productivity and living standards. Furthermore, private and public R&D expenditure data are published only at a relatively aggregate level, which typically does not make it possible to isolate the contribution of basic research or the role of non-profit organisations such as research institutes and universities or private companies such as startups and VC-backed firms.

New administrative data help address this observability problem. In *Where Do Technology Shocks Come From? Public Funding and Private Ownership*, Gazzani *et al.* (2026) address this gap by constructing long-term time series of US patents classified by both funding source and ownership, as well as type of research, research fields and organisation, using newly digitised administrative data. A key methodological contribution is to take account of administrative identification of government-funded patents rather than relying solely on text-based statements in patent documents, which can lead to underestimates of the extent of public involvement in earlier decades. Gross and Sampat (2025) introduce the Government Patent Register, a resource which identifies government-funded patents and distinguishes between cases where government has title and those where patents are assigned to private entities under government support.

Measured by counts, government-supported patents constitute a small fraction of total patenting. In the post-war data, privately funded and privately owned patents account for the vast majority of patents, while government-funded patents are split between those that are privately owned and those that are government owned. The policy implication is not that public funding dominates innovation in terms of volume but that its role is concentrated in particular kinds of innovation and particular institutional channels.

Volume shares can be misleading for two reasons: publicly funded patents are more science-intensive, and they are disproportionately represented among highly disruptive innovations (Figure 8-1), **especially in health and biotechnology.** This aligns with Bush's original rationale for public financing of basic research, namely that new products and processes are founded on new principles, and the institutions best suited to creating those principles are those able to pursue fundamental inquiry.

Figure 8-1 Patent importance and reliance on science



Science, Research and Innovation Performance of the EU 2026

Source: Gazzani *et al.*, 2026.

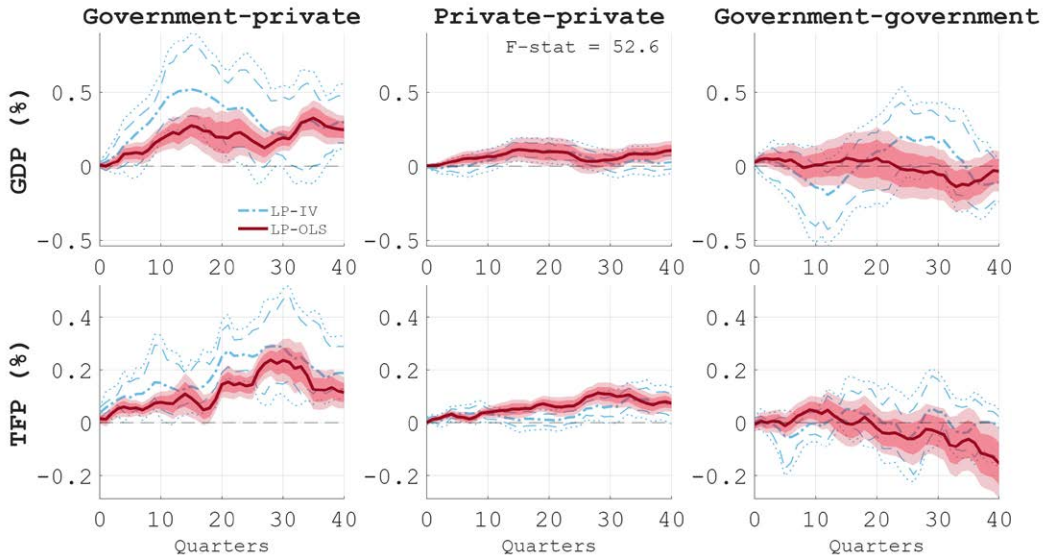
Note: The share of public interest patents for different levels of basicness is from Kelly *et al.* (2021). That of reliance on science, measured by the number of citations of scientific papers, is from Marx and Fuegi (2020, 2022). The bottom bar reports the unconditional share of public patents among total patents. Sample: quarterly data 1950 Q1–2015 Q4.

Medium-term macro effects on productivity and GDP

The macroeconomic signature of innovation depends strongly on funding source and ownership structure, the nature of research and the incentives on offer to the organisation (profits vs non-profits) delivering the innovation (Gazzani *et al.*, 2026). When the economy experiences an unexpected rise in government-funded but privately owned innovation, GDP and productivity rise gradually and persistently, with effects peaking years later (Figure 8-2). This delayed response is consistent with the time needed for diffusion, adoption and complementary private investments.

Privately funded innovation also contributes significantly to aggregate outcomes, but the average medium-term effects tend to be smaller in relative terms. Government-funded and government-owned patents display muted average effects, which mask very significant heterogeneity. The top 25% most disruptive publicly owned inventions have very large impacts, whereas the bottom 75% are, in some cases, even associated with slight declines in output and productivity. One possible policy-relevant interpretation is that public funding paired with private ownership is an effective channel for converting publicly supported knowledge into economy-wide gains through decentralised experimentation and scale-up.

Figure 8-2 Dynamic responses of GDP and total factor productivity (TFP) to innovation shocks, by funding source and ownership category



Science, Research and Innovation Performance of the EU 2026

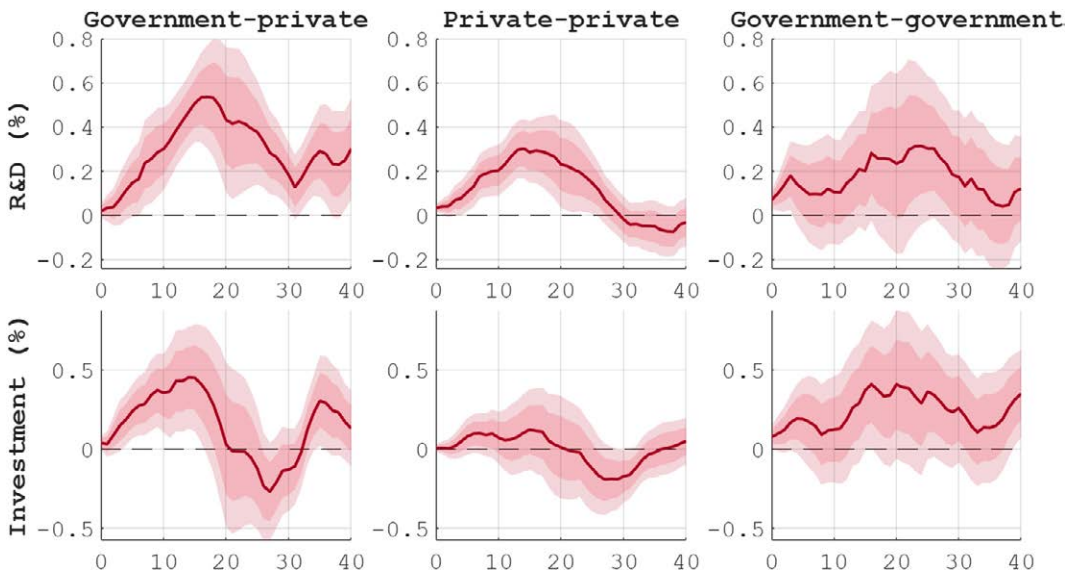
Source: Gazzani *et al.*, 2026.

Note: The figure displays the dynamic effects of innovation shocks in each category of patents (public-private, private-private, public-public; by column) on (log) real per-capita private GDP and (log) TFP. Red solid lines denote LP-OLS point estimates; red shaded areas report 68% and 90% confidence bands. Blue dash-dotted lines report the corresponding conditional LP-IV point estimates; blue dotted lines denote 90% confidence bands. See Gazzani *et al.*, (2026) for more details.

For policymakers, the crucial question is whether public support crowds in private activity and ultimately raises living standards. In the US evidence, government-funded but privately owned innovation is followed by large and sustained increases in business-sector R&D and private investment (Figure 8-3). The same innovation category is also associated with persistent increases in standards of living, as measured, for instance, by real wages and real consumption. These patterns are consistent with complementarity rather than substitution. Public support appears to create knowledge that raises private sector returns on investment and innovation, leading to follow-on private effort and broader diffusion of benefits. By contrast, the spillovers from purely private innovation to investment are smaller on average, and publicly owned innovation shows no significant average relationship with wages and consumption.

A striking finding is that the small volume share of government-funded but privately owned patents, which comes to about 2%, makes a large contribution of about 20% to medium-term macroeconomic dynamics in terms of GDP and aggregate productivity, while contributing relatively little at short horizons (Gazzani *et al.*, 2026). This horizon dependence matters for policy evaluation. Innovation policy is unlikely to deliver its main benefits within a single budget year. Instead, it operates at long and variable lags, with payoffs emerging at multi-year horizons. At the same time, the earliest significant impacts can materialise within the space of a single parliamentary term.

Figure 8-3 **Spillovers to business R&D and private investment**



Science, Research and Innovation Performance of the EU 2026

Source: Gazzani *et al.*, 2026.

Note: The figure displays the dynamic effects of innovation shocks in each category of patents (public-private, private-private, public-public; by column) on (log) real per-capita private R&D and (log) real per-capita investment. See Gazzani *et al.*, (2026) for more details.

Agencies and Fields

Aggregate results concerning innovation impact conceal significant heterogeneity across public funders and innovation fields. Among government-funded but privately owned patents, innovations supported by the National Institutes of Health (NIH) and the National Science Foundation (NSF) display the strongest medium-term associations with GDP and productivity, with other agencies such as the Department of Energy (DoE) and NASA also showing sizable effects. Heterogeneity is even larger among publicly funded and publicly owned patents, consistent with a portfolio that mixes very-high-impact/high-risk inventions with low-impact outcomes. At field level, health and biotechnology stand out among publicly funded patents, particularly as regards publicly owned inventions.

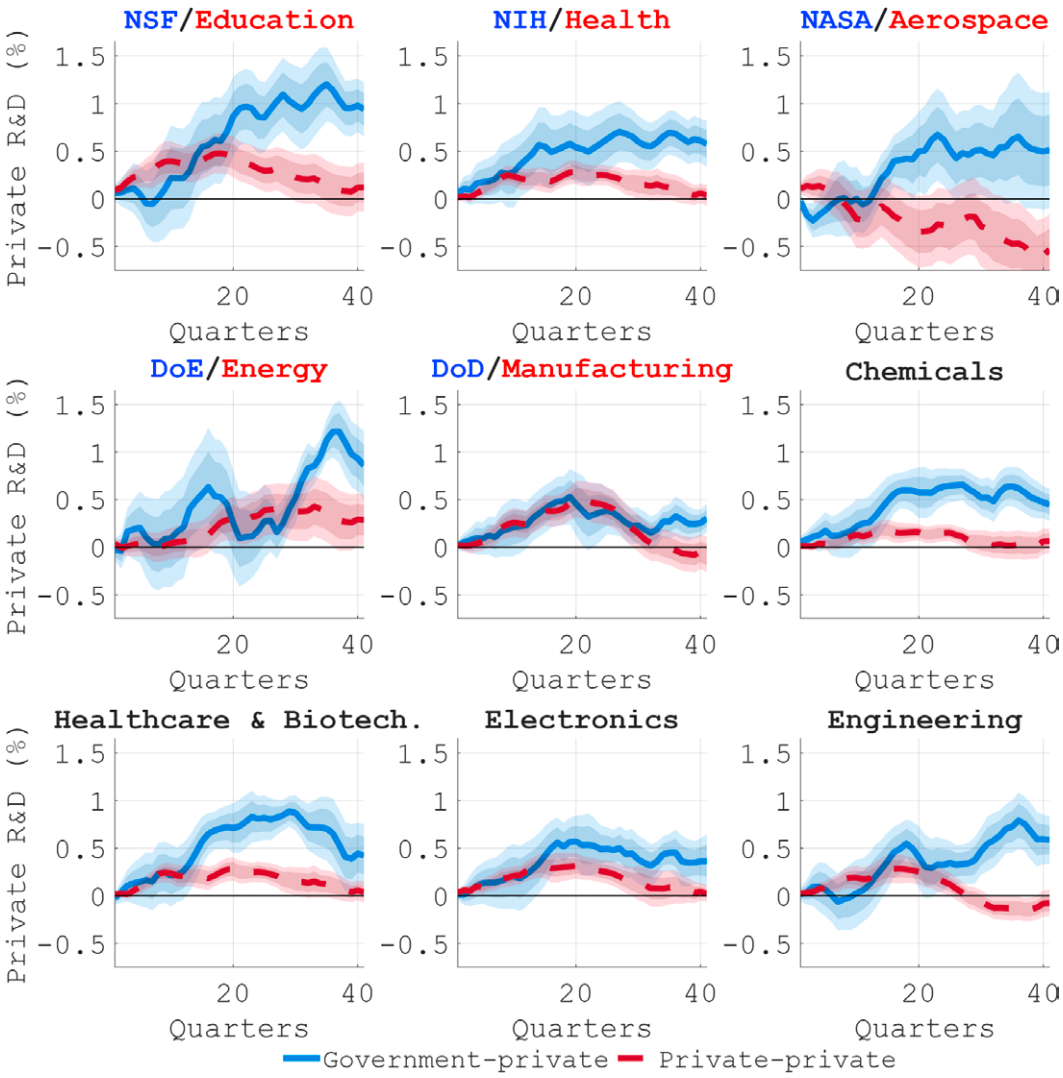
Research Institutes and Universities

The strongest policy message in the US evidence concerns the role of performers, not only that of funders. Government-funded innovation produced by non-profit organisations is more strongly associated with a sustained rise in aggregate productivity than innovation by for-profit entities. Within the non-profit sector, universities and research institutes appear especially important. A useful within-institution comparison can be made by asking whether innovation produced by universities and research institutes has different macro associations depending on whether it is publicly funded or privately funded. The evidence indicates that publicly funded innovation in these organisations is associated with larger medium-term gains than innovation by the same types of organisations financed privately. The role of publicly funded innovation by these institutions as a main transmission channel is underlined by the fact that research institutes and universities are by far the most successful institutions at crowding in private investment in R&D after a rise in the government-funded innovation that they patent (Figure 8-4). This aligns with the institutional logic of the post-war US model often associated with Bush, i.e. public support for basic research within universities and institutes combined with channels for broader diffusion and downstream commercialisation.

Startups vs Incumbents

A further design lesson concerns who drives frontier innovation. A prominent view in modern growth theory is the Schumpeterian framework of creative destruction, formalised by Aghion and Howitt (1992), in which growth is propelled by entrants that replace incumbent technologies and business models. In that framework, policies that shape entry, experimentation and the reallocation of resources toward new firms can have first-order consequences for innovation-driven growth. The US evidence supports this perspective in a specific way (Figure 8-5). When patents are developed by startups, the estimated medium-term macroeconomic gains are larger than when patents are developed by established incumbent firms, but this difference is concentrated in the set of innovations that receive government support. In the absence of government support, the startup versus incumbent heterogeneity largely vanishes. This pattern suggests that public funding can be especially important in enabling high-risk experimentation by young firms and in supporting the scale-up of innovations that might otherwise be underfinanced. Furthermore, public support can steer the direction of innovation towards areas and dimensions that maximise the economic benefits for society, as opposed to corporate profits for shareholders, which is the most likely goal of private funding.

Figure 8-4 Dynamic effects of innovation on private R&D investment by funding source and agency or research field

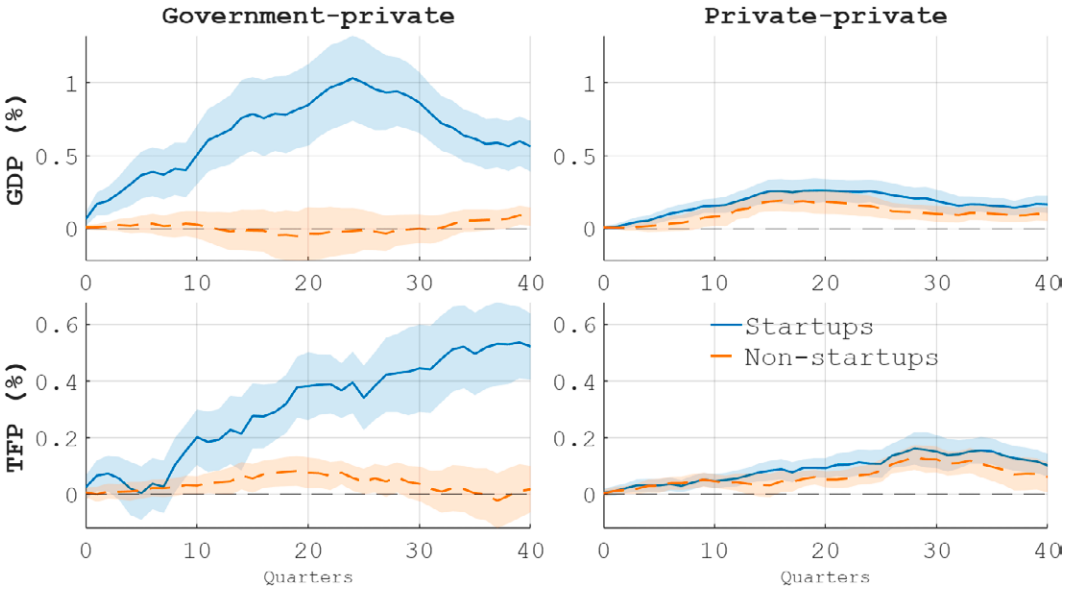


Science, Research and Innovation Performance of the EU 2026

Source: Gazzani *et al.*, 2026.

Note: The figure displays the dynamic effects of public–private technology shocks and private–private technology shocks on (log) real private R&D per capita, by agency, matched industry, and research field. Solid blue lines report public–private patent shocks; dashed red lines report private–private patent shocks. See Gazzani *et al.*, (2026) for more details.

Figure 8-5 Dynamic effects of innovation: startups vs incumbents under public vs private funds



Science, Research and Innovation Performance of the EU 2026

Source: Gazzani *et al.*, 2026.

Note: The figure compares the dynamic effects of technology shocks for public–private and private–private patents across firm types on (log) real per-capita GDP and (log) utilization-adjusted TFP. See Gazzani *et al.*, (2026) for more details.

Recent evidence synthesised in the book collection The Economics of Creative Destruction by Akcigit and Van Reenen (2023) expands on the empirical foundation of this Schumpeterian view, documenting how innovation, competition and firm dynamics interact and highlighting the policy role in shaping the conditions for entry and creative destruction.

Related literature on public spending and public R&D

In macroeconomic literature on government spending multipliers, modest short-term effects are often identified. Ramey and Zubairy (2018), using long-term historical US data, estimate multipliers of below one across a wide range of specifications. These findings are sometimes interpreted as reflecting scepticism about active fiscal policy.

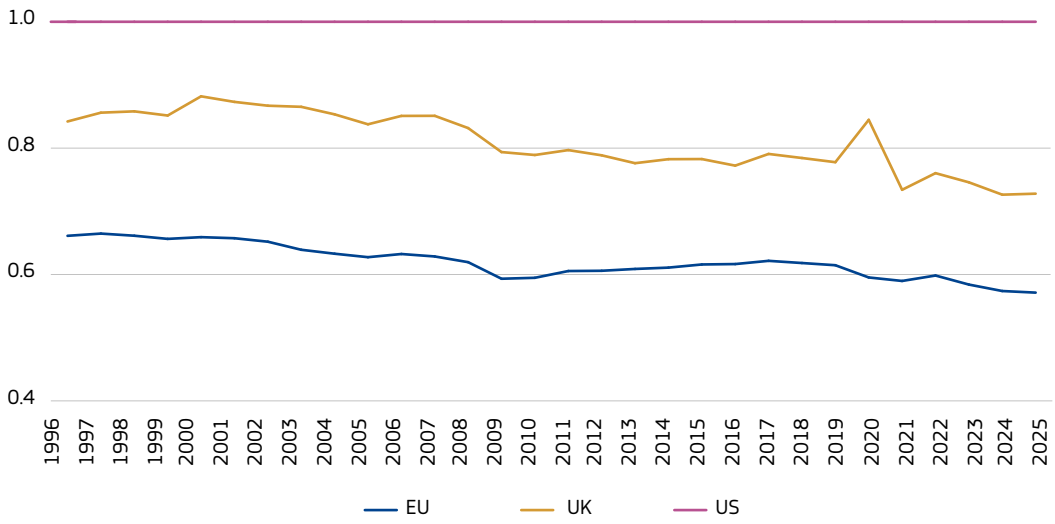
Three complementary strands of work help place innovation policy in context: horizon-dependent spending effects, large long-run returns to R&D appropriations, and strong knowledge spillovers from public R&D. Firstly, Antolin-Diaz and Surico (2025) show that the effects of government spending are horizon dependent: long-term effects can be much larger than business-cycle effects, especially when spending shifts the composition of public expenditure towards R&D and stimulates innovation and private investment. Secondly, Fieldhouse and Mertens (2023) apply narrative shocks to R&D appropriations and find large, long-run productivity effects and high implied returns on non-defence government R&D. Dyevre (2024) reaches a similar conclusion from a complementary perspective, showing that public R&D generates particularly strong knowledge spillovers and can have sizeable and persistent effects on firm productivity and aggregate TFP growth. Taken together, this body of evidence suggests that the composition of public spending on knowledge creation and diffusion can be central to long-term prosperity.

3. The structure of innovation: descriptive evidence for the EU and the UK and a harmonised comparison with the US

Setting the scene: productivity and R&D investment gaps

Both the EU and the UK have fallen further behind the US in terms of labour productivity over the past three decades (Figure 8-6). In the mid-1990s, the UK's productivity level stood at around 85% of that of the US, while the EU's stood at roughly 68%. By 2025, both had declined noticeably, with the UK's level decreasing to around 73% and the EU's level to approximately 57% of that of the US. While the trajectories are broadly similar in direction, the UK has consistently maintained a higher productivity level than the EU. One important aspect that can help explain this pattern is the innovation system. If public and private investment in research and knowledge creation shapes long-term productivity, as the US evidence in Section 3 suggests, understanding where the EU and UK stand on those dimensions relative to the US becomes directly relevant for understanding the productivity gap.

Figure 8-6 **Labour productivity as a ratio of that of the US, 1996–2025**



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on AMECO.

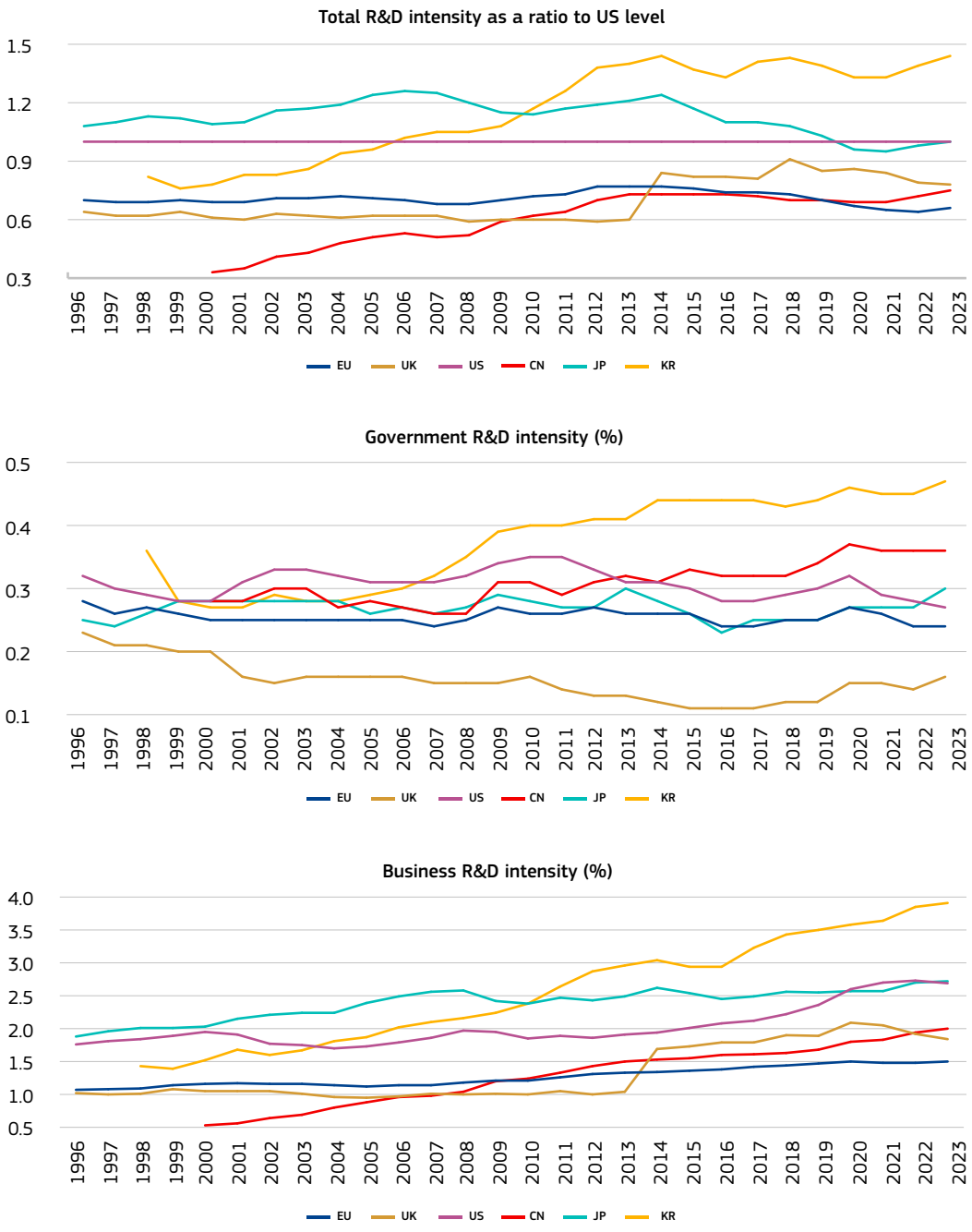
Note: Labour productivity is measured as real GDP at 2020 price reference/total annual hours worked.

As with labour productivity, the R&D intensity gap between the EU and the UK and other main global competitors has widened (Figure 8-7). Since the mid-1990s, the R&D intensity of both the EU and the UK has hovered around 70-80% of the US level. In sharp contrast, Asian countries such as South Korea and Japan have consistently been ahead of the US, with South Korea now investing around 1.5 times the US level. Also, China is approaching EU and UK investment levels after having rapidly increased R&D investment.

Business investment accounts for most of this gap. European and UK companies consistently spend less on R&D (as a percentage of GDP) than their Asian counterparts. At the same time, public R&D intensity in both the EU and the UK has been drifting downwards, with the UK experiencing a particularly sharp decline.

This may be more significant than it appears, as the evidence above suggests that public and private investment tend to move together rather than offset one another, i.e. when governments invest more, businesses follow, and when governments pull back, the private sector tends to do likewise. Meanwhile, Asian governments have been steadily increasing their public R&D commitments, potentially triggering the same crowding-in dynamic and further widening the R&D intensity gap.

Figure 8-7 R&D investment patterns across major economies, 1996–2023



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Eurostat (DOI link: https://doi.org/10.2908/RD_E_GERDFUND) and OECD (for the UK data).

The science intensity of innovation across regions

Beyond the question of how much is spent, patent evidence suggests that where public support goes and how science intensive the resulting research is may matter equally (see box 8-1 for details on how this data was collected). Looking at who files patents across the EU, the UK and the US, it is striking how similar the overall public sector share is across the three regions, hovering around 1.8% to 1.9% of total patents in each (Figure 8-8). While this may seem to suggest a broadly comparable role for public institutions in innovation, the science intensity of patenting differs considerably across regions. The overall share of basic research patents stands at 10.12% in the EU, 15.89% in the UK and 19.02% in the US.

Breaking this down by sector, basic research shares are substantially higher in the public sector than in the private sector across all three regions. In the public sector they reach 26.25% in the EU, 43.63% in the UK and 42.73% in the US, compared to 8.70%, 15.09% and 19.61%, respectively in the private sector. However, what stands out most clearly is the persistent gap between the EU and the US across all three measures within the public sector and the private sector, pointing to a structural difference in the basic research intensity of the innovation system.

The institutional composition of innovation across regions

Within the public sector, the geography of science-intensive patenting varies significantly by institutional type, adding nuance to the aggregate picture (Figure 8-9). Non-profit organisations account for a notably larger share of total patents in the EU: 0.99% compared to 0.41% in both the UK and the US. The share of their patents that are science-intensive, a proxy for basic research orientation, stands at 27% in the EU, 33% in the UK and 32% in the US. This suggests that Europe's non-profit sector is not only larger in relative terms but also actively engaged in science-intensive research, though somewhat less so than its UK and US counterparts. For universities, the within-country share of patents is notably lower in the EU: 0.85% compared to 1.39% in the UK and 1.37% in the US. The gap in science-intensive patenting is starker for universities, with only 25% of EU university patents being science-intensive, compared to 47% in the UK and 46% in the US. EU universities are therefore not only less active in patenting overall but also less oriented towards science-intensive invention. This double gap in university patenting is particularly relevant in light of the US evidence reviewed, which identified universities as the institutional channel most strongly associated with economy-wide productivity gains, suggesting that not only the scale but also the composition of Europe's public research system deserves attention. These patterns suggest that while European governments actively support science-intensive research, this support flows primarily through non-profit organisations rather than universities. Given the US evidence, this difference may negatively affect long-term returns on European public research investment.

Box 8-1 Measuring government-funded innovation in Europe: a proposed classification for the EU and the UK

The evidence in Sections 1 and 2 is based on the post-war US, a context in which the modern innovation ecosystem was built gradually and where institutional arrangements were shaped by the post-1945 policy settlement. The EU and the UK differ in institutional structure, in the organisation of research funding, in scale-up environment and in the relationship between public research organisations, universities and firms. For these reasons, the US findings should be interpreted as evidence about mechanisms and design principles rather than as coefficients that automatically apply to European economies.

A direct replication for Europe of the classification devised for the US by Gazzani *et al.* (2026) is not currently feasible. In the US, the Government Patent Register provides administrative records that directly link patents to public funding sources and distinguish government-retained title from privately held IP developed with public support. No equivalent harmonised data source exists for EU Member States or the UK. In these countries, public funding of R&D is channelled through a heterogeneous mix of national agencies, European framework programmes and contractual arrangements, without systematic administrative linkage to patent outputs. As a result, the funding source and ownership distinction that underpins the US analysis cannot be replicated directly in the European context.

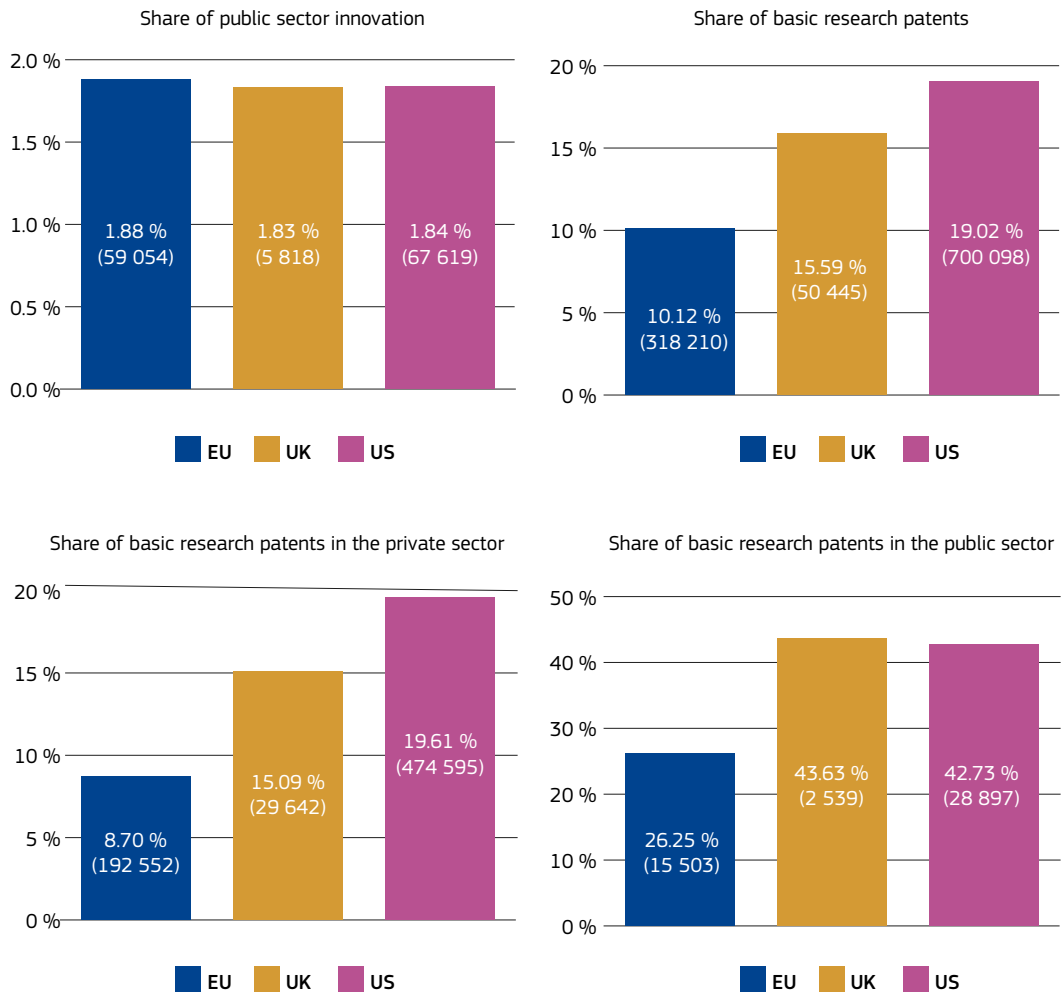
What can be observed, however, are the institutional type of the patent assignee and the degree to which an invention draws on scientific knowledge. Together, these two dimensions provide a tractable initial approximation of the public-private structure of European innovation. Assignees classified as government non-profits, universities or hospitals are predominantly embedded in the public research system, and patents assigned to these entities are plausibly more likely to reflect publicly supported research activity, even if institutional ownership is not a perfect proxy for funding source. Nonetheless, the classification is transparent, replicable and consistently applicable across countries and over time. In addition, it can be applied to US patents using the same methodology, enabling a like-for-like descriptive comparison across regions.

Data sources and unit of analysis

This section draws on patent data obtained from the European Patent Office Worldwide Patent Statistical Database (PATSTAT), a comprehensive repository of bibliographic and legal information on patent applications. Data on patent applications filed between 1996 and 2019 were extracted for assignees located in EU Member States (later reported as the aggregate), the UK and the US, with country attribution based on the recorded residence of the assignee at the time of filing. When a patent application lists multiple assignees, fractional counts are applied to avoid double counting across countries and sectors.

For each patent application, assignee information is drawn from PATSTAT's harmonised person table, which provides a disambiguated applicant name (psn_name) alongside a sectoral classification (psn_sector). The latter categorises assignees into institutional types (firms, universities, government research organisations and individuals) based on name-matching algorithms applied to raw applicant strings (Magerman *et al.*, 2006), making possible a decomposition of patenting activity by institutional actor. A non-trivial share of assignees in PATSTAT carry a psn_sector value of 'UNKNOWN'. To address this, unclassified assignees were reclassified using GPT-4o mini via the OpenAI Batch application programming interface, with each distinct name-country pair submitted alongside contextual indicators. Probability scores were obtained across six institutional categories (government body, commercial firm, individual inventor, university, research institute and hospital), and assignees were classified into the category exceeding a threshold of 50% probability or retained as unclassified. As this approach relies on name-based inference, some misclassification is inevitable, and its implications for the estimates should be borne in mind. To capture the extent to which patented inventions build on scientific knowledge, the dataset incorporates non-patent literature (NPL) citations (e.g. Narin *et al.*, 1997). Journal-related NPL references are identified using structured fields and bibliographic indicators (e.g. digital object identifier mentions and journal formatting conventions) and aggregated at patent level. Patents with at least one NPL citation are classified, for the purposes of the descriptive analysis that follows, as close to science, which we interpret as a proxy for more basic and fundamental research.

Figure 8-8 Science intensity of patenting: within-country shares of public sector patents and basic research patents in total and across the public and private sectors, EU, UK and US, 1996–2019

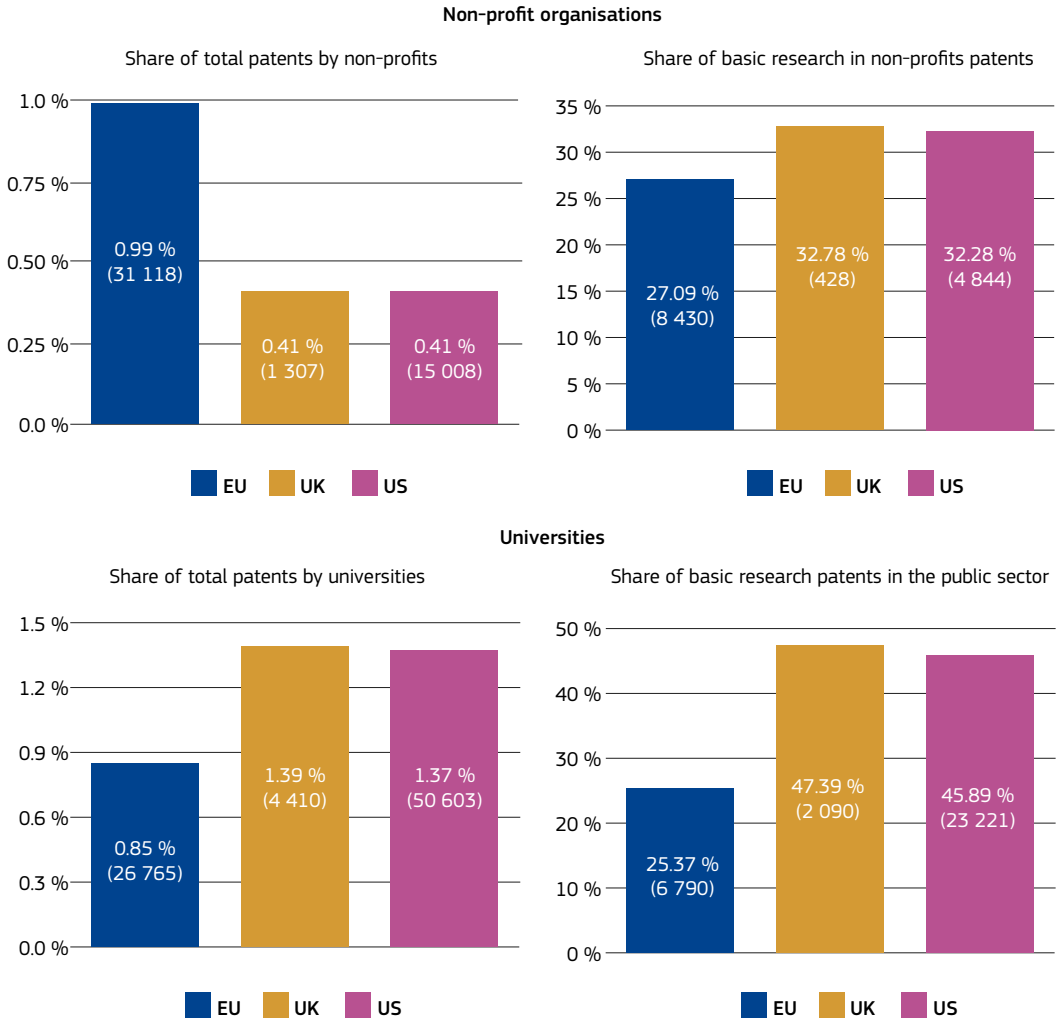


Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on PATSTAT.

Note: Basic research patents are defined as patent applications citing at least one non-patent literature reference. The private sector comprises companies, individuals and their hybrid categories. The public sector comprises government non-profits, universities, hospitals and their hybrid categories (government non-profit university, government non-profit hospital), plus cases where 50% of patents are jointly assigned to a company and a government non-profit entity. A residual 'not assigned' category covers assignees that cannot be classified into either sector. As a result, the totals of private and public sector shares do not add up to the total basic research share reported in the top-right quadrant. Percentages show the average shares between 1996–2019, while the corresponding average fractional counts are reported in brackets.

Figure 8-9 Institutional structure of patenting: within-country shares (1st column) and share in basic research patents (2nd column) of non-profits and universities, EU, UK and US, 1996–2019



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on PATSTAT.

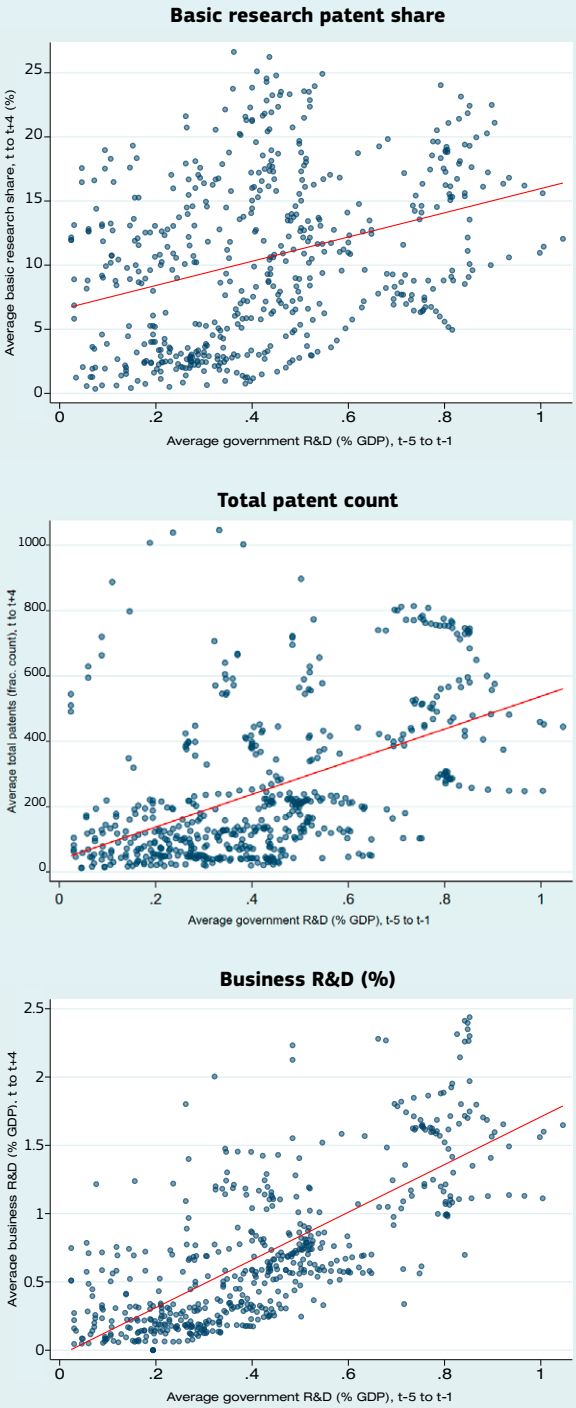
Note: Within the public sector, two specific sub-categories are distinguished: non-profits, covering standalone government non-profit assignees; and universities, covering universities and government non-profit universities. Basic research patents are defined as patent applications citing at least one non-patent literature reference. Percentages show the average shares in total from 1996 to 2019, while the corresponding average absolute fractional counts are reported in brackets.

Public R&D spending and subsequent patenting activity: cross-country patterns

A natural next step is to ask whether differences in government R&D spending across countries are associated with differences in the structure and scale of subsequent patenting activity. Looking across countries, those that have historically devoted a larger share of GDP to government R&D tend to exhibit a higher share of basic research patents in the years that follow, pointing to a meaningful link between public funding and the science intensity of the innovation system over the medium term (Figure 8-10). The relationship between government R&D and total patent counts per capita tells a similar story: more publicly research-intensive economies tend to file more patents. However, the dispersion around the trend is wide, reflecting the many country-specific factors that shape patenting activity beyond spending alone.

The strongest pattern concerns business R&D: countries with higher government R&D spending over the preceding five years tend to exhibit higher business R&D intensity in the years that follow, suggesting complementarity between public and private research investment (see also chapter 2.1). This echoes the crowding-in logic identified in the US evidence, where government-funded innovation was followed by sustained increases in business sector R&D investment. It also adds cross-country descriptive support to the idea that the same mechanism is at play across European economies. If this complementarity holds, the declining public R&D intensity documented in Figure 8-7 may carry costs that extend beyond the public sector itself.

Figure 8-10 Government R&D spending, science-intensive patenting and business R&D: cross-country correlations, EU, UK and US, 1996–2019



Science, Research and Innovation Performance of the EU 2026

Source: DG Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on PATSTAT.

Note: Each observation represents a country-year pair. The fitted line is estimated by ordinary least squares.

4. Policy considerations

The evidence reviewed in this chapter points to a simple but important lesson for innovation policy: composition may matter as much as scale. The post-war US experience suggests that the growth effects of public support depend not only on the amount of R&D spending but also on where that support is directed, which institutions perform the research and how effectively public research connects with private investment, commercialisation and diffusion. In particular, the US evidence is consistent with a division of labour in which public support to universities, research institutes and other non-profit performers helps expand the stock of science-based knowledge and frontier discovery, while private firms, especially young and dynamic firms, play a central role in translating that knowledge into new products, investment and productivity growth.

These findings should not be transferred mechanically to Europe. Institutional settings differ, the organisation of public research varies across countries, and the descriptive analysis presented here for the EU and the UK is necessarily more limited than the evidence available for the US. In particular, European patent data do not allow direct identification of funding sources and ownership structures in a manner that is comparable to that available in the US administrative data. The European evidence presented here should therefore be interpreted with caution since it is descriptive rather than causal and preliminary rather than definitive. The reflections that follow remain speculative in that they combine robust US evidence regarding mechanisms with an initial descriptive comparison of the institutional composition of innovation in Europe.

Despite the caveats in mind, several patterns are nonetheless suggestive, starting with the observation that both the EU and the UK appear to devote less public effort to R&D than the US, and even more so than leading Asian economies. More importantly, the patent-based indicators assembled in this chapter suggest that Europe's innovation system is less science intensive, especially in those parts of the system most closely associated with public and quasi-public knowledge creation, notably universities and non-profit research organisations. The UK appears somewhat closer to the US than the EU in some areas, particularly on account of its stronger private sector innovation, but the broader contrast remains. Europe appears to have a thinner pipeline of science-intensive innovation emerging from publicly embedded institutions, particularly universities, while its non-profit research network remains comparatively strong.

For policy, the implication is not simply that Europe may need more public R&D, although the level of support clearly matters. It is also that the direction of support may be equally consequential. Public funding that strengthens basic research capabilities, supports excellent universities and research institutes and improves links between those institutions and innovative firms may generate benefits that extend well beyond the immediate output of publicly funded projects. If the US evidence is indicative of broader mechanisms, public support for knowledge creation can crowd in rather than crowd out private investment, increasing incentives for firms to undertake business R&D, absorb frontier science and scale innovation commercially. In that sense, public R&D policy is not only about financing research; it is also about shaping the wider innovation ecosystem within which private investment decisions are made.

One possible interpretation of the European patterns documented here is that weaknesses in the public-facing part of the innovation system may spread into the private sector. The relatively low science intensity of patenting in universities and other non-profit institutions may help explain why

private sector innovation in Europe, especially in the EU, appears less science intensive than in the US. This should be treated as a hypothesis rather than as a result established by the present chapter. Even so, it is a policy-relevant hypothesis: if public support for frontier and basic research is too limited, too fragmented or too weakly connected to scale-up channels, the consequence may be not only fewer discoveries in public institutions themselves but also weaker spillovers to business R&D, entrepreneurship, productivity growth and, ultimately, long-term prosperity.

A broader lesson is that innovation policy should be evaluated over the long term and at systemic level, not only at the level of individual programmes. The main benefits of public support for innovation may take years to materialise and may appear in forms that conventional evaluation frameworks do not fully capture; stronger private investment, wider diffusion of scientific knowledge, greater experimentation by young firms and faster productivity growth over time. For that reason, a narrow focus on short-term outputs or immediate commercial returns risks understating the social value of public support for research and innovation.

For Europe, an immediate priority is therefore measurement. Before firmer conclusions can be drawn, policymakers need better and more systematic ways of identifying which innovations are publicly funded, which institutions produce them, how science intensive they are and how they are diffused through the economy. Building a more transparent and harmonised evidence base for the funding sources and institutional origins of innovation would not only improve policy evaluation; it could also help Europe design innovation strategies that are better aligned with its long-term productivity, resilience, health, decarbonisation and security objectives.

Europe's innovation challenge is therefore not only to spend more but to spend more strategically to build the institutional conditions under which public support for science and invention can catalyse private investment, diffusion and long-term growth. A central element of such a strategy could be the introduction of a European framework granting research institutions ownership rights over publicly funded inventions and the ability to license them to private firms, thereby aligning commercialisation incentives and strengthening the link between public science and private investment. For example, the US Bayh-Dole Act of 1980 granted universities, non-profits and small businesses the right to retain ownership of inventions arising from federally funded research and to license them to private firms. By clarifying IP rights and aligning incentives for commercialisation, it helped transform publicly funded science into a more active engine of innovation.

The Bayh-Dole Act is widely seen as instrumental in the development of the US innovation ecosystem. It encouraged the creation of technology transfer offices, facilitated university-industry collaboration and supported the growth of startups built on academic research. Although institutional differences mean that any European version would need careful adaptation, a clearer and more harmonised framework for ownership and commercialisation of publicly funded research could help address Europe's relatively weak translation of frontier science into scalable innovation, strengthening the links between public research, private investment and long-term economic performance.

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CHAPTER 9

THE IMPORTANCE OF A PLACE-BASED APPROACH IN FUTURE EU R&I POLICY

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For decades, the regional dimension has played a pivotal role in EU policy aimed at boosting research and innovation (R&I) and competitiveness. Since 2014, the EU has implemented a place-based innovation policy, known as the *Smart Specialisation Strategy* (S3), that involves active participation of local actors and targets specific priority activities that are rooted in regional capabilities. In the first programming period (2014-2020), the European Regional Development Fund (ERDF) allocated EUR 59 billion to support R&I in regions (European Commission, 2024b). More recently, the Regional Innovation Valleys initiative has been launched as part of the *New European Innovation Agenda* to develop regional innovation valleys involving regions with lower levels of innovation.

The 2024 Draghi Report on EU Competitiveness has been fully embraced by the European political leadership because it provides a compelling narrative on structural weaknesses in Europe, such as lagging digital capacity, slow diffusion of frontier technologies, underperforming productivity growth, low levels of commercialisation of research ideas, fragmented capital markets blocking scaling-up of European firms and regulatory bottlenecks. Mario Draghi proposes an ambitious programme to create new European champions, to close the productivity gap with the US and to tackle the 'middle-tech trap' in the EU. However, his report does not focus on the diversity of capabilities in the different regions of Europe that could help achieve these goals.

The objective of this chapter is to outline why the regional dimension and place-sensitive strategies are indispensable elements of EU policies for tackling major societal challenges such as competitiveness, technological sovereignty, climate change, social inclusion and territorial cohesion. Building on a large body of scientific research, this chapter discusses the crucial importance of regions for promoting European competitiveness (Section 1), strengthening technological sovereignty (Section 2), boosting the green transition (Section 3), building European cohesion (Section 4) and addressing populism and discontent (Section 5). Ignoring the crucial importance of regions and place-based policies in the EU runs the risk of failing to deliver fully on any of these major policy challenges.

1. Competitveness

As argued by Draghi (2024), Europe largely missed out on the digital revolution and the productivity gains it brought. It is undeniable that a productivity gap has emerged between the EU and the US. This productivity gap can largely be attributed to spectacular growth in the digital tech sector in the US, leading to the emergence of high-tech giants like Nvidia, Meta, Apple, Alphabet, Microsoft and Amazon. Draghi claims that the EU has little capacity to create European champions and develop new and more complex technologies, referring, among other things, to a list of the world's top 50 tech companies, of which only four are European. Draghi is strongly in favour of an active industrial policy, in which making choices and priority-setting are key to increasing European competitiveness.

The embrace of the Draghi Report by the European political leadership has led to the creation of the European Competitiveness Fund to boost technologies and strategic sectors, as proposed in the 2028-2034 MFF. However, Draghi pays limited attention to the crucial role that EU regions play in enhancing European competitiveness. There is overwhelming evidence that regional capabilities (as embodied

in knowledge, skills and institutions) are key inputs for technological change, industrial diversification and European competitiveness (Boschma, 2017). It is rare that new technologies or sectors develop from scratch. Instead, they build on and exploit existing capabilities that are geographically localised. Because regional capabilities are often technology- and industry-specific, they provide opportunities but also set limits to diversification (Neffke *et al.*, 2011). If, for instance, the necessary digital capabilities are not locally available, it would be close to impossible for a region to diversify into artificial intelligence (AI) (Balland and Boschma, 2021a; Bachtrögler-Unger *et al.*, 2023). Copying Silicon Valley has been attempted repeatedly throughout history but with little success. In this context, it might be challenging for the EU to catch up with the US in those parts of the digital revolution in which the US has managed to create 'intellectual monopolies' (Rikap, 2021).

Draghi's focus on creating new (digital) champions in Europe would also imply the need for a policy shift that concentrates massive investments in a limited group of technologically advanced superstar regions, such as Île-de-France, Oberbayern, Stockholm and Noord-Brabant, as only these regions possess the necessary capabilities (knowledge, talent, institutional capacity) to close the EU-US technology gap. A uniform prescription to develop such highly complex technologies in every region would be unrealistic. As a consequence, many regions would be left on their own. However, almost all regions in Europe possess capabilities and domain-specific opportunities that can contribute to European competitiveness – these are not the sole preserve of superstar regions. If the policy objective were to shift to promotion of competitiveness in, and exploitation of the local capabilities of, every European region (rather than privileging a few superstar regions), it would activate potential in many regions that has so far remained unexploited (Barca, 2009).

Exploiting diversification opportunities in all EU regions would boost European competitiveness. Europe's wide range of regional capabilities can be considered a strength, not a weakness. It provides a broad set of assets and diversification opportunities that, if mobilised, can contribute to the development of a range of new technologies and activities. Opportunities exist everywhere but differ in nature, as regions have accumulated different capabilities over time. Their diversification opportunity sets will thus look different, implying that 'one-size-fits-all' policies should be avoided. Local capabilities provide directionality to policy, as they condition which opportunities can be exploited more easily in each region and which societal challenges can realistically be taken up by place-based innovation policy (Balland *et al.*, 2019). Evidence-based policy of this kind promises to be more effective. It also implies that regions should refrain from promoting new activities in which they have no relevant capabilities (Foray *et al.*, 2012).

The Draghi Report was crystal clear on the need to make choices and set priorities (you cannot do everything), but it was not very specific on how (and on what grounds) to select priorities. Directionality can be articulated in a top-down manner, but that runs the risk of duplication of policies (all countries and regions going for the same thing), misallocation of resources or too narrow an exploration of opportunities in only a few regions and a few technologies. Directionality can also be the outcome of a bottom-up process by giving local actors a role in its articulation (Cappellano *et al.*, 2024). This type of place-based approach to directionality is embedded in local capabilities and needs. It is also the outcome of collective involvement of local actors. Because a bottom-up strategy is informed by local capabilities, it is less likely to result in duplication of efforts across regions.

Since 2014, the EU has built up valuable experience in S3, with more than 200 regions having implemented place-based approaches of that type. The objective of S3 is to select priorities for boosting new technologies and activities, based on the capabilities available in each region on the one hand, and through the active involvement of local actors (referred to as the 'entrepreneurial discovery process') on the other. Studies have examined this S3 priority-setting process (Uhlbach *et al.*, 2022). Priorities are often broadly defined, although choices are made in regional strategies (McCann and Ortega-Argilés, 2016). Regions tend to focus on priorities which do not always reflect their local capabilities. Marrocu *et al.* (2022) argued that S3 strategies in European regions target and activate new growth paths that leverage local capabilities only to a limited extent. This is supported by a recent evaluation of smart specialisation policy (European Commission, 2025). The study examined how EUR 59 billion in ERDF funding spent in the period 2014-2020 contributed to Europe's regional competitiveness. The findings tend to indicate that S3 played a pivotal role and was particularly effective where priorities had been grounded in regional strengths. A key outcome was that research, technological development and innovation support (mainly grants to firms and collaborative projects) through the ERDF increased knowledge production and science-industry collaboration in EU regions.

To increase competitiveness, it is increasingly evident that focus on capabilities in place-based policy should be extended to linkages to other regions through which capabilities can be accessed. The capacity of regions to tap into external knowledge is considered crucial but differs between regions (Grillitsch and Nilsson, 2015). It is critically dependent on the absorptive capacity of regions, which positively impacts their capacity to make connections and get access to crucial knowledge and, above all, their capacity to benefit from such external knowledge (Miguelez and Moreno, 2018). Balland and Boschma (2021b) stress the need to connect with regions that provide complementarities that are needed to diversify into a specific priority. Not all interregional connections are relevant. Instead, it is crucial to make connections with regions that give access to missing capabilities that are complementary to the regional capability base. Bachtrögler-Unger *et al.* (2023) show that such complementarities across regions are poorly exploited in Europe with regard to the development of twin transition technologies: regions collaborate mainly with other regions in their own country, while complementarities for digital and green technologies are often found outside the country. This national bias in collaborations undermines efforts to utilise capabilities and relevant complementarities that are available across European regions. This underlines the need for place-based policy that activates capabilities in regions and connections to regions with complementarities in order to boost European competitiveness.

2. Technological sovereignty

Due to ongoing global geopolitical tensions, sovereignty has gained prominence on the political agenda of the EU (Cagnin *et al.*, 2021; European Commission, 2021). This renewed interest in sovereignty shows deep concerns about dependencies on other countries, which are an inevitable outcome of globalisation. Dependencies reveal themselves in many forms: from dependencies on international supply chains, such as for critical raw materials and chips from China or military technology from the US to lack of control and autonomy over digital technologies

and content, reliance on Russian energy resources and so forth. Diemer *et al.* (2025) mention the (limited) options for the EU to become less dependent on foreign supplies of critical raw materials that form crucial inputs for digital items (e.g. mobile phones) and green products (e.g. batteries). The notion of sovereignty encompasses multiple dimensions (Edler *et al.*, 2020; Damen, 2022), including strategic autonomy and economic, technological, digital and regulatory sovereignty.

At the European level, the debate on sovereignty is also linked to defence and security issues in the context of the war in Ukraine, the rapid expansion of military budgets and radical changes in US national security policy (White House, 2025). Draghi (2024) also refers to Europe's dependence on US defence technology and the rise of China as a technological powerhouse. A key challenge is to build capabilities and forge collaborations across European countries and their regions to tackle technological and market fragmentation, strengthen coordination and increase technological autonomy (Giacomello and Preka, 2023). Such capacity-building efforts should include the development of military production capabilities (like for weapons and ammunition), but above all research and technological capabilities (e.g. cybersecurity) (Mitra and Steeman, 2024). When these concern 'dual-use' technologies (i.e. military or security-related technologies that also have civilian applications) like AI or drones (Edler *et al.*, 2023), this capacity building can contribute to the achievement of other policy objectives, such as European competitiveness.

Technological sovereignty has attracted special attention (Bauer and Erixon, 2020; Crespi *et al.*, 2021; Edler *et al.*, 2023; March and Schieferdecker, 2023; Edler, 2024; Mueller and Boeing, 2024). There is growing interest in whether the EU can independently produce critical technologies and develop and preserve strategic industries. This view of technological sovereignty often focuses on specific areas of strategic importance such as defence and key technologies such as 5G and quantum technology. Many countries have recently introduced policies related to technological sovereignty. A prime example is the *CHIPS and Science Act* of 2022 in the US (Luo and Van Assche, 2023) and the *European Chips Act* of 2023 (Dachs, 2023) aimed at boosting technological development and production of semiconductors.

Technological sovereignty is seen as a means to build innovative capacities and strategic industries and sustain European competitiveness (Draghi, 2024). Achieving technological sovereignty is a precondition for reaching the broader goal of strategic autonomy, which is reflected in having a degree of independence in strategic choices in the geopolitical context while exploiting beneficial interdependencies with third countries (Edler *et al.*, 2020). Edler *et al.* (2020) and Edler (2024) argue that technological sovereignty does not simply imply full technological autonomy in every strategic activity. There is an acknowledgement that no territorial unit at whatever spatial scale (EU, country, city, region) is able to rely only on its own technological capacities and market size. Instead, technological sovereignty refers to the ability of a territorial unit to keep or develop a certain level of autonomy in strategic fields, although it will remain a matter of debate how high a level is sufficient.

Technological sovereignty is directly linked to capabilities that are available in a territorial unit. Local capabilities provide opportunities for, but also set limits to, the achievement of technological sovereignty. For example, when digital capabilities are missing, it is close to impossible to attain sovereignty in digital technologies, as the costs of building from scratch are insurmountable (Balland and Boschma, 2021a; Crespi *et al.*, 2021). Lee

et al., (2024) distinguish between three components for building technological sovereignty: techno-scientific (or innovation) capabilities, production capabilities and supply-chain independence (reliance on a single country for imports). Their study shows that the three components are unevenly distributed across countries. The US and China, for instance, exhibit strong innovation and production capabilities, especially in highly complex industries, but they score low on supply-chain independence. Lower-income countries show low levels of technological capability and supply-chain independence. Mueller and Boeing (2024) analysed patent citation data to determine the strength and direction of global and bilateral influences on countries in order to assess their technological sovereignty. They found that the US holds substantial technological sovereignty. Europe depends on other countries, while China is expanding its technological capabilities rapidly but shows the highest level of global dependence.

While many countries aim for technological sovereignty, these insights suggest that technological sovereignty policies should differentiate and prioritise activities in which a country has strong capabilities, rather than activities in which its degree of competitiveness is low. If territories follow this place-based logic, policy duplication will hardly ever happen. However, the reality looks very different: the technological sovereignty policies of European and other countries look very similar (Lee *et al.*, 2024). Despite their different techno-industrial histories, countries target similar critical technologies and industries (Ramahandry *et al.*, 2021; Dortmans *et al.*, 2022; European Commission, 2023), such as AI, cybersecurity, biotech and quantum technologies. This raises questions about whether these policies are derived from a thorough account of the country's specific capabilities and needs, or whether they are just copied from other countries, possibly resulting in a waste of public resources (Lee *et al.*, 2024).

Building a strategic field from scratch makes the achievement of technological sovereignty highly unlikely. Instead, building on strong regional capabilities and adopting a place-based policy makes it more likely that a country will develop its chosen field successfully. In the last five decades or so, the US has managed to build sovereignty in digital technologies on capabilities that are strongly concentrated in Silicon Valley. At the same time, considerations other than technological feasibility and economic affordability, such as geopolitical risks and access to alternative imports, might be as relevant when selecting strategic fields (Lee *et al.*, 2024). This requires EU-level coordination of policies in areas like trade or what Draghi (2024) refers to as 'foreign economic policy'.

To sum up, it is crucial to start from existing capabilities at European and Member State level to decide in which fields it is possible, and in which not, to build and increase technological sovereignty. As stated, capabilities are often specific to regions, and this needs to be taken into account. That is not to say that regions should strive for technological autonomy. On the contrary, the more one moves from the global to the local scale, the less feasible it will be to achieve technological sovereignty, especially in complex technologies. Moreover, technological sovereignty contains a political-governance dimension (Edler *et al.*, 2020); regions often do not have the autonomy, political power or administrative capabilities to implement technological sovereignty policies. And it also requires a coherent mix of science, technology, education, industrial and trade policies that are primarily run by countries, not regions (European Commission, 2021).

3. The green transition

The issue of European sovereignty is closely connected to the political agenda of the green transition (Kivimaa *et al.*, 2026). This is evident in the EU's 2024 *Critical Raw Materials Act*, which aims to make Europe less dependent on the supply of critical raw materials that are key to the green energy transition by boosting domestic production (extraction, processing), promoting circularity (recycling) and diversifying imports away from individual countries like China (Diemer *et al.*, 2022; Li *et al.*, 2024).

There is a longstanding debate about whether the green transition is compatible with further economic growth (Kallis, 2011; Hickel, 2020). Draghi (2024) perceives the green transition (or decarbonisation) as a growth opportunity, claiming that the political agendas on competitiveness and sustainability should be pursued jointly. The view that the transition to climate neutrality should be growth enhancing has been embraced in the *European Green Deal* (Diodato *et al.*, 2024). According to Draghi (2024), the EU is performing relatively strongly in the green transition, especially when compared with its weaker performance in the digital transition. Europe is world leading in a number of clean technologies, such as wind turbines, leaving the US behind. Veugelers *et al.* (2024) argue that the EU is also at the forefront of green policy implementation across regional, national and supra-national levels. The green gap with the US is likely to continue to widen under the Trump administration, but Draghi (2024) warns that China is moving fast in many green activities.

Regions play a critical role in the green energy transition (Coenen *et al.*, 2021). The green transition tends to unfold differently across regions as enabling and constraining factors are often place-specific. It also impacts on regions in different ways in terms of economic (job dynamics), industrial (non-renewables), environmental (green vulnerability) and social outcomes (just transition). Moreover, the political and administrative capacity to actively govern the green transition also varies across European regions.

A large body of literature has demonstrated that regional capabilities both enhance and constrain the capacity of regions to develop green activities in areas such as batteries, solar energy or wind turbines. As regions accumulate distinct capabilities over time, they also differ in their ability to diversify into new green activities. There is strong evidence that regions are more likely to diversify into green technologies that can build and draw on relevant capabilities already present in the region (Tanner, 2016; Corradini, 2019; Montresor and Quatraro, 2020; Van den Berge *et al.*, 2020; Li *et al.*, 2021; Santoalha and Boschma, 2021; Moreno and Ocampes-Corrales, 2022; Castaldi *et al.*, 2026).

Besides enabling factors, the green transition is also contested by powerful vested interests in non-renewables that are part of the 'old' regime (Rip and Kemp, 1998; Unruh, 2000; Geels and Raven, 2006). The more the established regime is spatially concentrated, with few other activities around, the easier it is to form a powerful local coalition with political actors who oppose new green initiatives, such as in coal mining regions. Recently, anti-green sentiments and acts of outright resistance with their own specific geographical features have emerged among local populations (Garcilazoa and McCann, 2025; Rodríguez-Pose *et al.*, 2025). As recognised in a recent EU report on territorial cohesion (European Commission, 2024a), growing discontent with the green transition, notably in left-behind regions, raises questions about the capacity of these regions to implement effective green policies.

Climate change affects some activities more than others. The transition to a low-carbon economy is a typical example of what Schumpeter referred to as creative destruction: it provides new job opportunities in some activities (like renewable energy, water management and waste treatment), but it will also cut jobs in high-emission and carbon-based activities, such as coal mining (Breul and Atienza, 2022; Kapetaki *et al.*, 2020). This process of creative destruction has a peculiar geography. Bachtrögler-Unger *et al.* (2023) found that less-developed regions in Europe are, on average, more capable than more-developed regions of contributing to the development of green technologies. These technologies are often closely linked to agrifood products, such as biocides, biofertilisers, biofuels and sustainable packaging, that are well represented in peripheral regions. Sustainable technology is also often land-intensive, providing opportunities for less urbanised regions. The costs of climate mitigation are also unevenly distributed. Rodríguez-Pose and Bartalucci (2024) show that costs and potential victims of the green transition tend to be concentrated in economically weaker regions (Alves Dias *et al.*, 2018). Their capacity to accommodate decline in use of non-renewables is lower as there are few job opportunities, and the skills of redundant workers will not match demand in other local industries. This is likely to lead to structural unemployment, which necessitates serious policy efforts to re-educate affected workers and reintegrate them into the labour market.

This implies that green policy need, to some extent, to be place-based, alongside climate change policies, such as carbon pricing and research and development policies, that are conducted at global, European and national levels. To foster green regional development, it is essential to avoid an undifferentiated 'catch-all' green policy approach (Rodriguez-Pose and Bartalucci, 2024; Jové-Llopis *et al.*, 2025) because green capabilities, environmental vulnerability and socio-political sentiments are unevenly distributed across regions. Local capabilities condition the green opportunity space and shed light on which sustainability challenges it might be feasible to address in which region. Acting thus will prevent the directionality principle from being articulated in a top-down manner, as happens in the cases of the Sustainable Development Goals (SDGs) and the *European Green Deal* (Wanzenböck and Frenken, 2020). Place-based green policy can engage more directly with regional realities on the ground: bottom-up consultation and participation of local communities in green policy initiatives are of paramount importance. Ignoring that runs the risk of fuelling discontent and making lagging regions perceive green policy as something that is imposed on them (Vihma *et al.*, 2021; Bourdin and Torre, 2023). Indeed, Santoalha and Boschma (2021) show that a positive effect of relevant regional capabilities on green diversification in European regions is closely associated with strong political support for environmental policy.

A place-based approach is also important for making the green transition fair and just. The transition towards climate neutrality has a tendency to widen income disparities across regions (Guarascio *et al.*, 2026). The EU introduced the Just Transition Fund into its cohesion policy for 2021-2027 to help regions most affected by the green transition tackle growing inequality. Rodriguez-Pose and Bartalucci (2024) show that vulnerability to the negative externalities of the green transition is indeed positively correlated to GDP levels. This means that less-developed regions are more environmentally exposed, especially in eastern and southern Europe, and therefore risk falling further behind. This stands in contrast to core metropolitan regions that are less environmentally vulnerable. These advanced regions are also characterised by stronger local support for environmental policies and are economically better equipped to address major green challenges.

4. Regional inclusion

As discussed previously, Draghi's recommendations on European competitiveness imply the concentration of vast public resources in the most technologically and economically advanced European regions, many of which are capital regions (e.g. Île-de-France, Stockholm), though some are not (e.g. Noord-Brabant, Oberbayern). Such regions are best equipped to push back technological frontiers because they have the most advanced research infrastructure, a huge supply of human capital, a wide diversity of technological activities and international connectivity (Iammarino *et al.*, 2019). Balland and Boschma (2025) argue that these regions often find themselves in a complexity loop, meaning that their capabilities allow them to diversify into the most complex activities (Rigby *et al.*, 2022; Pinheiro *et al.*, 2025). Balland and Rigby (2017), among others, see a positive correlation between the complexity level of a region's activities (technologies, industries, occupations), its income levels and its long-term economic performance.

It would be good for both competitiveness and cohesion in Europe if this dynamic growth in superstar regions could generate a trickle-down effect, resulting in subsequent growth in less-developed regions. However, there is little evidence of that (Lee, 2024). A main reason for this is that knowledge creation is a cumulative, localised and path-dependent process (Dosi, 1982) that leads regions to develop specific capabilities and follow distinct technological trajectories over time (Storper, 1997). Without regional absorptive capacity, knowledge spillovers remain geographically constrained.

It is well known that innovation has an inherent tendency to widen income disparities (Iammarino *et al.*, 2019; Boschma *et al.*, 2025). A key indicator of innovation is the ability of regions to diversify into new activities (technologies, industries, occupations), which is considered crucial to compensate for inevitable processes of decline in their economies. Research indicates that regional diversification contributes to widening income disparities across regions (Pinheiro *et al.*, 2025) because the diversification opportunity spaces of high-income and low-income regions are completely different. The capabilities of high-income regions provide them with lots of opportunities to move into complex technologies, industries or occupations. In contrast, some low-income regions are stuck in a low-complexity trap: their capabilities do not enable them to move into high-complexity activities (Balland *et al.*, 2019). Other low-income regions have almost no diversification options at all (Tessarin *et al.*, 2025). This has negative economic implications (Balland and Boschma 2025): the more trapped a region in Europe is (that is, the lower its structural capacity to diversify into new (complex) activities), the lower its employment and wage growth. These findings suggest that income disparities across regions in Europe are more likely to be reinforced than reduced by diversification processes.

EU cohesion policy has a long-standing tradition of addressing such regional imbalances (Fratesi, 2025). While competitiveness policy, following Draghi (2024), primarily focuses on technological and economic objectives, cohesion policy embraces a broader conception of development, including social inclusion and well-being, deficiencies of which are disproportionately felt in less-developed regions. For decades, it has served as a key instrument for socio-economic development in less-developed areas. Since 1989, the EU has invested more than EUR 1 trillion in EU regions through its cohesion policy (Rodríguez-Pose, 2025a). Econometric evidence (Ali *et al.*, 2025) demonstrates a positive impact of cohesion policy on regional economic performance over the period 2007-2022, particularly in less-developed and rural

regions. Rodríguez-Pose (2025a, 2025b) argues that the achievements of cohesion policy have been substantial, notably through improvements in infrastructure, fostering of innovation and contributions to sustainable development. Investments in technology and human capital have played a key role in enhancing Europe's overall competitiveness (Capello *et al.*, 2025). Cohesion policy has also contributed to poverty reduction and catch-up growth, especially in eastern Europe (Rodríguez-Pose, 2025a). Furthermore, it has explicitly addressed socio-institutional dimensions of regional development, including institution building, trust in EU institutions and social cohesion (Karo and Kattel, 2015; Rodríguez-Pose and Dijkstra, 2021).

Having said that, the effectiveness of cohesion policy interventions has been context dependent, with considerable returns delivered where institutional capacity is strong (Crescenzi *et al.*, 2016). Rodríguez-Pose and Di Cataldo (2015) show that poor quality of government often forms an obstacle to regional innovation. Cortinovis *et al.* (2017) find that a combination of low quality of government and bonding social capital in European regions impacts negatively on the ability to diversify, especially in less-developed regions. So even when regional capabilities are in place, low institutional capacity prevents successful diversification. Ali *et al.* (2025) confirm that institutional quality is a key factor in cohesion policy effectiveness in terms of regional economic performance. Similarly, it is hard for S3 to deliver in regions with weak institutions and low innovation capacity (Barzotto *et al.*, 2020; Rodríguez-Pose and Ketterer, 2020; Di Cataldo *et al.*, 2022).

In other words, cohesion policy invests in less-developed regions where it activates pools of underutilised capabilities. This type of directional, place-based policy can, together with local actors, explore the specific needs and challenges regions face, select activities that it is feasible to develop and identify local bottlenecks (such as low skills, weak research infrastructure and poor regulations) preventing successful development (Schwab, 2024). European programmes like 'Research and innovation for rural communities' target untapped innovation potential in rural regions and show it is possible to induce innovation-driven growth in non-urban areas (Sasso and Perpiña Castillo, 2025). Ignoring the regional heterogeneity of opportunities would leave untapped the potential of many regions to contribute to EU competitiveness.

5. Discontent and populism

The bottom-up and place-based approach to innovation and competitiveness described in previous sections must aim to be inclusive and participatory (Dąbrowski, 2014; Capello and Perucca, 2019). Active involvement of local stakeholders, such as local authorities, businesses and civil society (Bachtler *et al.*, 2014) is crucial in a Europe concerned about rising populism and growing discontent, especially in lagging regions (European Commission, 2024a; Rodríguez-Pose, 2025a).

A prime example is S3, which has been the flagship of regional innovation policy in the EU since its introduction in 2014. Rather than constituting a top-down planning strategy, it is a decentralised, bottom-up and place-based policy, which has also been described as an 'entrepreneurial discovery process' (Hausmann and Rodrik, 2003). It is grounded in the premise that local stakeholders are best placed to identify the R&I domains in which a region is most likely to excel, given its existing capabilities (Foray *et al.*, 2012). They know best which

market growth potentials are most suitable for exploitation and which bottlenecks hinder their exploitation and growth. The primary focus of S3 is on designing and governing an effective, collective policy process (Rodrik, 2004). In such a policy framework, extensive involvement of local stakeholders is essential, not only in identifying regional potential but also in the implementation process.

This is all happening in a context of growing discontent, rising populism and increasing Euroscepticism concentrated largely, but not only, in 'places that do not matter' (Rodríguez-Pose, 2018). Dijkstra *et al.* (2020) argue that economic decline in regions, combined with poor job opportunities and low educational attainment, result in more votes for Eurosceptic parties. Rodríguez-Pose *et al.* (2023) found that discontent is disproportionally concentrated in European regions that are trapped in persistently low levels of economic growth and declining provision of public services. Their study suggests a close connection between being trapped and support for parties that oppose European integration and resist climate change-mitigation policies.

Concerns have been raised regarding the implications of growing political discontent. Rodríguez-Pose *et al.* (2025) found a negative relationship between support for extreme political parties, especially extreme right-wing parties, and regional levels of scientific research and technological innovation in the EU. This finding also holds for levels of green research and innovation. But these concerns also include increasing political polarisation and instability, lower civic participation, problems building local partnerships and reduced policy effectiveness.

Place-based policy may be crucial in tackling this growing discontent in vulnerable places and its negative consequences for regional development. Firstly, discontent is growing in places that have been confronted with structural economic and industrial decline. As mentioned before, moving out of a regional development trap (Balland and Boschma, 2025) implies building on regional capabilities to exploit local opportunities and activate local stakeholders through tailor-made programmes and avoiding top-down, 'one-size-fits-all' policies. Local contexts are more conducive to addressing concrete problems and finding solutions (Wanzenböck and Frenken, 2020). Secondly, place-based policy at subnational level makes local people feel involved and included in their own development, in contrast to centralised policies, in which regions outside capital cities are reduced to the role of mere spectators. According to Arrighi *et al.* (2022), European citizens have retained more confidence in local politicians than in national politicians. Thirdly, cohesion policy generates visible and concrete results for citizens (Crescenzi and Giua, 2020; Di Caro and Fratesi, 2022). Rodríguez-Pose and Dijkstra (2021) found a positive relationship between cohesion policy investments since 2000 and lower electoral support for Eurosceptic parties.

Consequently, in the 2028-2034 programming period, it is important to maintain a place-based innovation approach that allows regions to be directly involved (Molica, 2025; Molica *et al.*, 2025; Rodríguez-Pose, 2025b). This will avoid fuelling further discontent in vulnerable places, widening core-periphery divides in the EU and weakening territorial solidarity that might harm the European integration process (Rodríguez-Pose and Dijkstra, 2021; Rodríguez-Pose, 2025a).

6. Concluding remarks

This chapter has outlined why place-based strategies are indispensable for tackling societal challenges. Rather than simply serving a regional development agenda, a place-based approach is considered a key pillar of policy for steering economic competitiveness, building technological sovereignty, boosting the green transition, promoting social inclusion and strengthening territorial cohesion in Europe. Directed place-based policies have the potential to bring together and strike a balance between what once seemed like isolated policy areas on competitiveness, security, environment, inclusion and cohesion (Sedita *et al.*, 2025).

In contrast to place-blind policies that are imposed uniformly across heterogenous territories, place-based policies are tailored to exploit opportunities and tackle bottlenecks that are region-specific. To be more effective, EU policies on competitiveness, technological sovereignty, the green transition and cohesion should be capability-based. Region-specific capabilities, as embodied in knowledge, skills and institutions, play a crucial role: they provide opportunities but also impose limits (Boschma, 2017). Regional capabilities provide directionality to policy, as they condition which activities are more feasible and which societal challenges can be taken up most effectively. This type of directed strategy needs to be territorially inclusive to ensure that the wide diversity of regional potentials in the EU is mobilised. All regions matter, but in different ways, as their technological, industrial and institutional histories and underlying capabilities have evolved differently over time. In other words, a place-based approach should not favour a limited number of regions but should activate and exploit the heterogeneous landscape of regional capabilities in Europe. In this respect, it is crucial to promote crossovers across regions and foster collaborations to get access to capabilities elsewhere and exploit synergies (Balland and Boschma, 2021). There is a growing recognition that regions in the EU have not been successful in exploiting potentially beneficial, complementary interregional linkages. Tackling this fragmentation across Member States and exploiting untapped interregional potential through EU-wide collaboration is considered crucial for delivering on policy.

Instead of imposing a top-down approach, place-based policy needs to be locally empowering, involving the participation of local citizens and other stakeholders and the formation of regional partnerships. This is challenging, as regions differ in their capacity to organise collective action and administer and implement effective policies. To tackle societal challenges, place-based policies should be complemented by policies at global, European and national levels (Flanagan *et al.*, 2023). Relevant policy domains, such as trade, fiscal and education policy, are often organised at national and international scale. Such policies are, however, not spatially neutral: their outcomes differ from region to region. This warrants a prominent role for a place-based approach incorporated into a multi-scalar setting to tackle societal challenges (Garcilazoa and McCann, 2025).

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CHAPTER 10

BUILDING THE EU TECHNOLOGICAL LEADERSHIP: ABSOLUTE AND RELATIVE CAPABILITIES IN ADVANCED MATERIALS

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The past 25 years have been marked by a significant expansion in global patenting activity. This process reflects the underlying expansion of global knowledge and innovation. Nevertheless, not all countries have managed to benefit from this process. Innovation remains highly concentrated in space, with the top 10 countries holding 87% of the total patents (World Intellectual Property Organization, 2026).

This persistent concentration reflects deep asymmetries in innovation capabilities rather than temporary gaps in effort or investment. Advanced technological capabilities tend to emerge only in highly diversified and mature innovation ecosystems, where dense networks of scientific, technological, entrepreneurial and production capabilities reinforce one another. Technologically diversified economies can recombine existing capabilities, sustain cumulative learning and move into increasingly sophisticated fields of innovation. This makes concentration not an anomaly, but a defining feature of contemporary innovation dynamics.

The EU has remained one of the world's major hotspots of innovative activity, accounting for a substantial share of global patent filings and technological knowledge creation. However, this position is increasingly under pressure. The rapid rise of China as a technological powerhouse, combined with growing geopolitical fragmentation and strategic competition, has intensified global innovation dynamics and placed the EU's technological leadership under strain (see chapter 4.1).

Moreover, innovation performance today is not solely a matter of volume, but increasingly of direction. Leadership in strategic technologies – such as advanced materials, semiconductors, net-zero technologies and digital infrastructures – plays a decisive role in shaping long-term competitiveness, resilience and economic security. In response, the EU has progressively reoriented its policy framework towards fostering specialisation in these strategic domains (European Commission, 2025).

Measures of the potential for countries and regions to innovate in emerging strategic areas usually rely on pre-existing stocks of related capabilities, such as human capital or technical know-how. The economic complexity framework (Hidalgo and Hausmann, 2009; Tacchella *et al.*, 2012), and in particular the literature on relatedness (Hidalgo *et al.*, 2007), have put forward several metrics – such as relatedness density (Hidalgo *et al.*, 2018; Li and Neffke, 2024) – that convey information on how close a country, region or city is to acquire specialisation in a target technology. Such measures are inspired by the principle of relatedness (for a review, see Hidalgo *et al.*, 2021), according to which new economic activities are more likely to emerge and succeed in places where similar activities already exist. Relatedness metrics leverage information on pre-existing economic or technological specialisation patterns, combined with the degree of proximity between such activities. However, they assess a degree of relatedness that is irrespective of external and internal constraints such as competition or limited resources. These are referred to as absolute capabilities.

While useful in their own right, such measures of relatedness fall short in assessing the effective ability of policymakers to mobilise existing related capabilities towards the target. By combining measurement of absolute capabilities (relatedness density) with metrics that predict the likelihood of countries to develop significant specialisation, policymakers can gain new insights into investment decisions and their trade-offs, especially given competing priorities. Building on this idea, absolute capability measurements can be complemented with metrics that focus not on whether countries or regions could

theoretically develop new technologies, but on the likelihood of them actually doing so. These metrics, which will be referred to as relative capabilities, estimate probabilities that account for various constraints (technological or otherwise) that might limit a territory's ability to specialise in new activities despite having related absolute capabilities[1].

Advanced materials make a very suitable case to examine how relative and absolute capabilities can be used to inform innovation policies. The first reason is that advanced materials have recently occupied an important place on the EU's policy agenda, due to their potential to enable innovation across a wide range of industrial sectors. This is demonstrated by the recent communication[2] *Advanced Materials for Industrial Leadership*, which sets the EU's overarching approach to build a dynamic, secure and inclusive advanced materials ecosystem, and which paves the way to the upcoming *Advanced Materials Act*[3]. A broad overview of the EU performance in advanced materials patents has been outlined in Albora *et al.* (2025a). Secondly, advanced materials categories such as composite materials, nanomaterials, and biomaterials[4] cover a broad scope in the realm of the relationship between relative and absolute capabilities. They also capture three different placements for the EU in terms of predicted performance: the EU has been found to have strong opportunities in composites but lags behind in nanomaterials, while biomaterials seem to provide reachable opportunities to the EU and its competitors alike (Albora *et al.*, 2025a). Focusing on these three technological classes is especially useful for outlining the heterogeneity of the EU's technological positioning across advanced materials, and in illustrating how differentiated capability endowments translate into distinct innovation trajectories, competitive pressures and policy needs.

1. Measuring capabilities with economic complexity

A country's economic growth and development can be boosted by embracing a diverse range of industries, rather than specialising in just one area. Classical economic theories, such as Ricardo's theory of comparative advantage, suggest that specialising in a particular sector can lead to greater efficiency and productivity; if countries produce only 'what they are relatively good at', employing factors of production that abound in their endowments, the resulting aggregate output will be larger compared to a scenario where all countries produce all products. The free trade of produce enables the sharing of the aggregate output. However, growing evidence that diversity increases as countries develop (Imbs and Wacziarg, 2003) has put this model of economic development into question and suggested that, instead, accumulating multiple capabilities can benefit the expansion

1 One such measure has been proposed in recent reports (Albora *et al.*, 2025a; 2025b) with the name of Technological Progression Probability (TPP). TPP quantifies the probability for a given country or region to develop a Revealed Comparative Advantage (RCA) in a given technological area in a period of 5 years after the observed data.

2 Commission Communication, COM(2024) 98: https://data.consilium.europa.eu/doc/document/ST-7172-2024-INIT/en/pdf

3 https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/chemicals-and-advanced-materials/towards-advanced-materials-act_en

4 Composite materials are engineered materials made by combining two or more distinct constituents, typically a matrix and a reinforcement acting together to deliver superior properties (e.g. carbon-fibre-reinforced polymers). Nanomaterials are materials with at least one dimension in the 1 to 100 nanometre range, leading to enhanced properties (e.g. titanium dioxide nanoparticles used in self-cleaning or anti-pollution coatings). Finally, biomaterials are materials designed to interact with biological systems for medical, pharmaceutical or biological applications; they include also biomass.

of the economy in different sectors and foster economic growth (Hidalgo and Hausmann, 2009; Tacchella *et al.*, 2012; 2018).

However, having the capability to produce a given product or technology does not necessarily imply that a country also holds a comparative advantage in that product. The textile industry serves as a good example. While advanced countries have the capabilities to produce textiles, as shown by their exports, their textile output is usually small compared to their overall production. Therefore, advanced countries often lack a comparative advantage in this sector, as their resources can be used more productively elsewhere. This highlights the importance of considering the constraints that limited resources and competing priorities can impose on industrial policies when evaluating technological opportunities.

Economic complexity highlights the importance of accumulating capabilities, which can be recombined in various ways to drive economic growth. However, as mentioned above, achieving full diversity is hindered by limitations such as resource constraints and the rivalry of capabilities. To better understand these dynamics, it is useful to introduce two distinct measures of capabilities: relatedness density and Technological Progression Probability (TPP)[5], which capture the absolute and relative capabilities of a territory, respectively, and account for the trade-offs countries and regions face when specialising in new activities.

The tension between the need for capabilities and their effective availability may have important consequences for policy goals. It might, in fact, not be sufficient to have many relevant capabilities to develop a technology if those capabilities are required somewhere else. At the same time, it may not be sufficient to have available capabilities if they are not enough to achieve policy goals (e.g., technological sovereignty or strategic autonomy). The former is an example of how relative capabilities can hamper absolute capabilities, while the latter illustrates the opposite.

The joint use of metrics accounting for the absolute and relative capabilities embedded in the countries and regions of the EU is crucial for policymakers. While relatedness density identifies candidate territories in which targeted policies and research support may effectively nurture emerging capabilities, progression probabilities aim to help prioritise areas where such efforts are more likely to yield tangible economic returns. Using both perspectives in conjunction allows policy to move beyond a binary view of technological 'strengths' and 'weaknesses', and instead design differentiated, place-based strategies that balance long-term capability building with near-term competitiveness objectives across Member States and regions. This approach builds on previous economic complexity work focused on predicting countries' entry into new advanced materials technologies based on relative capabilities (Albora *et al.*, 2025a)[6], and extends it by examining potential in terms of absolute capabilities, allowing for a more comprehensive understanding of a country or region's ability to expand and innovate in a given technology, even without gaining a comparative advantage.

5 Relatedness density quantifies the absolute distance between a country/region's technological portfolio and a target technology, while TPP estimates the probability of future specialisation in a target technology based on past patterns, using a machine learning model that considers potential competition effects between technologies.

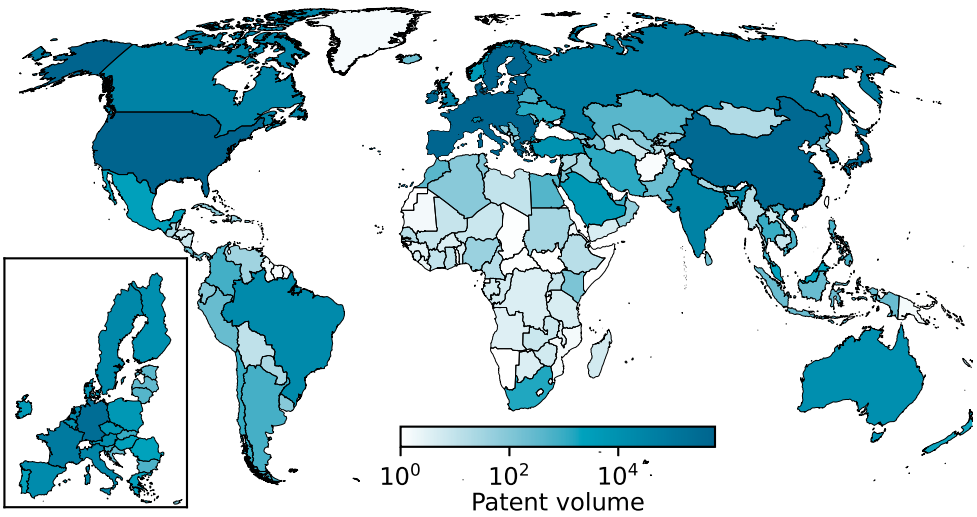
6 This report on advanced materials assessed countries' current and potential comparative advantage profiles, but did not account for absolute capabilities.

2. An outlook on EU performance and innovation capabilities

Absolute and relative performance in innovation

Although the number of patents worldwide has increased in recent years, innovation remains largely concentrated among a few major players. Patent volumes only tell part of the story on technological performance and economic opportunities, and a relative approach considering economies' constraints is required for a more comprehensive outlook. As Figure 10-1 shows, technological knowledge is concentrated in the US, the top performer in terms of patent applications, followed by the EU, South Korea, Japan and China. When analysing the volume of patents filed by Member States rather than the EU as a whole, only two Member States appear among the top 10: Germany (5th) and France (6th) (see bottom-left inset map of Figure 10-1). However, the number of successful patent applications filed provides only a partial outlook on the development opportunities and economic advantages gained by countries.

Figure 10-1 **Patenting activity worldwide, 2017 –2021**



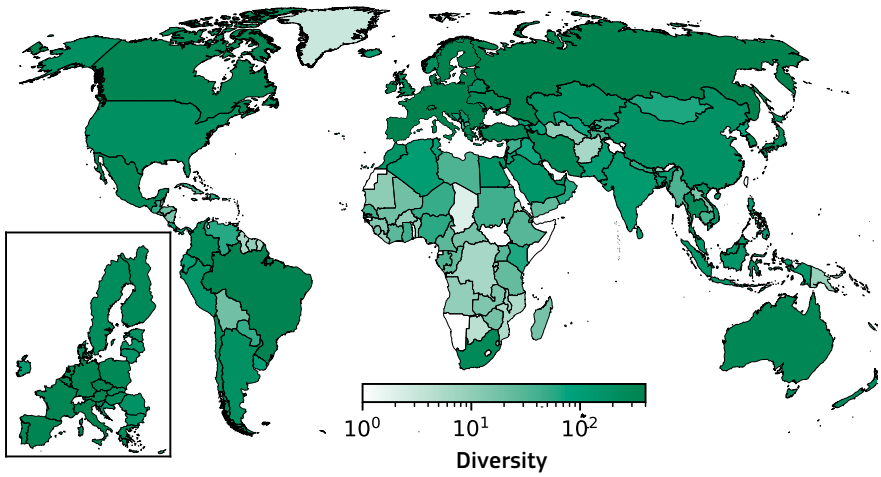
Science, Research and Innovation Performance of the EU 2026

Source: Joint Research Centre based on PATSTAT (Autumn Edition 2023, all patents).

Note: Patent volume refers to the number of patents filed (all technologies) in 2017–2021. In the world map, the EU is considered a unique country. Member State-level data are specified in the bottom-left inset map.

Leadership in technological innovation is not always related to the number of patents per se, but rather to strategic specialisation in given technological domains. Specialisation in certain sectors can be more advantageous for some countries than others; this can be measured indirectly using the RCA of a country in each technology. The map in Figure 10-2 shows countries' diversity, i.e., the number of technologies in which a country is specialised. When economic constraints are taken into account through the RCA, the US no longer holds the top position but is replaced by the EU. In terms of diversity, Italy emerges as the top performer, followed by Czechia, Russia, Austria and Spain. Although the US has the largest pool of patents, not all sectors can be equally advantageous, resulting in the country's diversity ranking falling outside the top 10.

Figure 10-2 **Relative patenting performances in the world, 2017–2021**



Science, Research and Innovation Performance of the EU 2026

Source: Joint Research Centre based on PATSTAT (Autumn Edition 2023, all patents).

Note: Diversity refers to the number of technologies with RCA by country, based on the patents filed (all technologies) in 2017–2021. In the world map, the EU is considered a unique country. Member State-level data are specified in the bottom-left inset map.

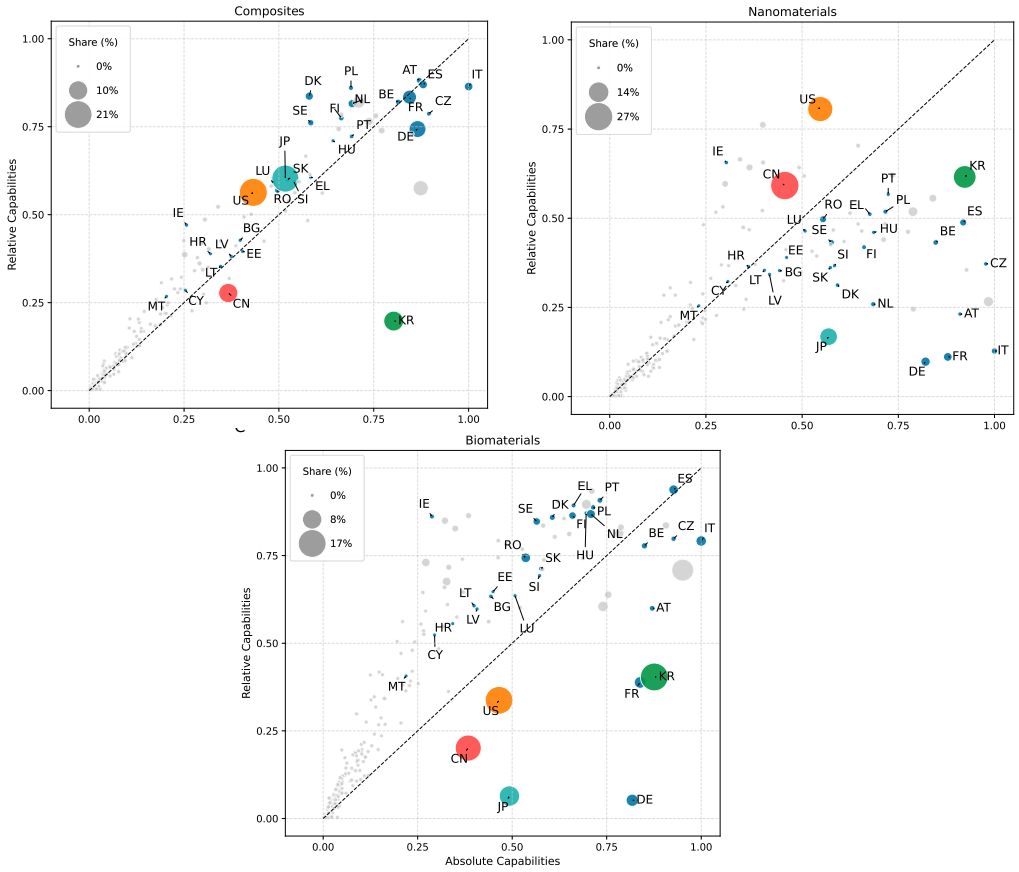
Understanding a country's full technological potential requires leveraging a broader set of metrics that capture both the absolute and relative capabilities. A simple comparison between patent volume and technological specialisation of countries demonstrates the need for both measures to provide more accurate information on the technological profile of countries. However, these two measures reflect the current state of an economy and its placement among competitors. By applying the economic complexity framework to patent data, it is possible to predict the potential diversification and specialisation of an economy by comparing a country's absolute and relative capabilities. Absolute capabilities relate to the accumulation of capabilities that can, in principle, be exploited for further technological development. Similarly, patent volume measures patent accumulation. In contrast, relative capabilities consider the constraints imposed by the pool of relevant competitive sectors and the presence of competitors, predicting the likelihood for an economy to gain a comparative advantage in the near future. This relative measure of capabilities quantifies the ability of the economy to effectively exploit accumulated capabilities to develop new ones.

Absolute and relative capabilities of the EU and its main competitors in advanced materials

Absolute and relative capabilities vary across technological fields. While alignment between the two is ideal and always desirable, relative capabilities may either underperform or outperform absolute ones.

Across different advanced materials technologies, Figure 10-3 identifies three distinct scenarios. In general, a positive correlation emerges between absolute and relative capabilities: countries that are well endowed with relevant absolute capabilities also tend to exhibit higher probabilities of future comparative advantage. However, this relationship is not uniform across technologies or countries.

Figure 10-3 Absolute vs relative capabilities of Member States and main competitors



Science, Research and Innovation Performance of the EU 2026

Source: Joint Research Centre based on PATSTAT (Autumn Edition 2023, all patents).

Note: Data refer to the 5-year period from 2017 to 2021. For each technology, relevant patents are first identified via natural language processing (NLP), comparing patents' abstracts and technology descriptions and then aggregated by regions[7]. The x-axis indicates absolute capabilities as measured by the relatedness density, and the y-axis indicates the relative capabilities as measured by the TPP. The diagonal line defines the perfect match between absolute and relative capabilities. The size of the dots is proportional to the share of the country in the technology fixed on the plot. The blue coloured dots highlight the Member States of the EU. The blue coloured dots highlight the Member States of the EU, specifically, AT: Austria; BE: Belgium; BG: Bulgaria; CY: Cyprus; CZ: Czech Republic; DE: Germany; DK: Denmark; EE: Estonia; ES: Spain; FI: Finland; FR: France; EL: Greece; HR: Croatia; HU: Hungary; IE: Ireland; IT: Italy; LT: Lithuania; LU: Luxembourg; LV: Latvia; MT: Malta; NL: Netherlands; PL: Poland; PT: Portugal; RO: Romania; SE: Sweden; SI: Slovenia; SK: Slovakia. Other coloured dots refer to non-EU countriest: CN: China; JP: Japan; KR: South Korea; US: United States. The rest of the world is coloured in grey.

7 See the Handbook of Economic Complexity (European Commission, 2024) for additional methodological details.

In the field of composite materials, a country's technological capabilities are a strong indicator of its potential for future specialisation. In the case of composite materials, as shown in Figure 10-3A, absolute and relative technological capabilities tend to coincide, indicating a strong correlation between the two. Countries with higher relatedness density typically display higher TPP values, suggesting that the presence of relevant capabilities is a good indicator of the likelihood of future specialisation. South Korea is a notable exception, as it combines high absolute capabilities with low relative ones. This pattern suggests that, despite South Korea being one of the most capable countries in composite materials in absolute terms, the technology does not represent a particularly strong opportunity when evaluated relative to the country's overall technological portfolio. In other words, composites are unlikely to become a major source of comparative advantage for South Korea compared to other technologies in which it is active. In contrast, many Member States are well-positioned in composite materials, with solid absolute capabilities and high relative capabilities. Several EU countries, including Italy, Austria, Germany and Czechia, show capabilities on par with – or even better than – major competitors such as the US, China, Japan and South Korea. This indicates a favourable positioning of the EU in composite materials, both in terms of existing capabilities and future specialisation potential.

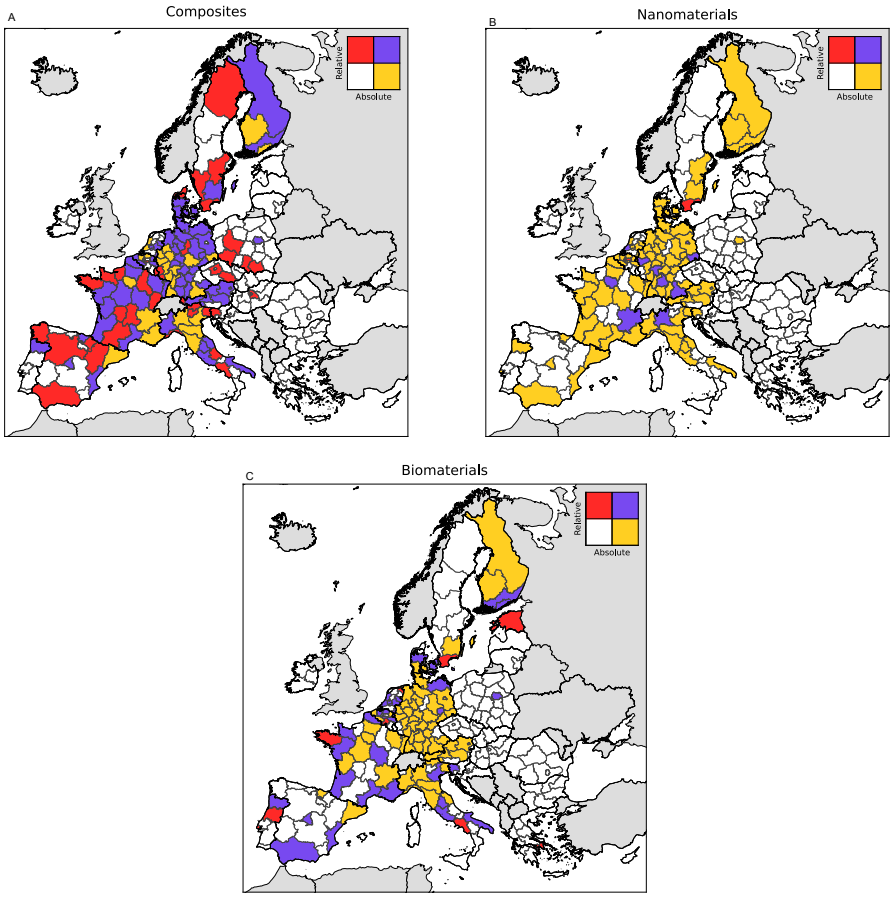
The development of nanomaterials presents a unique challenge, where having strong technological capabilities does not necessarily guarantee a competitive advantage. A different dynamic emerges in the field of nanomaterials, as depicted in Figure 10-3B. Here, the correlation between absolute and relative capabilities weakens, particularly at higher levels of relatedness density. This dispersion implies that, although many countries possess the technological prerequisites needed to develop nanomaterials, only a limited subset of them is likely to translate these capabilities into an RCA. In other words, the presence of related capabilities alone does not guarantee future specialisation in this field. Within the EU, Ireland stands out as the only Member State with relatively lower absolute capabilities but comparatively higher relative capabilities, suggesting a potential opportunity. All other Member States display probabilities of developing an RCA lower than those of China, the US and South Korea.

The biomaterials sector offers a promising opportunity for the EU to gain a competitive advantage, but it also poses significant challenges for countries seeking to establish themselves as major players. In this case, most countries are located above the diagonal, indicating that relative capabilities tend to exceed what would be predicted by absolute capabilities alone. This suggests that biomaterials could be an opportunity for the EU as a whole to gain an advantage (in line with the broader findings of the report by Albora *et al.*, 2025a). Interestingly, several of the largest global players in biomaterials – including the US, China, South Korea and Germany – are positioned below the diagonal. While these countries account for a large share of global biomaterials patents in absolute terms, this technology represents a relatively smaller component of the aggregate inventive activity, resulting in a comparative disadvantage when evaluated in relative terms. For EU countries positioned above the diagonal, however, the presence of large incumbent players with substantial patenting activity implies that, despite favourable prospects for comparative advantage, they may still remain minor players in global markets.

EU regional analysis of absolute and relative capabilities in advanced materials

The regional landscape of technological capabilities can be nuanced, with local strengths and weaknesses often differing from national trends. When examining the distribution of absolute and relative capabilities across regions, a more complex picture emerges. As the analysis of composite materials, nanomaterials and biomaterials reveals, regional capabilities can exhibit non-linear relationships with national-level capabilities, with some regions punching above their weight and others facing unique challenges. The maps in Figure 10-4 complement the information provided by the scatter plots in Figure 10-3 by evaluating the absolute and relative capabilities of EU regions at level 2 of the Nomenclature of Territorial Units for Statistics (NUTS2).

Figure 10-4 Absolute vs relative capabilities of EU NUTS2 regions



Science, Research and Innovation Performance of the EU 2026

Source: Joint Research Centre based on PATSTAT (Autumn Edition 2023, all patents).

Note: Data refer to the 5-year period from 2017 to 2021. For each technology, relevant patents are first identified via NLP, comparing patents' abstracts and technology description and then aggregated by regions[8]). Maps comparing the regions' absolute technological capabilities (relatedness density) and relative ones (TPP). The colours categorise regions as locations of low-to-high absolute capabilities (categories discern for the value to be less or greater than the average) and the probability of gaining an RCA in the next 5 years (categories discern for the probability to be less or greater than 50 %). Red regions are those with low absolute capabilities but high relative ones; yellow regions are those with low relative but high absolute capabilities. Top potential performers are in purple.

8 See the Handbook of Economic Complexity (European Commission, 2024) for additional methodological details.

In the case of composite materials, the alignment of regions' absolute and relative capabilities determines the competitive edge of countries. Considering all regions within a single Member State, the results are in line with those shown in Figure 10-3. Among the three technologies under consideration, composite materials are the ones in which absolute and relative capabilities align. As Figure 10-4A shows, for example, that most German regions see a match between relative and absolute capabilities, except for a few where the relatedness density outweighs the TPP indicator. This result is in line with Figure 10-3, which locates the country slightly below the diagonal line. The rest of the EU countries are mostly scattered with red or purple colour regions, confirming the competitive edge of the EU in this technological field.

The potential for comparative advantage in nanomaterials is limited for most EU regions, despite some areas showing high technological capabilities. For nanomaterials (Figure 10-4B), the analysis at the regional level confirms the low potential for comparative advantage of most EU regions. Nevertheless, high technological capabilities are observed for some regions, especially across Italy, Germany and France. Interestingly, the strong potential for comparative advantage observed for Ireland (Figure 10-3A) is not matched in the regional analysis. Especially for smaller countries, comparative advantage can result from the joint efforts of all the innovative activities of their regions, despite the regions' constraints and their low level of relative capability.

Peripheral regions can play a crucial role in driving innovation and competitiveness in emerging technologies like biomaterials. Finally, in the case of biomaterials (Figure 10-4C), the results are in line with those for nanomaterials, but the map brings to the attention the key role of more peripheral regions. Andalucía in Spain and Puglia in Italy, for instance, are among the regions with the highest absolute and relative capabilities.

Interpretation and policy use

The analysis reveals that the relationship between absolute and relative technological capabilities is complex, and understanding their interplay is crucial for informing policy decisions that can drive innovation and competitiveness. The analysis of three advanced material technologies – composites, nano and biomaterials – reveals that the distinction between relative and absolute capabilities is not always clear-cut. While the two dimensions often align, there are many situations where one outweighs the other. High absolute and low relative capabilities indicate strong competences that may be needed in other sectors or technologies, making a policy push to stimulate development potentially successful; however, this might occur at the detriment of other technologies and might not fully result in the specialisation of the country in that technology. Conversely, high relative and low absolute capabilities may have higher chances of succeeding without policy intervention, but may be less impactful. Sure enough, low absolute capabilities indicate a lower quantity and variety of competence, which in turn may mean fewer dynamic externalities and future growth opportunities.

The implications of this interplay are significant for EU countries seeking to innovate and gain a competitive advantage in advanced material technologies. Some EU countries, such as Ireland in nanomaterials or Romania in biomaterials, have high relative and low absolute capability levels, making innovation a viable option because of the high probability of gaining an RCA despite a low absolute capability level. However, the overall gain may be small and insufficient to enhance the EU's competitiveness as a whole. In con-

trast, countries like Germany, Spain and France have lower probabilities of gaining a comparative advantage but exhibit higher shares and capabilities, offering greater potential benefits due to their larger size – but also potentially more constraints.

Combining relative and absolute indicators gives a richer and more nuanced picture, which can help design tailored policies for very specific cases. This comes at the cost of a generalisation of policy recommendations. Notwithstanding, some key messages can be extracted, distinguishing two more general cases. First, if the aim of policy is to foster innovation in a country or region, but the aim comes without a specific technological priority, relative measures can be of great help. It gives an indication of the probability that a territory will successfully develop a technology. Policymakers can thus rely on relative indicators to prioritise a technology. Second case, if the aim instead is to foster a target technology, the absolute measure can help prioritise regions or countries, as larger absolute capabilities may be a signal of stronger impact. Nevertheless, in both cases, it is wise to take into account the other indicator, as together they can give a sense of the potential impact in the broader technological and economic landscape.

3. Conclusions

The EU position in advanced materials varies across technologies, which requires informed policies that consider the relative and absolute strength of Member States. The EU holds a leadership in these composite materials and – fittingly – high capabilities are observed in the bloc, both in relative and absolute terms. This implies there may be ample opportunities for the EU to further expand this sector.

On the other hand, Member States show strong absolute, but weak relative capabilities in nanomaterials. These results indicate that, although the competences to expand innovation in this sector are present across the EU, it is unlikely that this would result in the development of a comparative advantage. The required competences are likely employed in other sectors and technologies, making it costly to switch to nanomaterials.

Lastly, for biomaterials, the EU has great potential to develop a comparative advantage; however, it exhibits lower absolute competences, implying that the impact of growth in biomaterials might be lower. Policies could take these differences into account, for instance, by mitigating the strain on scarce resources that the development of biomaterials might entail.

Effective policies can incorporate these lessons to help countries and regions build on their strengths and address their weaknesses, driving innovation and competitiveness. Policies should, in fact, take into account that the development of a technology might be hampered if the required capabilities are in use in other sectors or for other technologies. Future research could explore this mechanism further, refining both our measurement and our understanding of the ideal policy response in such situations.

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CHAPTER 11

PRODUCTIVITY AT THE CROSSROADS OF TECHNOLOGICAL TRANSITIONS

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Recent years have seen rising productivity dispersion in many economies, with widening gaps between firms at the technology frontier and those lagging behind. Going forward, productivity will be shaped by two structural transitions that are transforming how firms innovate, invest and organise production. On the one hand, the digital transformation has the potential to substantially affect productivity, as artificial intelligence (AI) – and in particular, recent advances in generative AI – increasingly displays key features of a general-purpose technology. On the other hand, the net-zero transition is already reshaping production processes as economies decarbonise, requiring changes in investment and innovation that can affect productivity through short-run adjustment costs and longer-run efficiency gains. At the same time, these technological transitions affect each other in complex ways. Digital technologies can support decarbonisation by improving efficiency and enabling innovation in 'clean' technologies, while the expanding footprint of digital infrastructure may affect net-zero targets by raising energy and resource demands.

This chapter explores how the digital and net-zero technological transitions, and the interactions between them, are likely to shape productivity outcomes. It focuses on the key mechanisms linking these transitions to both aggregate productivity performance and productivity dispersion, drawing on recent evidence at the firm and sector levels. The chapter highlights the implications of uneven diffusion, differing complementary capabilities and heterogeneous adjustment pressures. It concludes by outlining policy directions to support diffusion and capability building that could trigger broad-based productivity gains.

1. How will the digital transition affect productivity and divergences?

Digital transformation in the age of AI

The transformative effects of the digital transformation, and especially the recent diffusion of AI and other advanced digital technologies, have sparked renewed debate in the academic literature and among policymakers around the productivity and growth implications of this transition. While digital transformation refers to broad organisational change enabled by multiple digital technologies (and digitalisation to the digitisation of activities and information), recent breakthroughs in AI, particularly generative AI, have made AI a central catalyst in the current transformation, increasingly driving and amplifying these changes.

An emerging body of literature studies the productivity potential of AI, documenting productivity gains from its adoption at the worker level (Calvino *et al.*, 2025d; Noy and Zhang, 2023; Brynjolfsson *et al.*, 2025). At the aggregate level, the expected productivity impacts of AI vary depending on assumptions regarding exposure, the speed of adoption and task-level productivity gains. Estimates range from less than 1% over a decade (Acemoglu, 2025) to more than a percentage point annually (Aghion and Bunel, 2024; Filippucci *et al.*, 2025), where diffusion dynamics are central to turning technology into measured gains (see also chapter 7).

* The opinions expressed and arguments employed in this chapter are those of the authors, and do not necessarily reflect the official views of the OECD or its Member countries.

The transformative potential of AI technologies may become especially relevant with recent advances in generative AI in the form of large language models (LLMs). Generative AI may act as a long-run driver of growth, as the technology appears to fulfil the key characteristics of a general-purpose technology: widespread diffusion (pervasiveness), continuous improvement over time, and innovation spawning (driving follow-on innovation) (Calvino *et al.*, 2025c). As such, AI may not only increase productivity levels, but also long-run productivity growth.

Digital transformation increasing productivity through innovation

The digital transition may also positively affect long-term productivity by accelerating innovation activity across sectors. For example, in a case study in Italy, digital technologies have been found to increase the likelihood of research and development (R&D) to result in patented innovation (Calvino *et al.*, 2022). In particular, the applicability of AI has been associated with the 'invention of a method of invention' (Crafts, 2021; Cockburn *et al.*, 2019). Indeed, generative AI patents appear to be playing a key role in spawning follow-on innovations (Calvino *et al.*, 2025c). Additionally, it has been suggested that AI will increase returns to R&D investments (Jones, 2025; Besiroglu *et al.*, 2024).

At the firm level, innovation in technologies at the core of the digital transformation has been positively related to productivity. Recent Organisation for Economic Co-operation and Development (OECD) evidence shows that firms that patent technologies related to the Fourth Industrial Revolution (4IR), such as AI, quantum computing, autonomous vehicles and smart data management systems, are more productive than similar firms without 4IR patents (Calvino *et al.*, 2025b). However, these 4IR-patenting firms also tend to already be larger and more productive than non-4IR patenting firms, indicating potentially unequal benefits of 4IR innovation between leader and laggard firms. Focusing on AI, an emerging literature has highlighted the positive link between AI innovation and productivity (Damioli *et al.*, 2021; Alderucci *et al.*, 2024), with firms developing AI in France shown to experience positive productivity returns beyond selection (Calvino and Fontanelli, 2024).

Lessons from the ICT era: the Solow paradox, the J-curve and cross-country differences

Historically, during the early emergence of information and communication technologies (ICTs), productivity improvements were not immediately observed – a pattern often described as the 'Solow paradox' (Solow, 1987; David, 1991; Brynjolfsson, 1993). Over time, however, macro- and micro-level evidence showed that ICTs contributed significantly to productivity growth through capital deepening, process re-engineering and improved efficiency in information flows (Draca *et al.*, 2006; Cardona *et al.*, 2013; Pilat, 2004; Colecchia and Schreyer, 2002). For example, ICT is estimated to have contributed between 0.3 and 0.9 percentage points per year to economic growth in the second half of the 1990s across OECD countries, with larger gains in the US than in European countries (Colecchia and Schreyer, 2002).

This is consistent with the 'J-curve hypothesis': the introduction of a general-purpose technology does not immediately benefit productivity, which may initially even decline. Instead, productivity gains depend on complementary assets, such as skills, data, software and organisational capital, which need to be acquired in parallel, and may not materialise until workflows are re-engineered. As complementary assets accumulate with continued investment, positive productivity impacts may only be realised in the medium- to long-run (Brynjolfsson *et al.*, 2021). For the EU, direct pro-

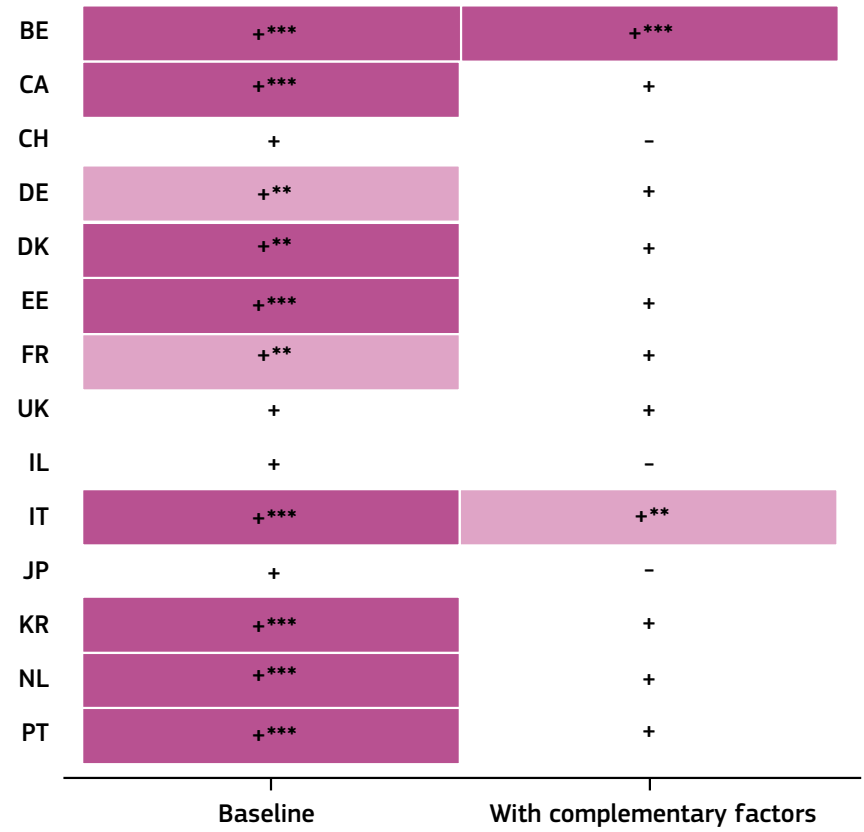
ductivity contributions from digital-producing industries (such as electrical and optical equipment, publishing, audiovisual and broadcasting activities, telecom services and IT and other information services) have been comparatively smaller than in the US, where the digital-producing sector, despite its small share in the economy, contributed to the majority of labour productivity growth in the period of 2013 to 2017. Meanwhile, it is the adoption of digital-intensive industries that has contributed more to high EU labour-productivity growth in this period, an important structural difference for understanding the EU-US productivity gap (van Ark *et al.*, 2019). This production-side comparison may nevertheless understate EU welfare gains if some of these US productivity gains are passed through to EU customers in the form of lower prices for digital and digital-intensive goods.

Productivity gains from digital technology adoption depend on firms' characteristics

Beyond frontier innovation, an important mechanism through which digital transformation may affect productivity is the adoption of advanced technologies by the wider firm population. In a cross-country context, Calvino and Fontanelli (2023) find that AI adopters tend to be more productive than other firms due to their higher human and technological capital. This is corroborated more recently also for other advanced digital technologies such as big data analytics, Internet of Things, robotics and 3D printing, where EU adopters of most digital technologies are more productive than their non-adopting counterparts (Calvino *et al.*, 2026). This is illustrated in the first column of Figure 11-1, which focuses on AI.

However, when considering complementary factors related to human and technological capital, a more nuanced picture emerges. While more established technologies such as big data and robotics are still associated with higher productivity, this is not the case for AI. This is illustrated in the second column of Figure 11-1, which shows that the relationship between AI adoption and productivity generally does not remain statistically significant after adjusting for the abovementioned complementary factors. When comparing firms with similar levels of human and technological capital, the remaining difference in productivity is more plausibly linked to AI adoption itself. In this adjusted comparison, most adopters of the technology do not appear to be significantly more productive than non-adopting firms of similar size or age in the same sector. However, this does not imply that no productivity gains from AI are to be expected. In fact, the pattern is consistent with the J-curve hypothesis: thus far, the adoption of AI, a more recent technology, may not yet have materialised in measurable productivity gains, much like the early phases of ICT diffusion. This is less the case for more mature technologies such as big data, the Internet of Things and robotics, which may already be better integrated in production processes. The results in Calvino *et al.* (2026) illustrate that in many OECD countries, productivity advantages of these technologies exist even when accounting for human and technological capital. These findings generally hold for countries both in and outside of the EU, although they refer to a period preceding the more recent boom in generative AI.

Figure 11-1 Regression results on use of AI by firms and productivity, with and without taking human and technological capital into account



Science, Research and Innovation Performance of the EU 2026

Source: OECD based on Calvino *et al.* (2026).

Note: The figure presents the sign and statistical significance of the coefficients on AI use indicators in productivity regressions, estimated separately for each country. The dependent variable is the logarithm of firm-level productivity, measured as turnover over employment. The key explanatory variable is a binary indicator for whether a firm uses AI. All regressions are weighted, except for Canada, Germany and South Korea. Although not reported, the model includes, where available, controls for firm size and age classes, sector and year fixed effects. In the second column, the regressions also include control variables that account for the role of human and technological capital: broadband use, presence of ICT specialists, ICT training and digital technology intensity. Years in estimation sample by country: Belgium (2021, 2023); Canada (2023); Denmark (2016-2018, 2020); Estonia (2022-2023); France (2020, 2022); Germany (2018, 2020); Israel (2020); Italy (2021, 2023); Japan (2019, 2021); Netherlands (2020-2022); Portugal (2020, 2022); South Korea (2017-2019); Switzerland (2018-2020); UK (2023). Statistical significance is denoted as follows: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Digital transformation risks further increasing productivity divergence

While the digital transformation is expected to have considerable impacts at the aggregate level, given the uneven diffusion of digital technologies, these effects are likely to be heterogeneous across sectors and firms. At the sectoral level, the invention and diffusion of digital technologies remain highly uneven, with uptake concentrated in the ICT sector and among large, already digital and high productivity firms. Microdata from cross-country studies show this for the diffusion of advanced digital technologies such as AI (Calvino and Fontanelli, 2023; Calvino *et al.*, 2026), big data analytics,

robotics, Internet of Things and 3D printing (Calvino *et al.*, 2026), as well as for other technology classes such as IT systems, digital workplace, digital sales, business/industry software, and advanced applications and analytics (Calvino *et al.*, 2024a). Consistent with these findings, substantial gaps between sectors are also evident across different dimensions of AI intensity, such as AI human capital, AI innovation or actual AI use (Calvino *et al.*, 2024b), in line with earlier findings on the sectoral heterogeneity of digital intensity (Calvino *et al.*, 2018). The ICT sector appears to lead in the development, skill demand and use of the technology.

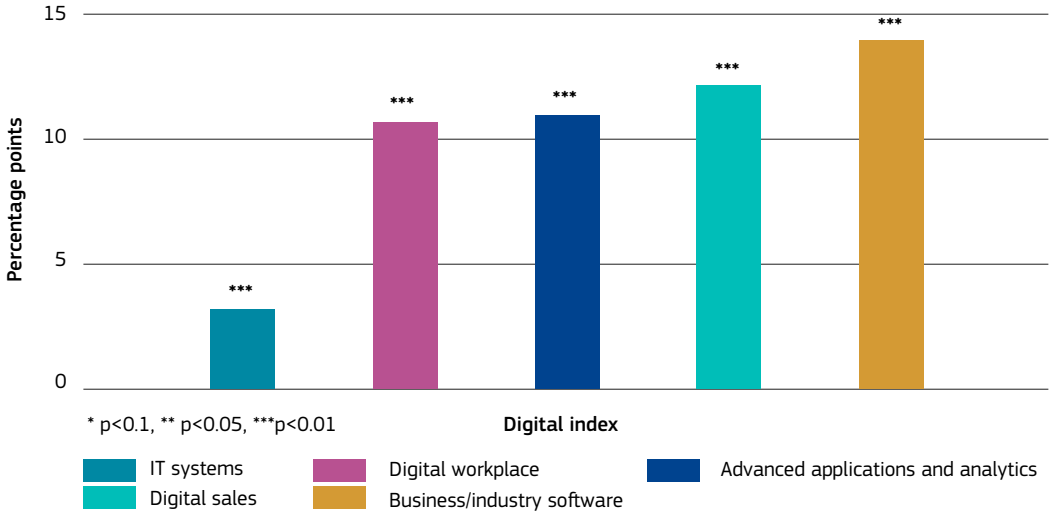
Furthermore, considerable gaps in digital technology diffusion are evident when comparing large and small firms, with larger firms consistently exhibiting a greater propensity for technology use. This is the case of advanced digital technologies across several OECD countries, including all EU Member States represented in the sample, even after taking into account the sectoral composition of economies (Calvino *et al.*, 2026), and is notably the case for AI (Calvino and Fontanelli, 2023). In fact, throughout 2024, significant gaps in AI use remain between large firms and small and medium enterprises (SMEs) (OECD, 2025a). Similarly, firms at the core of the supply chain network are more likely to be digital, as evidenced in the case of Estonia (Criscuolo *et al.*, 2025).

Firm-level evidence also points to a potential rise in productivity divergence. Following the J-curve hypothesis, firms with higher human and technological capital are better positioned to realise productivity gains from digital technologies. Early evidence on France corroborates this hypothesis by focusing on a subgroup of AI users with stronger digital capabilities: those developing AI in-house (Calvino and Fontanelli, 2024). A finding that emerges from Calvino *et al.* (2026) is that human and technological capital are associated with a higher likelihood to adopt advanced technologies, pointing to a selection effect. While technology adopters are more productive than non-adopters before such factors are considered, this productivity advantage is reduced when accounting for human and technological capital, or in the case of AI, almost disappears (see Figure 11-1, comparing the first and the second columns). This not only suggests that it is the most productive, more digitally adept firms that adopt in the first place, but also that divergences may increase, as those appear best positioned to realise further productivity gains as technologies such as AI mature. 3D printing appears to be an exception, where productivity advantages are not broadly observed, potentially due to its specific role in manufacturing (Calvino *et al.*, 2026).

Whether frontier gains translate into broad-based productivity growth then depends on competition and diffusion conditions. Where product-market competition is weak or diffusion channels are constrained due to a lack of complementary assets, frontier gains are unlikely to spread to less productive firms, and aggregate productivity growth will underperform. Firm-level evidence across OECD economies has shown that stronger divergence between the best-performing firms and the rest is more prevalent in sectors with scalable digital technologies and less competition (Andrews *et al.*, 2016). Additionally, digital-intensive sectors are more dynamic on average than other sectors, but have experienced stronger declines in dynamism recently, which may indicate increasing divergence between firms (Calvino and Criscuolo, 2019). The digital transformation may therefore exacerbate existing trends of increasing inequality among firms and, by extension, wages (Criscuolo *et al.*, 2021).

The COVID-19 pandemic (2020-2021)[2] appears to have amplified these dynamics. The acceleration of digitalisation during this period was driven by larger and more productive firms, contributing to a widening technological divide and a decline in business dynamism (Cho *et al.*, 2024). It has been shown that more productive firms were more likely to embrace digital technologies during the pandemic and thus may be able to better harness the productivity benefits from the digital transition going forward (Calvino *et al.*, 2022; 2024a). Additionally, firms investing in new digital products were also already more digitalised, as is illustrated in Figure 11-2. Recent evidence from Estonia, however, shows that spillovers from digitalisation during this period have reduced the gap between digital leaders and laggards (Criscuolo *et al.*, 2025).

Figure 11-2 Firm digitalisation in 2019 and likelihood of introducing new digital products during COVID-19, regression coefficients by digital technology class, across 20 European countries



Science, Research and Innovation Performance of the EU 2026

Source: Calvino *et al.* (2024a).

Note: The figure displays the relationship between firm digitalisation (in 2019) and probability of introducing new digital products during the COVID-19 pandemic (2020-2021), for each digital technology class (IT systems, digital sales, digital workplace, advanced applications and analytics, business/industry software). The ex-ante level of digitalisation is computed as an index [0,1] which accounts for the overall number of digital functionalities (across classes) at the plant level relative to the maximum number of digital functionalities (across classes) available for each country-sector (2-digit). The digitalisation index is then standardised to have a mean of 0 and a standard deviation of 1 (z-score). The estimated regression model is an LPM with, as the dependent variable, a digital class adoption dummy and includes the digitalisation index, productivity performance group, size and age classes, firm structure, and presence of IT staff as main independent variables. The digital class dummy is equal to 1 if the firm has introduced a new digital product during the pandemic crisis. If the coefficient of the digitalisation index is, for example, 0.1 for a given technology class, it means that a one standard deviation increase in the digitalisation index (i.e. being more digitally advanced than the average by one standard deviation) is associated with a 10 percentage point increase in the probability of the firm introducing a new digital product during the pandemic in the given class, ceteris paribus. Results are robust to using the log of employment in 2019 as an independent variable and to employing a logit regression model. Results generally hold within classes, i.e. for digital applications within each class. Each regression includes two-digit sector-country fixed effects and employs robust standard errors. Countries included in sample: Austria, Belgium, Czechia, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland and the UK.

2 The analysis underlying these results uses data for the years 2019, 2020, and 2021 for 20 countries in Europe.

Taken together, the unevenness at the sectoral level interacts with selection in adoption at the firm level: already more productive firms that deploy AI and possess the right complementary assets – in the form of technological, human and organisational capital – are positioned to capture outsized productivity gains, potentially reinforcing concentration and giving rise to 'champion' firms. Adoption is also strongly correlated with firm size, further tilting potential benefits toward large incumbents and providing a policy challenge for the digital transformation among SMEs (OECD, 2025a). Looking ahead, some of the observed dispersion is likely to widen given the transformative potential of digital technologies – particularly AI. This highlights the importance of accelerating diffusion of digital technologies across firms and sectors so that productivity gains at the frontier can spread more widely. Supporting complementary factors such as human and technological capital as well as lowering adoption barriers, especially outside the ICT sector and among smaller firms, will be key to avoiding persistent divergence.

2. How will the digital transition affect the net-zero transition?

There is an ongoing public debate on the effects of the digital transformation on sustainability goals. On the one hand, the quickly expanding and increasingly integrated use of digital technologies poses several challenges to sustainability. The computational requirement of digital technologies implies a surge in energy demand. Especially in the context of the AI revolution, there is growing concern regarding the energy consumed by data centres for processing of data and computing power (OECD, 2022a). For example, the energy demand for data centres alone is expected to increase by up to 70% in Europe by 2030 (IEA, 2025a). As electricity grids are not yet fully decarbonised, they are among the fastest-growing sources of CO_2 emissions (IEA, 2023). As a consequence, early evidence suggests that – despite its optimisation potential – digitalisation may have contributed to scope 2 emissions: increasing emissions through increased electricity demand (Dann and Straub, 2026, forthcoming). Additionally, the expanding infrastructure for AI and other digital technologies is creating a strain on water resources (Li *et al.*, 2023) and induces pollution from the mining of critical minerals, with effects on local and global ecosystems (IEA, 2025a; 2025b; Sonter *et al.*, 2018).

At the same time, AI is often cited to be a catalyst for environmental solutions. For example, in the context of climate change, AI may accelerate the net-zero transition by helping transform energy systems, accelerate low-carbon innovation, enable behavioural change and improve policy design (Stern *et al.*, 2025). In this regard, various studies foresee a major role of digitalisation and AI in achieving net zero (Cao *et al.*, 2023; World Economic Forum, 2022). Similarly, AI shows promising applications in protecting biodiversity (Silvestro *et al.*, 2022).

To better understand the key mechanisms through which the digital transformation can influence the net-zero transition, Calvino *et al.* (2025a) identify five relevant channels through which digital technologies can affect the transition to zero-carbon energy. They can:

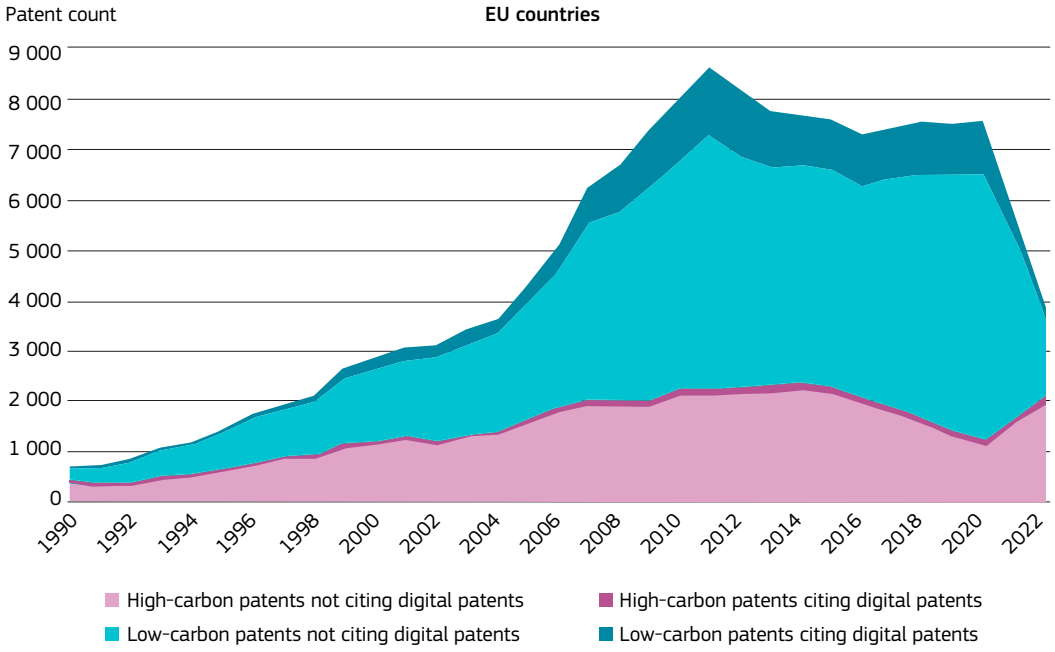
- increase energy consumption by machines due to higher computing demand, or reduce energy intensity due to digitally optimised energy efficiency;
- increase or decrease the use of machines relative to labour in production;
- encourage the use of clean or polluting energy sources;
- favour innovation in clean or dirty technologies;
- increase overall output growth, leading to higher energy demand.

The impact of these mechanisms on the net-zero transition remains theoretically ambiguous, as their effects depend on their relative magnitudes. For many of these mechanisms, conclusive evidence is still lacking. However, initial aggregate trends indicate opposing effects, as illustrated by Calvino *et al.* (2025a). For instance, the energy intensity of the capital stock has been decreasing across OECD member countries, and highly digital sectors use relatively cleaner energy sources than less digital ones. Conversely, the ratio of energy-using capital and labour to production has been increasing, particularly due to growth in ICT capital, pointing towards higher energy demand. Moreover, the potential productivity and growth effects of the digital transformation may place an additional burden on the net-zero transition by increasing energy demand to satisfy a growing economy.

In the context of innovation, early empirical evidence using patent data suggests that low-carbon innovation can benefit from digital technologies. For example, patent citation data show that low-carbon patents rely heavily on digital patents, and that is the case to a much larger extent than for high-carbon patents, as illustrated in Figure 11-3. This finding is consistent across both EU and non-EU countries. Similarly, recent work on patent data finds that digital innovation has significant positive spillover effects on environmental innovation (Aklilu *et al.*, 2025; Bello *et al.*, 2025). The relevance of digital for the net-zero transition is also evident among young firms: green startups rely heavily on digital technologies to offer green products and services (Dechezleprêtre and Kelly, 2025). Recent OECD work also suggests that digital adoption and innovation are associated with lower emissions (Dechezleprêtre *et al.*, forthcoming).

Considering the complex ways in which digital technologies affect the net-zero transition, these may provide additional channels through which the digital transformation may affect productivity. This is particularly relevant since the net-zero transition can directly affect productivity, as is explored below.

Figure 11-3 **Low-carbon and high-carbon patents citing versus not citing digital technologies in the EU, by year**



Science, Research and Innovation Performance of the EU 2026

Source: OECD based on STI Microdata Lab: Intellectual Property Database (May 2024).

Note: Data refer to patent applications filed under the Patent Cooperation Treaty (PCT) by the earliest filing date in the EU. Low-carbon technologies are identified using the taxonomy developed by Haščič and Migotto (2015). High-carbon technologies are derived from the taxonomy developed by the International Energy Agency (IEA) and the European Patent Office (EPO) in 2021 (IEA, 2021). Digital technologies rely on the taxonomy developed in Inaba and Squicciarini (2017).

3. How will the net-zero transition affect growth and productivity divergences?

Environmental policy and productivity growth

Public debate often frames environmental policy, such as climate policy targeting a net-zero economy, as a trade-off between economic growth and the benefits of a cleaner environment. However, a large body of work suggests that sustainability and growth objectives can be complementary. Even though environmental policies may be costly in the short run, the economic costs of unabated climate change are potentially catastrophic (Calvin *et al.*, 2023). Here, credible climate policy can redirect innovation toward cleaner technologies, thereby supporting sustained growth while reducing climate risks (Acemoglu *et al.*, 2012). In addition, path dependence in innovation implies that early and predictable price and regulatory signals, such as through carbon pricing, can shift firms' inventive activity toward clean technologies, reinforcing the case for timely action (Aghion *et al.*, 2016). Another channel is highlighted by the Porter hypothesis, which suggests that stricter environmental policies can sometimes boost productivity through innovation and efficiency

improvements (Porter and van der Linde, 1995). By helping firms overcome information gaps and organisational inertia as well as strengthening competition, such policies can induce sustainable innovations that improve productivity and therefore offset the costs associated with complying with the regulation (OECD, 2021). Additionally, recent OECD evidence shows that R&D projects primarily aimed at 'prosperity' goals (innovation and economic growth) are also described as relevant to environmental and health objectives, pointing to potential complementarities between sustainability and productivity aims in innovation (Aristodemou *et al.*, 2025).

One reason environmental policy may depress economic growth is that investment by firms in pollution-control technologies may crowd out other productive investments, potentially lowering productivity growth. In some settings, tighter regulation has been associated with total factor productivity (TFP) declines in regulated plants (Morgenstern *et al.*, 2002; Greenstone *et al.*, 2012), at least in the short run. In the medium run, investments in capital induced by energy price shocks have been shown to increase productivity for the average firm. In addition, at the macro level, average productivity may still increase even in the short run if low-productivity firms exit the industry.

Similarly, if environmental stringency pushes inefficient polluters to relocate abroad, known as the 'pollution haven hypothesis', this too may raise productivity domestically. For global pollutants such as greenhouse gases, this lowers the efficiency of decarbonisation policies and is certainly not a desirable outcome. Empirically, the evidence on relocation is mixed, and effects are generally small (Garsous and Kozluk, 2017; Koźluk and Timiliotis, 2016). The risk of carbon emissions being transferred abroad because of climate policy, known as carbon leakage, has received particular attention in the context of the EU Emissions Trading System (ETS). Model simulations in recent OECD work show that the 2023 reform of the EU ETS, which is predicted to raise emissions prices for EU producers, could reduce value added by around 0.3% in the EU and lead to carbon leakage. However, the EU's Carbon Border Adjustment Mechanism (CBAM) can partially mitigate this effect for the industries it targets and, above all, effectively prevent carbon leakage (Dechezleprêtre *et al.*, 2025).

Empirical evidence: energy and labour productivity

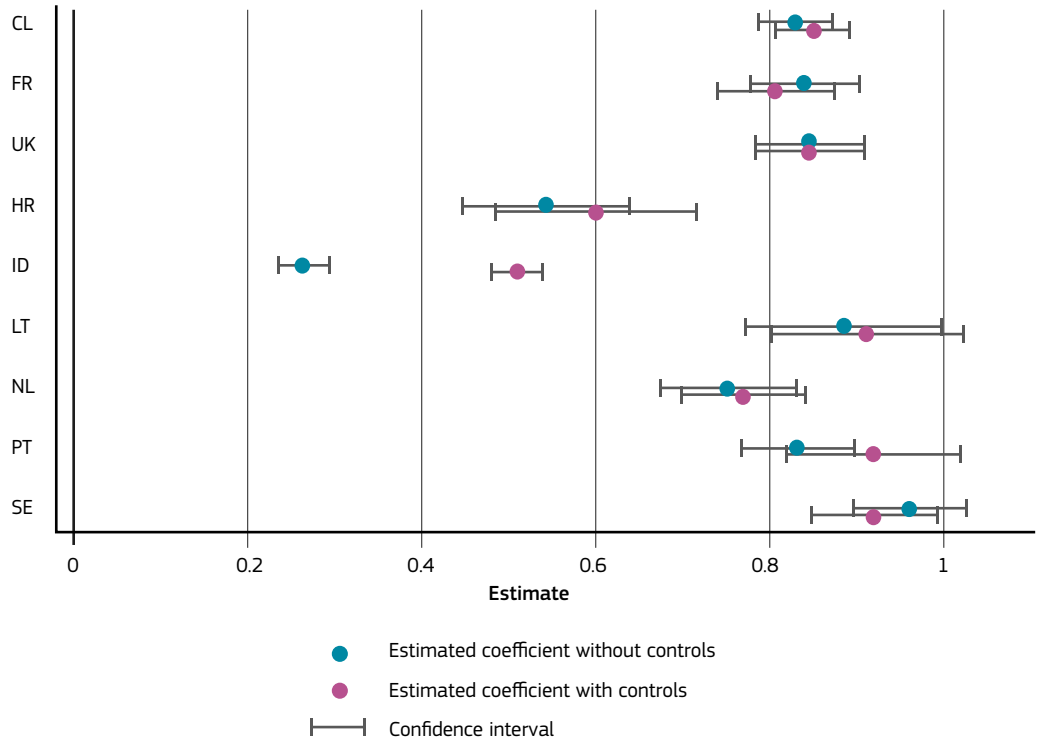
Empirically, evidence across OECD countries indicates that tighter environmental policy stringency is linked to short-term industry-level productivity gains, particularly in technologically advanced economies. These gains tend to diminish the further countries and industries are from the global productivity frontier (Albrizio *et al.*, 2017; OECD, 2021). Using the OECD Environmental Policy Stringency (EPS) index and cross country variation, the studies find that industry level multifactor productivity can increase in response to tighter stringency, especially nearer to the frontier, with no systematic evidence of significant negative aggregate impacts (Kruse *et al.*, 2002). The analysis also suggests differentiated impacts by instrument type, comparing market-based vs. non-market policies, highlighting the role of policy design choices.

At the firm level, a more heterogeneous picture emerges: the most productive firms tend to experience productivity growth as a result of tighter environmental policy, while less productive firms see slowdowns, widening dispersion within industries (Albrizio *et al.*, 2017). Even when short-run impacts appear negative, especially for highly polluting firms, policies such as carbon pricing are associated with improvements in energy productivity and, in some cases,

labour productivity (OECD, 2021). Firm-level studies on the effectiveness of the EU ETS find no detectable contractions in economic activity or on TFP alongside substantial emissions reductions, and no evidence for the pollution haven hypothesis and positive effects on innovation activity (Calel and Dechezleprêtre, 2016; Dechezleprêtre *et al.*, 2023; Colmer *et al.*, 2024).

Recent cross-country micro-level evidence reinforces the notion of complementarity between economic and energy-efficiency performance at the firm level. There is substantial dispersion in energy productivity among firms, and firms' energy efficiency is strongly associated with labour productivity. Improvements in energy productivity over time are associated with increases in labour productivity (De Lyon and Dechezleprêtre, 2025), as seen in Figure 11-4.

Figure 11-4 Firm-level OLS regression coefficients: change in energy productivity on change in labour productivity



Science, Research and Innovation Performance of the EU 2026

Source: De Lyon and Dechezleprêtre (2025).

Note: The chart shows estimates from ordinary least squares (OLS) regressions of the long change in log value added per energy on the long change in log labour productivity. Controls for (log) capital, (log) intermediate inputs, and (log) age are included in initial levels and, for the first two, in changes. Additional fixed effects are included for the firm's entry and exit years and the length of that period. The regressions also include industry-year fixed effects. They are estimated separately for each country, with country-specific coefficients reported in the plot. The y-axis corresponds to the explanatory variable in each regression. The bars indicate 95% confidence intervals with standard errors that are robust to heteroskedasticity. The sample is restricted to firms with at least 20 employees in manufacturing industries.

Productivity benefits from reducing air pollution

Productivity gains also flow through health. Recent large-scale OECD evidence from the EU shows that air pollution has measurable negative impacts on productivity via health channels (Dechezleprêtre *et al.*, 2019; Dechezleprêtre and Vienne, 2025). As economies shift to cleaner energy sources in the transition to a net-zero economy, reductions in greenhouse gas emissions are closely linked to reductions in air pollution. These pollution reductions are therefore expected to directly improve productivity. Microdata on over 2.5 million companies across 22 European countries show that higher PM2.5 concentrations causally reduce output per worker (likely through absenteeism and lower on-the-job labour productivity), implying that tighter air quality policies can directly raise productivity and growth (Dechezleprêtre and Vienne, 2025). From 2000 to 2022, it is estimated that a 1 $\mu g/m^3$ increase in PM2.5 concentration reduces labour productivity by around 0.55% within the same year, with stronger effects in specific sectors (construction and high-skill-intensive sectors), reinforcing the economic case for pollution reduction. In fact, about a third of European labour productivity growth in the period of 2011 to 2022 can be attributed to improvements in air quality (Dechezleprêtre and Vienne, 2025). Computable general equilibrium modelling also suggests that the welfare benefits of productivity improvements from air pollution reductions are large (Maniloff and Schreiber, 2025).

The net-zero transition and productivity dispersion

While there exists a clear link between improvements in environmental outcomes and productivity, the benefits of the net-zero transition are uneven. There is substantial dispersion in firms' energy productivity and in the adoption of energy-efficient technologies. If the least energy-efficient firms in each sector improved to the level already achieved by many of their peers, this could dramatically cut overall energy use without reducing output, implying major gains from policies to accelerate technology diffusion (De Lyon and Dechezleprêtre, 2025). This aligns with evidence that environmental stringency tends to boost productivity at the frontier while reducing it among the least productive firms (Albrizio *et al.*, 2017). It implies that environmental policy efforts may result in greater dispersion of firm productivity, and mirrors concerns from the digital transition. Since the adoption of both digital and low-carbon technologies depends strongly on firm characteristics (ranging from technological and human capital to financial access), both transitions could contribute to increasing productivity divergences between firms and regions.

4. The role of policies for productivity catch-up and reduced dispersion

The defining policy challenge of the nexus between the digital and net-zero transitions is not only how to raise average productivity through digitalisation and alongside decarbonisation. It is also how to mitigate the trend of a widening gap between firms, with frontier firms converting digital tools and more energy-efficient technologies into higher productivity and lower emissions, while lagging firms fall further behind.

As seen above, the diffusion of AI and advanced digital tools remains uneven, especially for SMEs, given persistent gaps in connectivity, skills, access to data, compute and finance. This means that digital investments can amplify dispersion if adoption remains concentrated among leaders. Similarly, more stringent environmental policies must be paired with diffusion support policies to help lagging firms adopt energy-efficient technologies. A dispersion-aware net-zero transition strategy, therefore, aims to lift low-productivity firms without dulling frontier dynamism, keeping environmental stringency credible and cost-efficient while ensuring that technologies, finance and capabilities reach all solvent firms. To achieve this, governments should consider the heterogeneous effects across the firm distribution rather than just aggregate productivity when evaluating digital and environmental policy actions, and consider firm characteristics, e.g. with respect to size or age (OECD, 2023a).

In practice, diffusion-oriented policy should explicitly support catch-up across non frontier firms, combining pro diffusion framework conditions (competition, experimentation and reallocation) with measures that lower barriers to adoption and organisational change (Andrews *et al.*, 2016; Berlingieri *et al.*, 2020). This implies a policy package that first strengthens cross-cutting diffusion enablers (skills, finance and connectivity), then applies domain-specific measures for the digital and net-zero transitions, complemented by investments in absorptive capacity.

Overall, these policy levers are in line with the EU policy agenda: the *European Green Deal* sets the climate-neutral growth strategy and investment framing, while the *Digital Decade* sets 2030 targets on skills, infrastructure and business uptake. EU instruments operationalise these aims via Digital Europe and European Digital Innovation Hubs (EDIHs) through capacity building, the *AI Act*, the *Fit for 55* package (including CBAM and the EU ETS reforms), the *Net-Zero Industry Act*, InvestEU and Horizon Europe.

Access to finance

Access to finance is a critical enabler of technological transitions and needs to be embedded in coherent policy frameworks coordinated across government and ecosystem actors. This is so that training, advisory support, risk guidance and financing form a single adoption pathway rather than fragmented schemes (OECD, 2025a).

A relevant policy lever in this context is finance that reaches smaller, riskier and harder-to-standardise investments. The latest OECD Financing SMEs and Entrepreneurs Scoreboard shows a restrictive financing environment and a shift toward smaller-scale, short-term finance that can come at the expense of longer-term investment (OECD, 2025d).

Financially-oriented interventions ('hard' support in the form of credit guarantees, loans, grants or subsidies) have indeed been found to have the most robust and consistent impact for SMEs (OECD, 2023a). This includes strengthening access to finance for technology adoption, especially for SMEs and productivity laggards.

Closing digital gaps

Given the uneven diffusion of AI and advanced digital tools, closing digital gaps should be a key component of digital transition policies. On the one hand, AI adoption depends on reliable and affordable connectivity and access to enabling digital inputs such as data, algorithms and compute; policies should therefore address gaps in network quality, affordability and capacity and expand access to data and compute resources (such as cloud and compute facilities, shared infrastructure and services) that lower adoption costs for a broad range of organisations. Additionally, large disparities in connectivity remain between regions. Therefore, closing persistent regional gaps may be an effective policy addressing inequalities (OECD, 2025b).

On the other hand, policy levers should more broadly consider the heterogeneity in firms' adoption pathways, with firms having different levels of digital maturity and facing varying potential applications and use-case complexity. Relevant policy levers can include coaching, vouchers, pilots and access to curated model libraries. While focusing on AI and SMEs, the G7 SME AI Adoption Blueprint (and recent OECD analysis informing it) highlights practical pathways and support instruments that can be adapted to broader business populations and the public sector (OECD, 2025a). Policies should also be targeted to assist SMEs specifically in adopting advanced digital technologies in the age of AI (OECD, 2024a).

In expanding digital infrastructure, policy should also manage the environmental footprint of ICTs so that data centre energy and water use do not undermine local environmental goals (OECD, 2022a; 2025f).

Enabling the net-zero transition

A desirable environmental policy mix is to combine strong price signals with practical support for the diffusion of technologies among lagging firms. Carbon pricing, environment-related taxes and emissions trading systems can anchor cost-efficient abatement; however, these instruments need to be complemented by financial and technical assistance that turns plans into implementation. These complementary measures are particularly important given that many firms face persistent barriers to greening, such as limited access to external finance, insufficient internal capacity and perceived high risks associated with sustainability investments (OECD, 2025e).

For SMEs, which face specific risks from carbon pricing, energy efficiency audits and advisory services should be scaled up and coupled with grants or guarantees to enable the adoption of identified measures. Reviews show that audits are pivotal for overcoming information and capability barriers in smaller firms (Herce *et al.*, 2024; OECD, 2025e).

Governments can also expand credit guarantees, concessional loans and co-investment for energy-efficiency projects, and clarify transition finance frameworks so that credible, stepwise decarbonisation is financeable. Where risk or scale is a barrier, blended finance can crowd in private capital for clean energy and efficiency upgrades (OECD, 2022b).

Building absorptive capacity and boosting innovation

Finally, enabling adoption is not sufficient, since firms also need absorptive capacity to convert technology and investments into productivity gains. This requires not only technical know-how, but also the organisational capability to implement change and realise returns. Policy should seek to strengthen human capital through lifelong learning in data and AI, energy management and advanced manufacturing, coupling technical skills with broader foundational and socio-emotional skills, which are increasingly critical in the age of AI (OECD, 2023d).

This includes expanding AI literacy and ensuring training is accessible to low-capability organisations and underrepresented workers while preparing for broader labour-market adjustments (OECD, 2023b; 2024a; 2025a; 2025c). Beyond training provision, firms' internal capabilities shape whether technologies translate into performance improvements. Better management practices, such as data-driven decision making, can help non-frontier firms convert technology into productivity gains and should be combined with education that emphasises both skills and attitudes that drive change (OECD, 2023d). Strengthening human capital also helps maximise the effectiveness of policy measures focusing on connectivity and investments in digital technologies (Calvino *et al.*, 2022), highlighting relevant policy complementarities.

In addition to adoption support, productivity catch-up also depends on firms' own innovation and R&D capability, since many laggards need to adapt, integrate and improve technologies (often through incremental innovation and experimentation) to translate diffusion into sustained productivity gains. In this sense, diffusion policy is most effective when it is complemented by policy that supports both the emergence of innovation and its subsequent scaling and diffusion. OECD analysis emphasises that policy must combine support for the emergence of innovation with policies that scale and diffuse it, pointing to the need for sustained, more directional investment in research and innovation. This includes public funding instruments and business-innovation support, as well as diffusion (OECD, 2023c; 2024b). Targeted measures, such as collaborative R&D, experimentation and piloting, and knowledge-transfer partnerships, are needed to help non-frontier firms and SMEs build capability through applied experimentation and partnerships while keeping the broader transition strategy directional (Larrue, 2021; OECD, 2013).

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CHAPTER 12

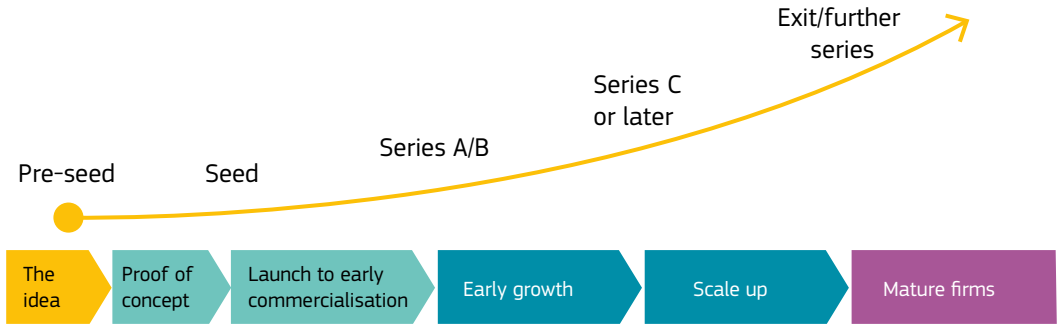
HOW TO PROMOTE ACCESS TO FINANCE TO DELIVER ON INNOVATION

Chiara Fratto, Matteo Gatti, Wouter van der Wielen (European Investment Bank, EIB)

Europe's competitiveness increasingly depends on its ability to innovate, yet significant gaps persist in financing high growth firms, particularly in strategic sectors such as digital, deep tech, construction and advanced manufacturing. While the EU attracts substantial global investment in green industries, it lags behind in the availability of later stage capital essential for scaling innovative companies.

High-growth, innovative companies face rising financing needs throughout their lifecycle (Figure 12-1). While funding at the seed and pre-seed stage is predominantly sourced from family and friends, equity financing through venture capital (VC) becomes essential at the start-up stage and during early growth. In these phases, equity financing is also often supplemented by quasi-equity instruments and venture debt to bridge gaps left by traditional bank lending, which remains limited because of asymmetric information costs and collateral constraints. As companies scale up, financing needs intensify, requiring larger equity rounds and growth capital. During the maturity and exit phase, access to deep and harmonised capital markets becomes crucial for initial public offerings (IPOs) and strategic acquisitions.

Figure 12-1 **Stages of firm growth**



Science, Research and Innovation Performance of the EU 2026

Source: European Investment Bank.

Despite the pivotal role that innovative firms play in shaping the future of the EU economy, limited access to capital hinders startups' ability to innovate, particularly at the scale-up phase. While innovative, high-growth firms are pivotal to Europe's economic dynamism, contributing disproportionally to its productivity growth, access to capital remains a major constraint on their development (see chapter 5.2 for a general overview). Compared to the US, the funding gap for EU startups is estimated at EUR 120 billion per year, of which the gap for scaleups accounts for the lion's share at EUR 80 billion per year. By the time they reach 10 years of operation, European scaleups raise 50% less capital than their peers in the US (Fratto *et al.*, 2024).

The EU has ample savings to finance substantial domestic investment needs. It has one of the highest saving rates in the world. Yet, EU households invest heavily in safe assets, such as real estate and bank deposits. The EU lacks sizeable equity and corporate bond markets, and the liquidity of European equity markets falls short of that of the US market. This weighs on corporate financing. Countries with deeper and more sophisticated capital markets tend to invest more in innovative technology. Equity issuance has been shown to significantly impact firm investment, growth and innovation.

Europe's large pool of institutional savings remains under allocated to high-return, higher risk assets. Institutional investors (especially pension funds) play a limited role

in the EU despite their stronger cross-border asset diversification and higher likelihood of investing in growth assets. Regulatory fragmentation, structural constraints and knowledge gaps have hindered pension funds and insurers from investing more in VC and growth equity – despite evidence that such investments can enhance returns and strengthen Europe's innovation ecosystem.

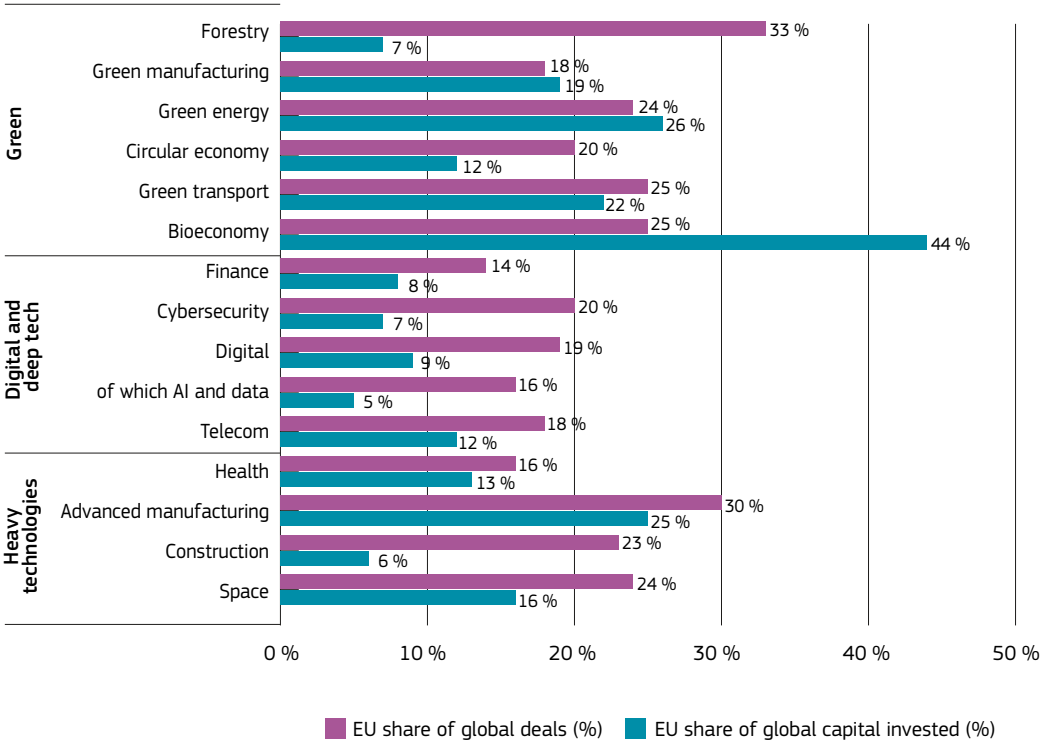
In this context, public support plays a central role in mobilising capital for innovative firms, crowding in private investment and supporting companies across their entire lifecycle. Pan-European initiatives such as TechEU and the second European Tech Champions Initiative (ETCI 2.0) supported by the European Investment Bank (EIB) Group aim to complement national programmes by pooling risk, reducing fragmentation and anchoring a more integrated EU wide scaleup market, alongside instruments such as the Scaleup Europe Fund providing large late-stage financing to promising European companies in strategic tech areas.

1. The state of innovation finance in Europe

Relative to the rest of the world, the EU invests more in innovation in green sectors (green manufacturing, bioeconomy, green energy and green transport), in many of which its capital investments accounted for over 20% of total global investment between 2023 and 2025 (Figure 12-2). Its investment share in these areas has been increasing over the last decade. Conversely, the EU accounts for 13-15% of global GDP, but it invests less, in relative terms, in digital and deep tech. In particular, it is responsible for only 5% of global capital investment in artificial intelligence (AI) and data (or 16% of all deals), as investment has become concentrated in the US.

European green sectors also attract a relatively high share of VC investments, while digital and deep tech lag behind. For green sectors, total VC investments hover around or above 20% of global investments (Figure 12-3). On the other hand, EU companies attract a smaller share of global VC investment in sectors such as digital, deep tech, health and heavy technologies. Later-stage VC is recognised as a bottleneck for the growth of companies in many industries. As a share of the respective global figures, later-stage VC investment in the EU is lower than total investment. Notable exceptions are cybersecurity and health, where the EU's share of global later-stage VC investment is in line with or higher than its share of total global VC investment.

Figure 12-2 The EU's position in strategic sectors relative to the rest of the world, 2023–2025



Science, Research and Innovation Performance of the EU 2026

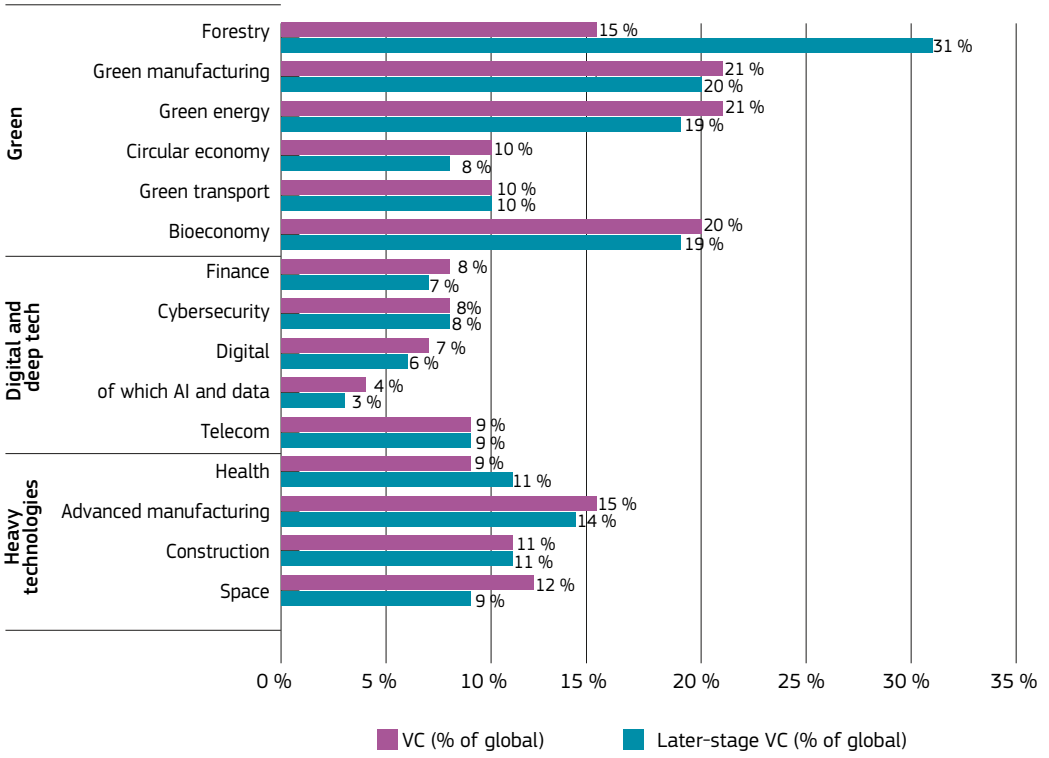
Source: European Investment Bank based on PitchBook.

Note: Capital invested includes VC, private equity, equity and capital raised during IPOs and acquisitions. AI and data is a subset of digital.

Financing for early-stage AI innovation in the EU remains dependent on US VC. Over the past decade, EU-based AI companies received a total of USD 210 billion in investment, of which 15 % came from VC, including seed funding and angel investment. Notably, 42 % of VC funding originated from the US; followed by 33 % from the EU; 14 % from the UK, Switzerland or Norway; and 11 % from the rest of the world (Figure 12-4). This underscores Europe's structural reliance on foreign investors to finance the growth of innovative early-stage and scale-up companies at the AI technology frontier. While the EU has a growing AI startup base, bridging the gap from financing private innovation to large-scale, globally competitive firms remains a challenge (see chapter 7). Recent evidence from the EIF Equity Barometer supports this conclusion as it suggests that investors in AI firms see scaling conditions and exit opportunities as Europe's main disadvantages relative to the US, with AI companies also perceived as relying more heavily on non-EU exit routes than firms in other sectors.[1]

1 EIF Equity Barometer Survey Q2 2026, p6.

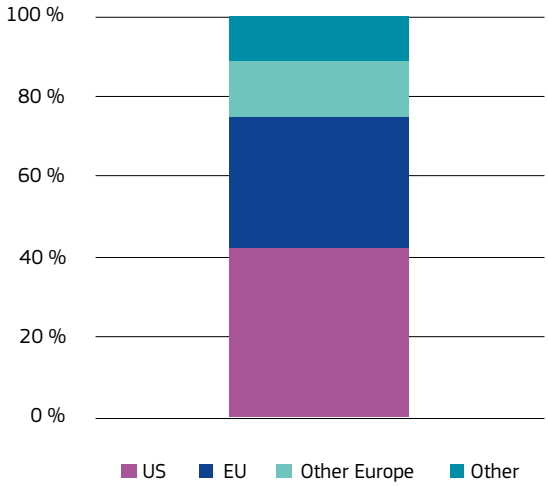
Figure 12-3 EU share of global VC investment, 2023–2025



Science, Research and Innovation Performance of the EU 2026

Source: European Investment Bank based on PitchBook.
Note: AI and data is a subset of digital.

Figure 12-4 VC investment in AI and data companies with headquarters in the EU, by location



Science, Research and Innovation Performance of the EU 2026

Source: European Investment Bank based on PitchBook.
Note: Aggregate data for 2014–2024. Other Europe includes Norway, Switzerland and the UK.

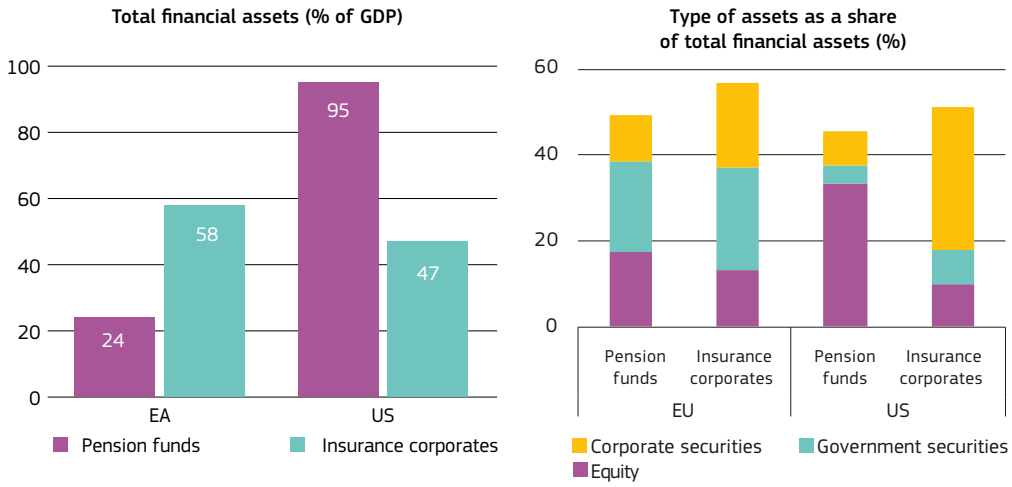
Financing for innovative security and defence ventures has been on the rise and is key to strengthening Europe's defence readiness. While governments have committed substantial resources, the ability to translate these commitments into real capabilities depends on the private sector's role in expanding manufacturing capacity and driving technological innovation. European defence companies are expanding rapidly and gaining market share (European Commission, 2025), and this trend is also noticeable from the amount of VC flowing into the sector. VC flows into European deep tech defence, security and resilience startups and scale-ups are at an all-time high, surpassing EUR 4.8 billion in 2024 (Dealroom, 2025), indicating renewed private-sector momentum and an opportunity to complement public investment with market-driven innovation. Cross-border mergers and acquisitions in defence-related sectors have also accelerated, growing by 60% since 2021, compared with the five years preceding the COVID-19 pandemic (EIB, 2026).

More broadly, European innovation finance increasingly relies on the strength and connectivity of its regional entrepreneurial hubs. The European Investment Fund's (EIF) latest VC Factor report shows that Europe's VC landscape remains shaped by distinct regional 'clans', yet the links between them have deepened markedly over time. While national and regional footprints are still clearly visible, cross-community investment flows have grown substantially – from just 23% of all VC volumes in 2007 to 43% in 2021 – demonstrating a significant rise in exchanges across regional innovation hubs. This increasing interconnectedness, driven by both strong local networks and the emergence of 'super-hubs' that bridge multiple regions, highlights the growing relevance of regional ecosystems in fostering a more integrated and dynamic European innovation landscape.

2. The role of institutional investors

Institutional investors' low-risk, low-return investment strategy hinders Europe's ability to channel private savings into productive investments. Europe's institutional investors allocate the bulk of their portfolios to low risk, income oriented assets (Figure 12-5). This conservative strategy results in structural underinvestment in productive, higher risk activities, notably VC and growth equity. The effect is a chronic mismatch between Europe's abundant savings and its investment needs in innovation intensive sectors. With European firms scaling more slowly and raising significantly less capital than their US counterparts (Fratto *et al.*, 2024), current institutional investment patterns are an important bottleneck with regard to Europe's competitiveness and technological sovereignty.

Figure 12-5 The role of institutional sectors and their asset holdings

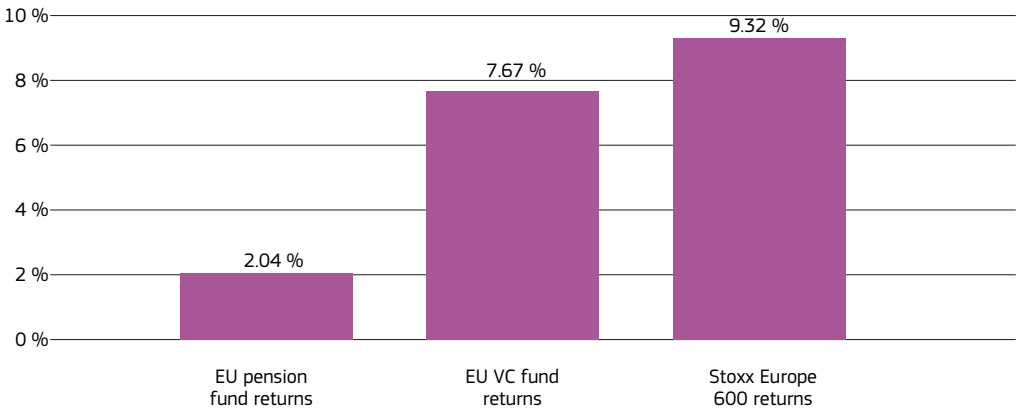


Science, Research and Innovation Performance of the EU 2026

Source: European Investment Bank based on EIOPA, Eurostat (DOI link: https://doi.org/10.2908/NAMA_10_GDP), ECB and FRED.
Note: Types of asset and equity exposures are averages from 2017 Q4 –2023 Q4. Total assets as % of GDP by institutional sector are from 2024 Q4. EA stands for euro area.

Equity and alternative asset classes can deliver higher returns for European citizens. Despite increasing demographic pressures, the average return on investment delivered by pension funds between 2014 and 2023 was only 2.04%, slightly below the average level of inflation during the same period (Figure 12-6). EU VC returns have often exceeded the average return earned by pension funds on their traditional portfolios. Similarly, the STOXX Europe 600 showed a 9.32% average annual return during the same period. By expanding allocations to equity and alternative assets, European institutions can enhance long term returns for beneficiaries while supporting innovation led growth.

Figure 12-6 Pension funds' returns on investment and selected asset classes



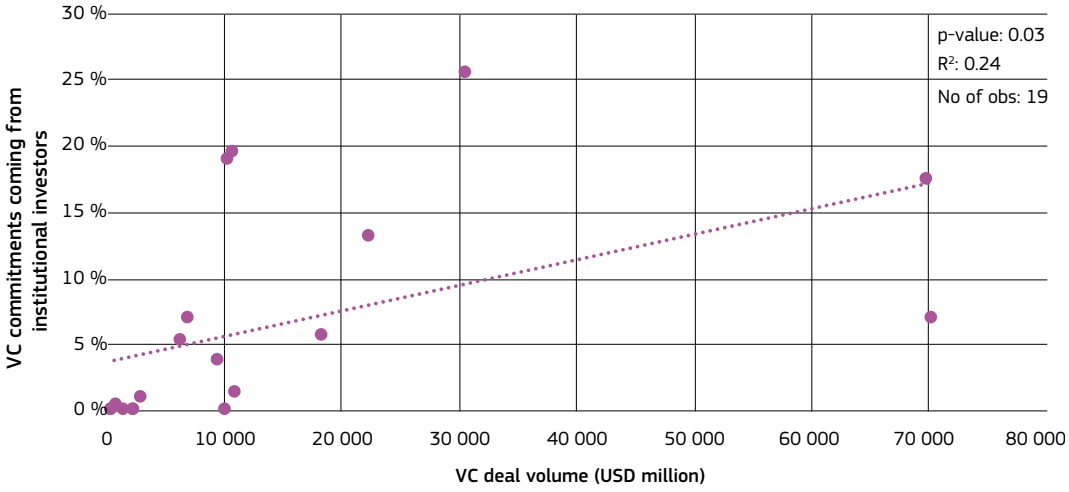
Science, Research and Innovation Performance of the EU 2026

Source: European Investment Bank based on TrackVC and Bloomberg.
Note: The data on VC returns refers to 2025 Q1. The chart includes internal rates of returns of VC funds (2016 vintage), returns on investment of pension funds (2014–2023) and average annual returns on STOXX Europe 600 (2016–2025): these are different metrics of the profitability of investments, and they should be compared with caution. Average returns on investment of EU pension funds are computed using the annual nominal assets by pension fund in each EU Member State as weights. Only countries for which all years are available are included.

Institutional investors can significantly contribute to filling the innovation finance gap. Even incremental shifts in institutional portfolios could be transformative. A greater presence in European equity markets could also provide the depth and liquidity innovative companies need to find exit opportunities in Europe. Raising pension fund allocations to private equity, VC and infrastructure from the current very low levels towards those seen in the US could mobilise up to EUR 250 billion for innovative ventures. Such capital would provide patient funding for scaleups, strengthen domestic equity markets and help retain European technology leaders.

Deepening the domestic VC market is one of the keys to unlocking participation of more institutional investors. Participation in VC is often low both for domestic and foreign institutional investors. Many countries, particularly in southern and southeastern Europe, have small VC ecosystems, and, as a matter of fact, pension funds and insurance companies often mention the depth and liquidity of the local VC market as key determinants of their willingness to invest (Figure 12-7). The converse is also true: greater participation would contribute to deepening and increasing the liquidity of VC markets. Public investment can jumpstart this virtuous cycle by helping VC markets develop. They will consequently be seen as better investment opportunities by large institutional investors, who will in turn contribute to their further development.

Figure 12-7 **VC volume and institutional investor participation**

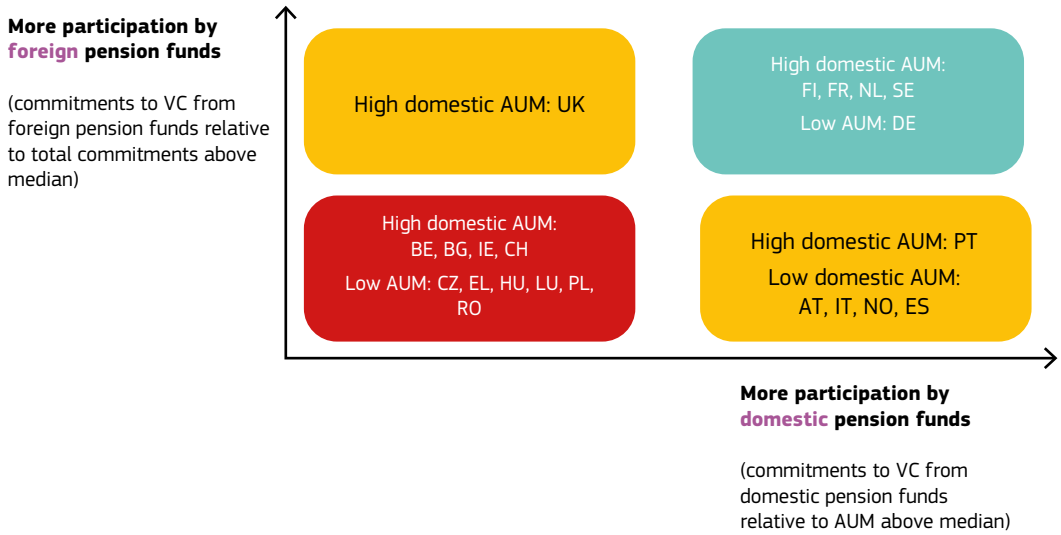


Science, Research and Innovation Performance of the EU 2026

Source: European Investment Bank based on PitchBook and Invest Europe.

The degree of institutional engagement in VC differs markedly across the EU. Figure 12-8 and Figure 12-9 map different European countries based on the degree of participation of insurance companies in the domestic VC ecosystem. Some ecosystems, such as those in Germany, the Netherlands and Sweden, attract both substantial domestic commitments and significant foreign pension fund participation. Others, including those in Italy and several central and eastern European countries, show strong domestic participation but limited inflows from foreign institutional investors, reflecting smaller fund sizes, lower levels of assets under management (AUM) and structural constraints in local VC markets. Conversely, the UK attracts considerable foreign pension fund participation but exhibits low domestic allocations relative to the European median. These cross country differences underline the importance of scale, ecosystem depth, regulatory clarity and market visibility in attracting institutional commitments.

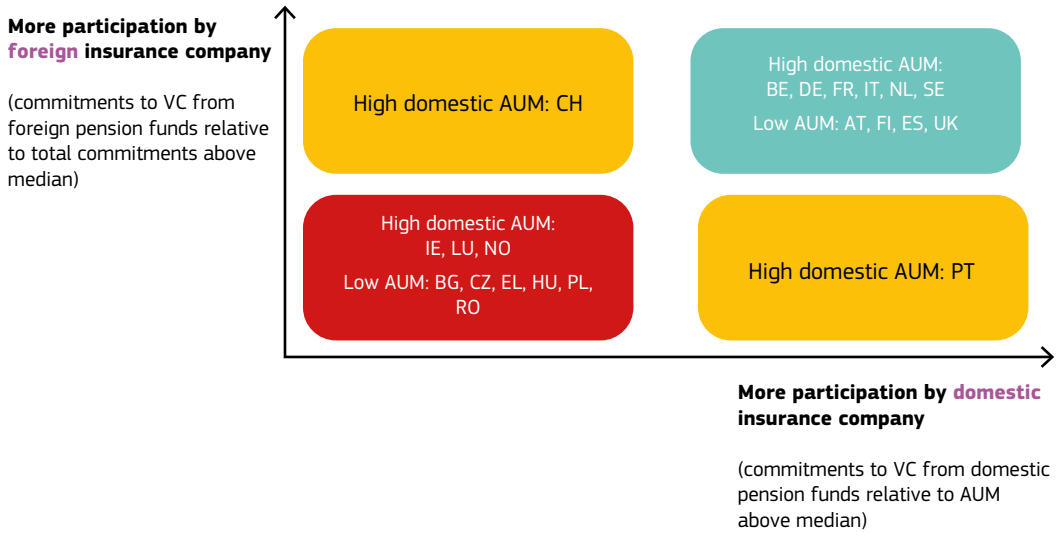
Figure 12-8 **Pension fund participation in VC**



Science, Research and Innovation Performance of the EU 2026

Source: European Investment Bank based on OECD, Invest Europe, EIOPA and IMF.
Note: High/low domestic AUM computed as above/below the median (as a share of GDP).

Figure 12-9 Insurance companies' participation in VC



Science, Research and Innovation Performance of the EU 2026

Source: European Investment Bank based on OECD, Invest Europe, EIOPA and IMF.
Note: High/low domestic AUM computed as above/below the median (as a share of GDP).

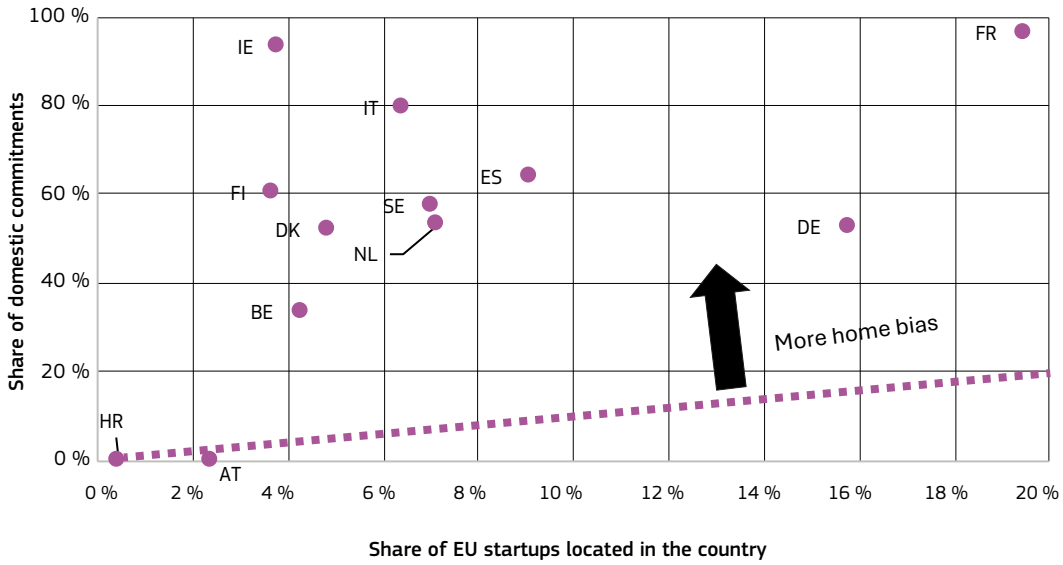
Institutional portfolios remain heavily tilted towards domestic markets. In VC, this home bias is pronounced: pension funds and insurers disproportionately commit to funds in their own jurisdiction, limiting geographical diversification and reducing exposure to higher growth ecosystems across Europe (Figure 12-10). For instance, French and Irish pension funds made more than 90% of their EU VC funding commitments to funds located in their own country. Fragmented regulatory frameworks, heterogeneous supervisory interpretations and structural market frictions contribute to this bias. Home bias restricts cross border risk sharing, limits the supply of large scale later stage funds and hampers the development of a truly pan-European VC market.

A combination of regulatory, structural and informational constraints suppresses institutional engagement in alternative assets.

- **Regulatory barriers**: National regulators apply EU rules unevenly, creating market fragmentation and discouraging cross-border investment. The amendments to the *Solvency II* regime and the Institutions for *Occupational Retirement Provision II* Directive could reduce capital and liquidity requirements and favour investment in equity and private equity.

- **Structural barriers**: VC's illiquidity, complexity and small fund sizes create a mismatch with institutional investors' preferences for scale and stability. Defined-contribution schemes are more likely to be invested in risky assets than defined-benefit schemes (see the Danish example). VC is a small asset class, too small to be administered separately.

Figure 12-10 **Pension funds' portfolio allocations to domestic VC funds and the size of the domestic VC market**



Science, Research and Innovation Performance of the EU 2026

Source: European Investment Bank based on PitchBook and Invest Europe.

- **Knowledge gaps**: Many pension funds and insurers lack internal VC expertise, face high due diligence costs and have limited access to standardised performance data.

A pan-European approach can scale successful national initiatives and build a unified European ecosystem. Several countries have launched successful initiatives to mobilise institutional capital: France's Tibi Initiative, Germany's Wachstumsfonds and WIN Initiative, the UK's Mansion House reforms and new tax incentives in Italy are notable examples (see box 12-1). National efforts have demonstrated strong potential to crowd in private capital and strengthen domestic VC markets. However, their reach remains nationally bounded, limiting geographical diversification for investors and perpetuating fragmentation. To achieve scale and unlock the full potential of Europe's savings, national schemes must be complemented by pan-European platforms and instruments, such as TechEU and ETCI 2.0, that create frameworks to pool risk, deepen late stage markets, enhance cross border investment and support a truly integrated *Savings and Investment Union*.

Box 12-1 Measuring government-funded innovation in Europe: a proposed classification for the EU and the UK

France: The Tibi Initiative, launched in 2020, mobilised EUR 15 billion in five years from insurers and pension funds, with strong results in late-stage VC. The Tibi charter is a voluntary commitment by institutional investors to provide funding to a set of eligible tech funds. A treasury-led technical committee vets eligible funds based on criteria related to technical focus and asset manager expertise. The Tibi Initiative has been extremely successful in mobilising private investment. However, French institutional investors display a strong home bias, with a resulting concentration of risk.

Germany: The *Wachstumsfonds* (that raised EUR 1 billion in 2023) and the WIN Initiative (launched in 2024 and committing to mobilise EUR 12 billion by 2030) are two important programmes for mobilising capital for innovation and startups. Moreover, small insurers can allocate up to 5% of their portfolio to infrastructure investments without affecting their overall risk-capital quotas.

UK: As part of the Mansion House reforms in 2023, nine of the largest defined-contribution pension providers in the UK committed to allocating 5% of their assets to unlisted equities by 2030. More ambitious targets were announced in 2025, with signatories (defined-contribution pension providers) pledging to invest 10% of their assets in infrastructure, property and private equity by 2030 (of which at least 5% in the UK). In 2023, the government also introduced an amendment to the annual charge cap to exclude specific types of fees, allowing pension funds to expand their VC/private equity investments without breaching the fee limit. Many EU Member States have similar fees.

3. The impact of EIB Group instruments for financing innovation

Public initiatives, such as the EIB-supported TechEU, help unlock patient capital for firms with high growth potential. Closing the innovation gap, as highlighted in Mario Draghi's report on the future of EU competitiveness, is paramount for supporting EU productivity. Through its *Competitiveness Compass* and *Startup and Scaleup Strategy*, the European Commission has introduced strategies to support the scale-up of innovative firms, including TechEU, a one-stop-shop platform managed by the EIB Group. Leveraging the EIB Group's experience and its wide range of products, TechEU connects innovative firms to different funding solutions to meet the capital needs of companies across their entire lifecycle.

To ensure the development of an EU-wide scale-up ecosystem, public financing needs to attract private sources. Partnerships between governments and private investors have a demonstrably positive impact on the reduction of information frictions, improving capital allocation and leading to stronger exit outcomes. For example, recent evidence shows that firms backed by both public and independent VC investors are generally more likely to be acquired or go public than those supported by only one group (Lerner *et*

al., 2021; Köppl *et al.*, 2025). These results underscore the need for a coordinated, lifecycle approach to innovation finance that mobilises both public and private capital to close Europe's late stage equity financing gap. The EIB Group has a proven track record in attracting private investment to finance innovation in the context of the European Fund for Strategic Investments and InvestEU.

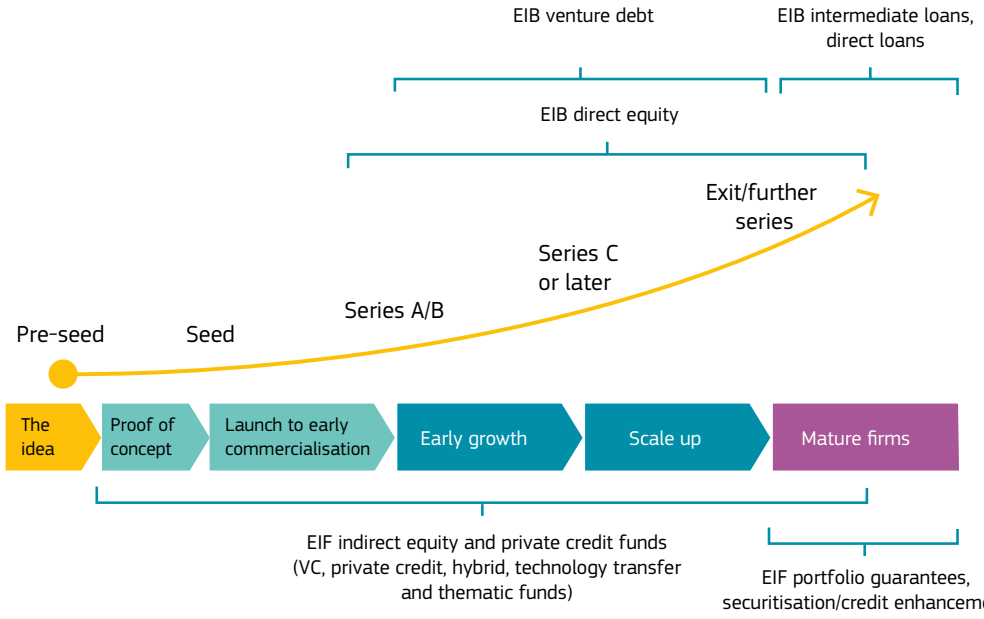
The EIB Group plays a pivotal role in financing innovative firms (Figure 12-11), co-investing with private actors. The EIF co-invests indirectly in VC funds targeting innovative firms' financing needs across the whole firm lifecycle. In 2025, it provided EUR 7.1 billion in equity investments, including almost EUR 3.1 billion to VC funds, making it the largest single investor in the EU. In addition to providing capital, the EIF plays a market-building role by crowding in private investors and supporting the development of larger and more integrated European fund ecosystems. The EIB co-invests alongside EIF-backed fund managers in innovative technology companies (mostly SMEs and mid-caps) to support their scale-up activities. It also acts as the investment advisor for the European Innovation Council (EIC) Fund, the VC arm of the European Commission for breakthrough technologies, targeting firms at the initial stage. At the scale up stage, the EIB provides direct funding to innovative firms through its venture debt programme, which covers about 30 % of the EU market and acts as a market builder in a segment historically underserved by private lenders. Since the instrument's introduction in 2015, the EIB has deployed more than EUR 8.2 billion across 320 transactions at year-end 2025, reaching an average annual volume of approximately EUR 1 billion as of 2022.

The EIB Group is launching new initiatives to strengthen financing for innovative firms across their growth cycle. In 2025, the EIB complemented its venture debt instrument with a scale-up debt product targeting later-stage clients, offering larger volumes and longer maturities. The EIB Group is also set to launch several initiatives to broaden its product range for scale-up financing and respond to market demand, including ETCI 2.0, acquisition finance, convertible instruments and support for companies listing on European markets. ETCI 2.0 aims to address the financing gap faced by highly innovative companies at the scale-up stage, which continues to push many European firms to relocate to the US or be acquired by foreign competitors. The initiative is expected to mobilise around EUR 80 billion in capital, with the EIB Group[2] and more than 20 EU Member States contributing EUR 15 billion, and institutional investors — including pension funds, insurers and banks — expected to provide the remainder. ETCI 2.0 will support European mega-funds and, for the first time, mid-sized growth funds of more than EUR 300 million. It is expected to anchor the creation of more than 100 funds in total, including up to 45 mega-funds that will invest in scale-ups with average ticket sizes of EUR 200 million per company.

Public financing instruments lead to sizeable gains in firms' performance outcomes (Figure 12-12). Five years after a VC round, firms benefitting from EIF-supported VC investment show capitalisation levels up to twice those of comparable peers, revenues between 19% and 97% higher and job creation rates double those of non-supported firms (Pavlova and Signore, 2019). Innovation outcomes improve as well, with patenting rates rising by 10 percentage points among EIF-supported firms (Pavlova and Signore, 2021). Similarly, two years after receiving venture debt financing, EIB beneficiaries are 25% larger, report 50% higher value added and about 30% higher turnover than comparable firms that did not sign any venture debt contract (Gatti *et al.*, 2022). EIF-supported lower mid-market financing also significantly enhances company growth performance, particularly growth in total assets, intangible assets and employment costs (Bertoni *et al.*, 2025).

2 The boards of the EIF and EIB committed a total of EUR 1.25 billion of their own funds

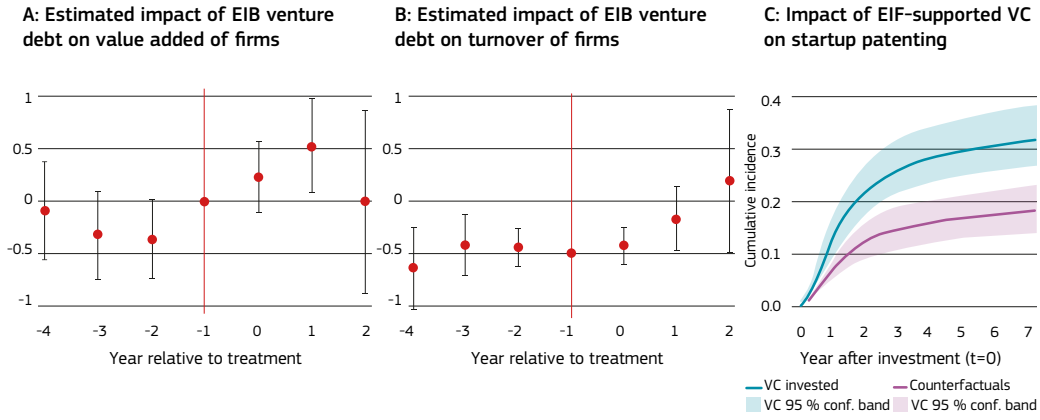
Figure 12-11 EIB Group financing across the firm lifecycle



Science, Research and Innovation Performance of the EU 2026

Source: European Investment Bank.

Figure 12-12 Impact of EIB Group financing on firm performance



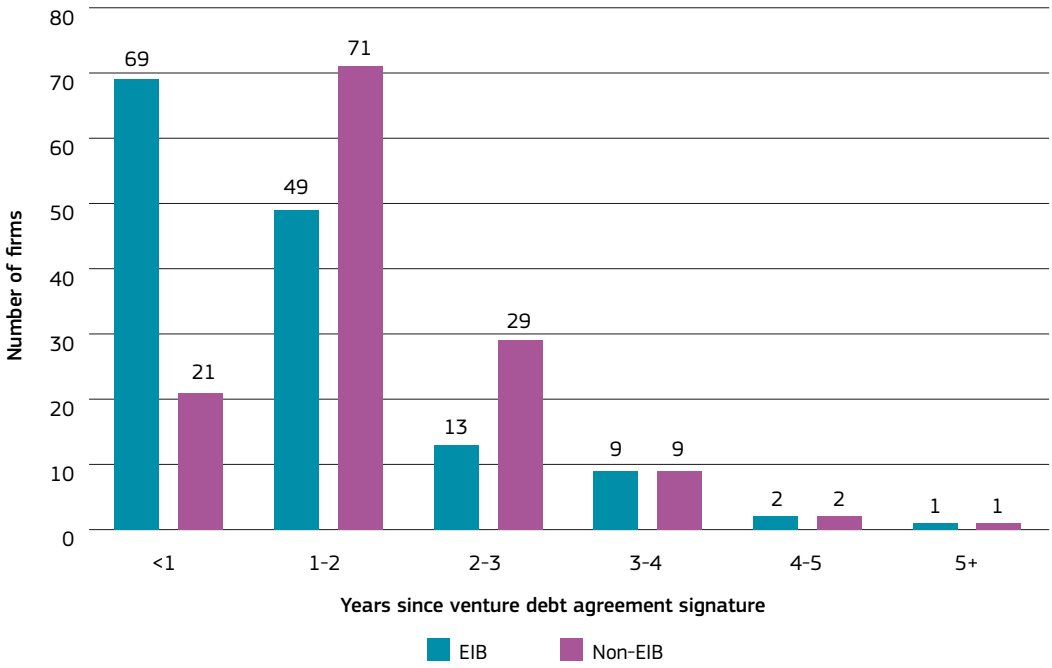
Science, Research and Innovation Performance of the EU 2026

Source: A, B: Gatti *et al.* (2022); C: Pavlova and Signore (2021).

Note: A, B: Coefficients are normalised with respect to the year prior to loan signature (t = -1) and can be interpreted as the cumulative effect of venture debt with respect to this baseline. The bands around the dots show the 90% confidence intervals of the estimates. C: Impact measured as cumulative probability of applying for a patent over time. The shaded areas show the 95% confidence intervals.

EIB Group support also crowds in additional private financing, confirming the EIB's primary role in signalling firm quality in an otherwise opaque market. EIB venture debt beneficiaries, for example, raise larger amounts of follow-up financing more quickly than their peers. One year after signature, 30% of EIB beneficiaries have signed at least one financing round, 20 percentage points higher than comparable firms not receiving EIB venture debt (Figure 12-14). Firms receiving venture debt from the EIB also close larger financing rounds than similar firms without such support. Figure 12-14 shows the distribution of deal sizes: while

Figure 12-13 Time at which firms receive their first financing round following the venture debt agreement signature

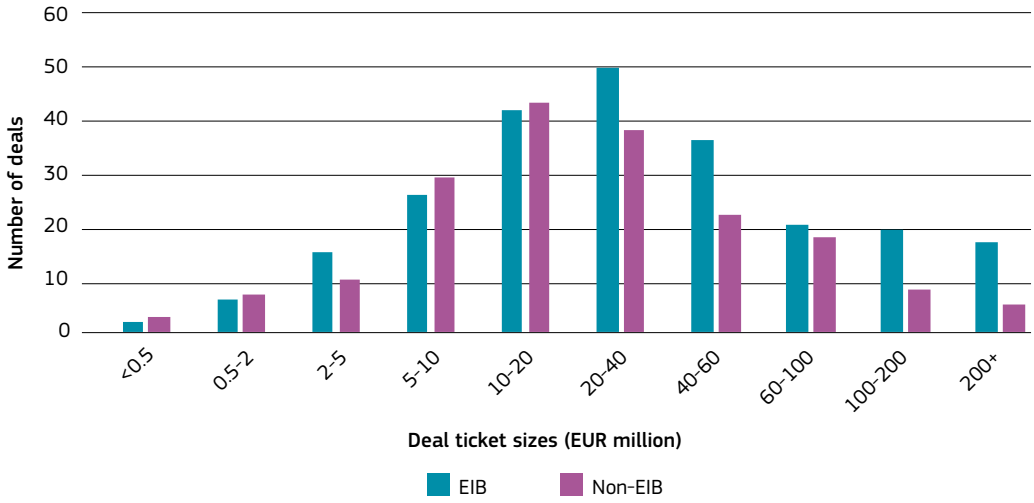


Science, Research and Innovation Performance of the EU 2026

Source: European Investment Bank based on internal data and PitchBook.

Note: Financing rounds include VC and private equity deals. The graph displays the time (relative to the venture debt agreement signature) at which a firm received its first round of financing. The EIB sample includes 234 firms that received EIB venture debt. The comparative sample of 234 non-EIB beneficiaries has been constructed by running propensity score matching for sector, venture debt size and age at the time of receiving a loan on a sample of 4 129 firms.

Figure 12-14 Deal size distribution for additional financing



Science, Research and Innovation Performance of the EU 2026

Source: European Investment Bank based on internal data and PitchBook.

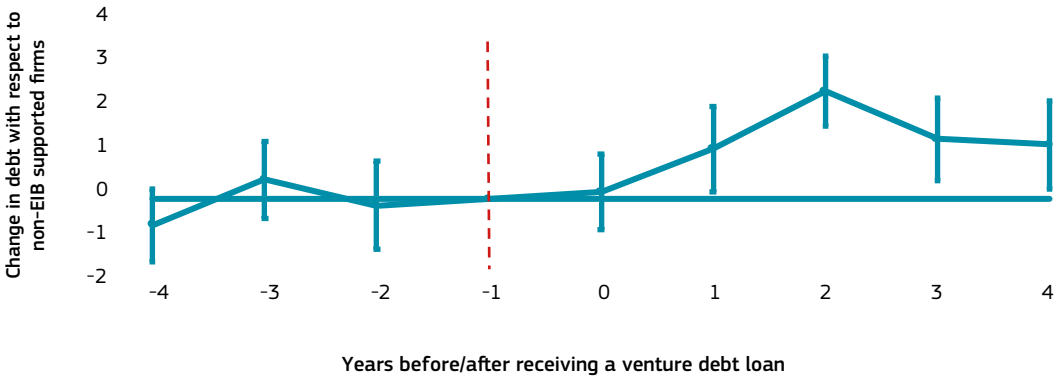
Note: Financing rounds include VC or private equity deals. The EIB sample includes 234 firms that received EIB venture debt. The comparative sample of 234 non-EIB beneficiaries has been constructed by running propensity score matching for sector, venture debt size and age at the time of receiving a loan on a sample of 4 129 firms.

both groups raise rounds of up to EUR 20 million, EIB beneficiaries are more likely to secure larger rounds, especially above EUR 20 million.

EIB venture debt beneficiaries also successfully raise 1.5 times more additional debt than non-EIB beneficiaries in the years following a venture debt agreement signature.

Figure 12-15 presents the results of a counterfactual analysis on a set of comparable firms, showing that while both groups follow similar patterns before signature, EIB beneficiaries raise substantially more debt within one year of signature. Venture debt from the EIB is a sign of creditworthiness, helping firms access significantly more debt than their peers.

Figure 12-15 **Impact of receiving EIB venture debt on additional debt financing, cumulative change in debt**



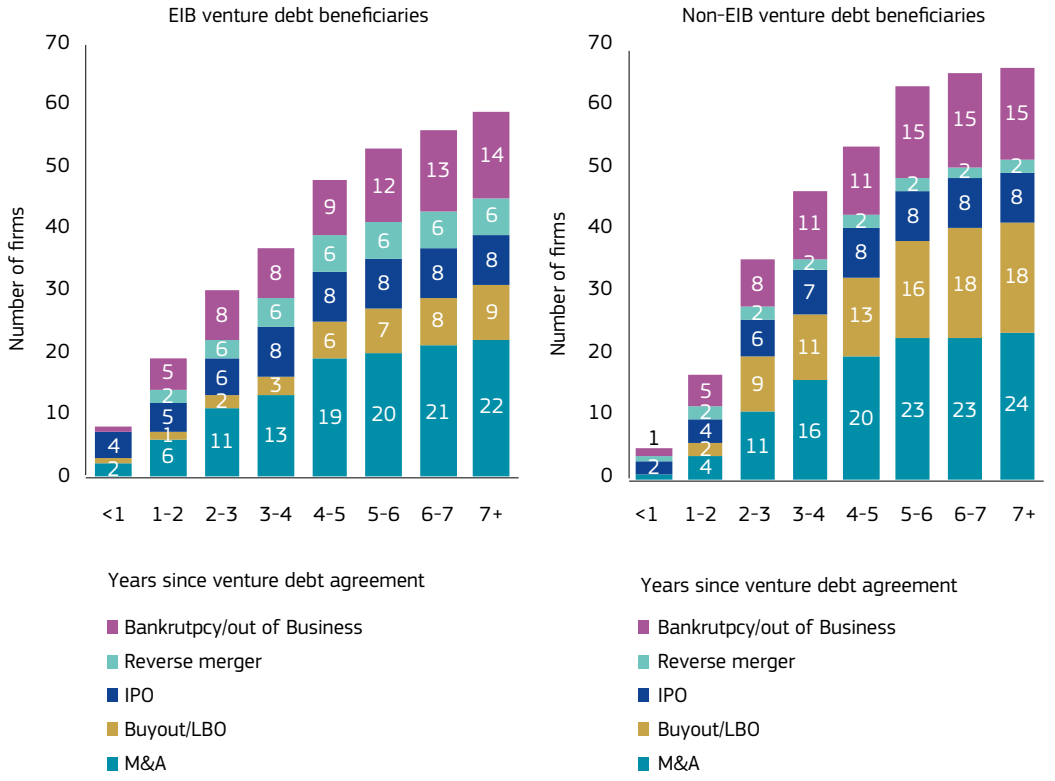
Science, Research and Innovation Performance of the EU 2026

Source: European Investment Bank based on internal data and Orbis.

Note: The control group has been constructed by running propensity score matching on the following financial variables from a sample of 3 651 EU-based firms: number of employees, total assets, fixed assets and long-term debt prior to receiving the loan. Coefficients are normalised with respect to the year prior to loan allocation (t=-1) and can be interpreted as the cumulative effect of the loan with respect to this baseline. The bands around the dots show the 95 % confidence intervals of the estimates.

Finally, EIB Group support improves companies' exit prospects. The prospect of a successful 'exit' – such as through an IPO on the stock market or through acquisition by a larger firm – provides a crucial incentive for entrepreneurs and for high-risk investments in early-stage companies. Efficient exit markets also support the recycling of capital into new generations of innovative firms, reinforcing the long-term sustainability of the European innovation ecosystem. As a result, good exit prospects not only encourage the formation of startups but also catalyse the flow of more private investment into the VC market and the innovation ecosystem. Public support for innovative firms has also been shown to boost exit opportunities. EIF-supported VC companies, for example, are three times more likely to exit through merger or acquisition (a 10.3 percentage point increase) and three times more likely to exit through an IPO (a 1.7 percentage point increase) than non-EIB VC supported companies (Pavlova and Signore, 2021). Similarly, seven years after signing a venture debt deal, nearly one in five EIB beneficiaries achieves a successful exit. While venture debt was designed to help firms bridge their liquidity prior to an IPO, the number of firms undergoing IPOs remains low (Figure 12-16), both among EIB-supported and non-EIB supported companies, confirming a general drying up of the market.

Figure 12-16 Exits by type and time relative to venture debt agreement signature, cumulative number of firms exiting



Science, Research and Innovation Performance of the EU 2026

Source: European Investment Bank based on internal data and PitchBook.

Note: Time is expressed in years and relative to the venture debt agreement signature. The EIB sample includes 234 firms that received EIB venture debt. The comparative sample of 234 non-EIB beneficiaries has been constructed by running propensity score matching for sector, venture debt size and age at the time of receiving a loan on a sample of 4 129 firms.

4. Conclusions

Despite strong research capabilities and entrepreneurial talent, innovative firms in the EU still struggle to access growth capital. Mario Draghi's report on European competitiveness underscores that closing the innovation gap and enabling scale-up is essential to prevent Europe from falling behind global peers, warning that without decisive action the EU risks a 'slow agony' (Draghi, 2024).

Catalysing investment is key to strengthening Europe's innovation ecosystem. Policy should aim to mobilise both public and private capital, support firms throughout their growth cycle and strengthen the environment for exits. Instruments should be tailored to each stage of development, with particular attention paid to the late-stage equity gap and supporting scale-ups, areas where European firms face the greatest challenges compared to their global peers. Stronger coordination between national and pan-European initiatives and further progress on the *Savings and Investment Union* can also facilitate cross-border investment and exits. Consequently, EU-wide programmes that mobilise institutional investors, such as TechEU and ETCI 2.0, play an essential role in closing the innovation finance gap and advancing the *Savings and Investment Union*. Evidence across EU-level instruments, including the EIB Group experience, confirms that public support targeting innovative, high-growth businesses raises productivity, encourages additional financing and reduces the misallocation of capital. Public support for innovative firms also boosts their growth, revenue, intangible assets and exit opportunities, while helping to build markets and reduce uncertainty.

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