INVESTMENT REPORT
2023/2024

Transforming for competitiveness

European Investment Bank

Chapter 4

Innovation in the global context

EUROPEAN INVESTMENT BANK INVESTMENT REPORT
2023/2024

Transforming for competitiveness

Part II Accelerating transformation for competitiveness

Chapter 4
Innovation in the global context

European Investment Bank

Investment Report 2023/2024: Transforming for competitiveness.

About the report

The annual EIB report on investment and investment finance is a product of the EIB Economics Department. The report provides a comprehensive overview of the developments and drivers of investment and investment finance in the European Union. It combines an analysis and understanding of key market trends and developments, with a thematic focus explored in greater depth. This year, the focus is on Europe's transition to an innovative and green future. The report draws extensively on the results of the annual EIB Investment Survey (EIBIS) and the EIB Municipality Survey, combining internal EIB analysis with contributions from leading experts in the field.

About the Economics Department of the EIB

The mission of the EIB Economics Department is to provide economic analyses and studies to support the Bank in its operations and to help define its positioning, strategy and policy. The director of Economics Department, Debora Revoltella, heads a team of 40 economists.

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Chapter 4

Innovation in the global context

EU policy is increasingly emphasising the need to enhance and preserve the global competitiveness of European firms. The focus is on innovation, the diffusion of innovation, and the resilience of global supply chains against a backdrop of strategic dependencies in critical sectors. The ability of the European economy to adjust and transform itself for the green and digital transition will also depend on the supportiveness of the operating environment.

The European Union may be at the forefront of clean technology, but it lags the United States and China in digital innovation. A successful transition will require sustained efforts in innovation and the widespread uptake of new green and digital technologies, as they are key drivers of European competitiveness and resilience to economic disruption and climate change.

The gap in digital adoption between the United States and the European Union is narrowing. EU firms are catching up with their US peers in the use of digital technologies. However, Europe should remain vigilant and invest more, particularly in the adoption of big data analytics and artificial intelligence. The adoption of these technologies is positively associated with firm performance and job creation and can be a catalyst for green innovation and transformation.

The adoption of digital and green technologies by EU businesses depends on internal and external factors. These include digital infrastructure, a dynamic innovation environment, adequate regulations and the availability of skills, as well as management decisions and investment in employee training. Access to finance also plays an important role, with innovative and fast-growing firms often reporting constraints. Difficult conditions for external finance, such as a lack of finance for innovative firms, can exacerbate market failures.

The European Union is well integrated in the global economy, which enables it to import the resources needed to produce the goods and services consumed by EU members and those sold abroad. However, experience in recent years has shown that fragile supply chains can expose firms and countries to trade disruptions, and that strategic dependencies may emerge. Difficult access to the resources needed for production, and disruption to logistics and transport, can be major obstacles for EU businesses. The most innovative firms were more likely to react to recent disruptions in global trade. They acted to make their global value chains more resilient, working with a broader and more diverse range of trading partners, expanding their stocks, and investing in digital inventory and input tracking.

To stay competitive, European firms need a strong mix of innovation, technological adoption, resilient supply chains and an efficient operating environment. Striking the balance of policies is a complex process for the European Union, as it is caught between societal and regulatory constraints, national preferences and global players that define the cutting edge of digital technologies.

Introduction

EU policy is increasingly emphasising the need to enhance and preserve the global competitiveness of European firms. The focus is on innovation, spreading innovation, and the resilience of global value chains against a backdrop of strategic dependencies in critical sectors. The ability of the European economy to adjust and transform itself sufficiently for the green and digital transition will also depend on support from the environment in which companies operate.

The European Union may be at the forefront of clean technology, but it lags the United States and China in digital innovation. A successful transition will require sustained efforts in innovation and the widespread uptake of green and digital technologies, as they are key drivers of Europe's competitiveness and its ability to withstand economic disruption and climate change. Europe also needs to develop resilient supply chains and look closely at the products and services for which it is strategically dependent.

This chapter is organised into four sections. The first section assesses the position of the European Union in global innovation and highlights current trends in the development of green technologies, biotechnologies and digital technologies. The second section discusses firms' investment in new products, processes or services and the adoption of digital and green technologies. It stresses how vital digital infrastructure and the innovation environment are to accelerating the twin digital and green transition. The third section discusses recent global trade disruptions and the action taken by firms to enhance the resilience of their value chains. The last section presents policies needed to support innovation in the European Union.

The European Union's place in global innovation

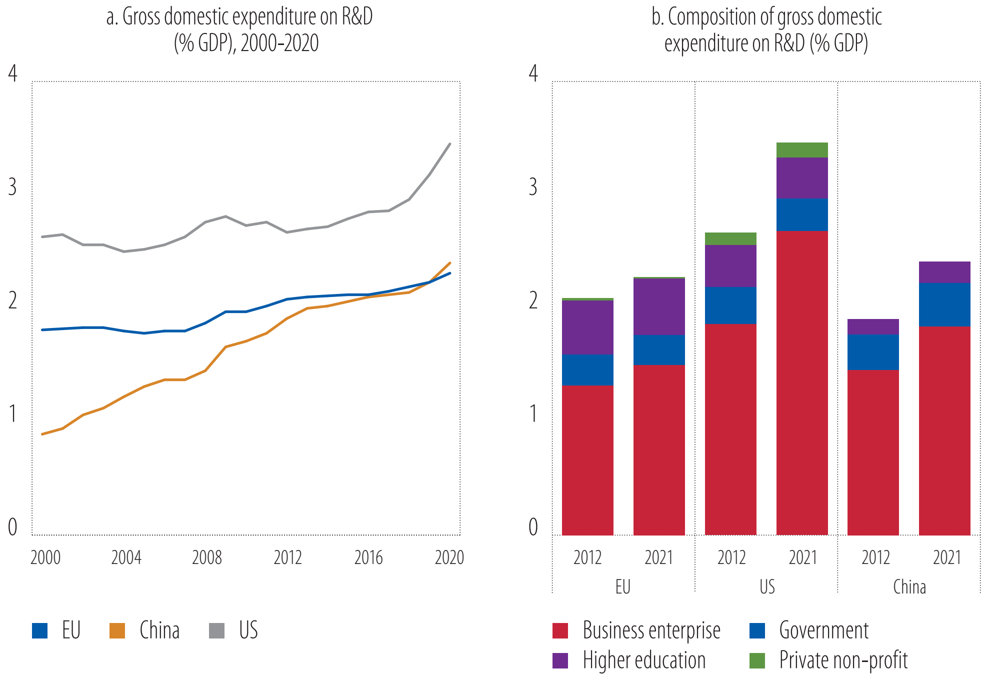
Investment in innovation is recognised as a key driver of productivity, long-term prosperity and economic growth for advanced economies such as the European Union and the United States. It fosters competitiveness, resilience and structural transformation. It is needed to address pressing policy and social challenges – including an ageing population, climate change, and numerous health and environmental issues.

Innovation is a broad term that covers several components, all of which require major investment. Innovation activity is usually seen as grouping research and development (R&D) spending, patenting activities and investment in new products, processes or services. This creates growth opportunities for firms, together with new skill needs and job opportunities for workers. Investment in innovation differs from capacity replacement (investments in existing buildings, machinery, equipment or information technology), or capacity expansion (investments in new buildings, machinery, etc.), as the returns are less cyclical but more uncertain and typically have a longer time horizon.

The European Union sets goals for investment in research and innovation for the public and private sectors. The European Commission has acknowledged the crucial role of creating and improving the dissemination of knowledge and technologies. A key goal is for the European Union to invest 3% of its gross domestic product (GDP) in R&D, 2% of which is expected to come from the business sector and 1% from the government, higher education and private non-profit organisations.

Global R&D expenditure has increased rapidly over the past two decades, but Europe has been losing ground. With an R&D intensity of 2.3% of GDP in 2021, the European Union is currently investing less in R&D than the United States or China (Figure 1a). The private sector has been driving the rapid increase in R&D spending in China and the United States over the past ten years (Figure 1b). If policy measures are not taken to support R&D, some highly innovative EU firms may lose their competitive advantage over firms based in other countries. Lagging EU companies may also find it difficult to catch up and adopt technologies developed elsewhere.

Figure 1
R&D expenditure



Source: *Eurostat and the Organisation for Economic Co-operation and Development (OECD).*
Note: *For China, 2021 is an estimate based on 2020 data, and no data on the private non-profit sector are available.*

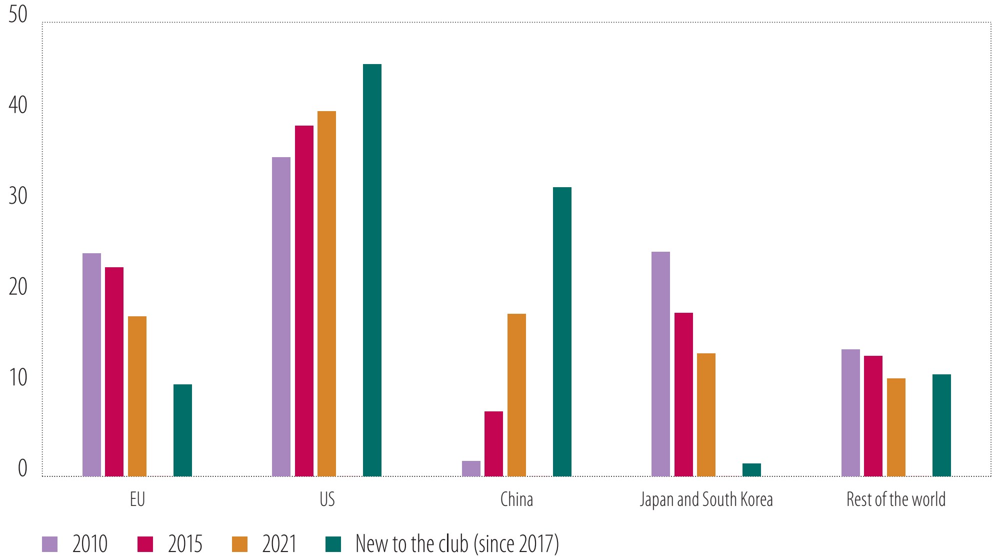
The rise of digital firms among the top global R&D companies

Europe is at risk of being overtaken in global innovation, particularly in digital technologies. R&D investment and patenting activities are highly concentrated among a small number of companies, sectors and countries. The world's top 2 500 R&D investors account for close to 90% of global business R&D expenditure and 60% of patent filings for all technologies (Amoroso et al., 2021). This concentration of innovation is particularly pronounced in high-tech sectors such as software and computer services, pharmaceuticals and biotechnology, and electrical equipment and technology hardware, as well as in industries like the automotive sector. Compared to sales or employment, R&D investment and patenting activities are more concentrated among a small number of firms that have grown bigger over time.

The European Union remains a major global player in R&D and innovation, but the share of EU firms in the top global R&D investors has fallen over time. The share of firms from the European Union and Japan in the list of the top 2 500 R&D investors decreased from 2010 to 2021 (Figure 2). This decline is largely attributable to the emergence of Chinese firms. While the United States remains an innovation leader, the number of Chinese companies included on the list of big R&D spenders has risen fast.

The global R&D landscape changed rapidly over the past decade as the digital economy increased in importance. Electrical equipment and hardware represent 23% of total R&D spending by the top 2 500 companies, followed by pharmaceuticals and biotechnology, which account for 22% (Figure 3). R&D spending by companies selling software and computer services has risen sharply over the past decade, with their share rising to 18% in 2021, from 8% in 2010. At the same time, the share of the automotive industry in R&D expenditure has declined, to 14% in 2021 from 20% in 2010.

Figure 2
Top global R&D companies (% of firms)**, by region**



Source: *EIB staff calculations based on EU Industrial R&D Investment Scoreboard.*
Note: *New to the club refers to firms that entered the list of top global R&D investors after 2017.*

Figure 3
Top global R&D companies (% of R&D expenditure)**, by sector**

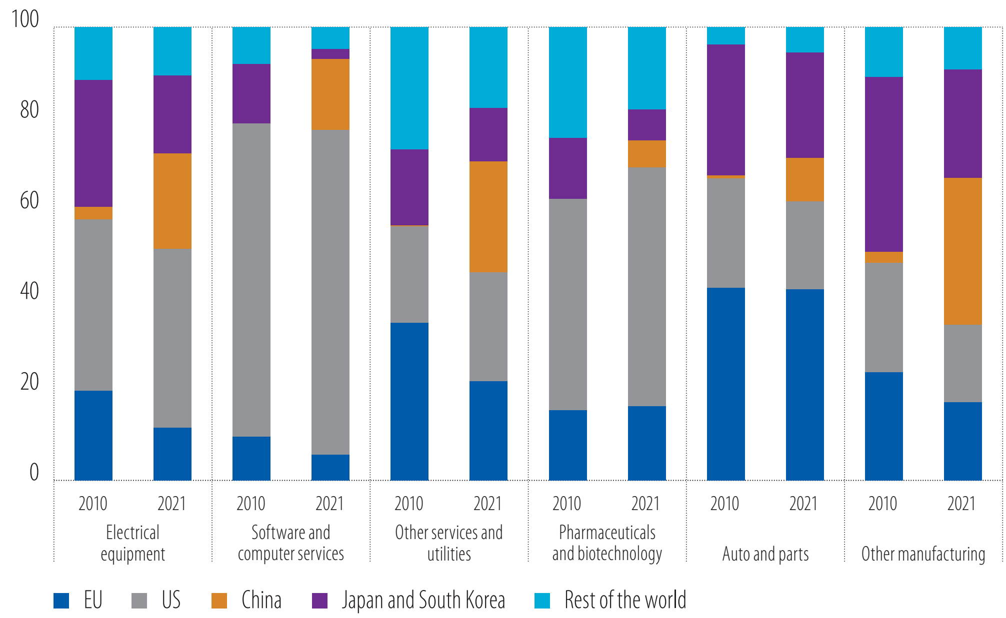
Source: *EIB staff calculations based on EU Industrial R&D Investment Scoreboard 2022.*
Note: *Electrical equipment includes electronic and electrical equipment and technology hardware and equipment. Other services and utilities includes fixed line telecommunications, mobile telecommunications, food and drug retailers, general retailers, industrial transportation, travel and leisure media, banks, equity investment instruments, life insurance, non-equity investment instruments, non-life insurance, real estate investment and services, support services, alternative energy, electricity, gas, water and multiutilities, industrial metals and mining, oil and gas producers, oil equipment, services and distribution. Pharmaceuticals and biotechnology includes healthcare equipment and services. Auto and parts includes aerospace and defence, automobile and parts. Other manufacturing includes beverages, food producers, tobacco, chemicals, construction and materials, forestry and paper, general industrials, industrial engineering, household goods and home construction, leisure goods and personal goods.*

Pharmaceuticals and biotechnology and software and computer services have a higher R&D intensity than other industries and are dynamic sectors with new players. In these two sectors, R&D investment by global leaders represents close to 15% of turnover, which is significantly higher than for the electrical equipment or automotive industries. This reflects the major investment and ongoing R&D efforts needed to stay competitive in critical digital technologies and biotechnologies. In addition, R&D expenditure by companies that are new to the club (firms that recently joined the list of R&D global leaders) is largest among software and internet firms, followed by pharmaceuticals and biotechnology.

The European Union specialises less in software and computer services than the United States and China. The European Union only represents 6% of R&D expenditure among the leading companies in software and computer services, compared with 72% for the United States and 16% for China (Figure 4). Similarly, the European Union accounts for 12% of R&D expenditure among leading companies producing electrical equipment and technological hardware, compared with 40% for the United States, 19% for China, and 19% for Japan and South Korea.

Figure 4

Share of R&D expenditure in 2010 and 2021 (in %)**, by sector**



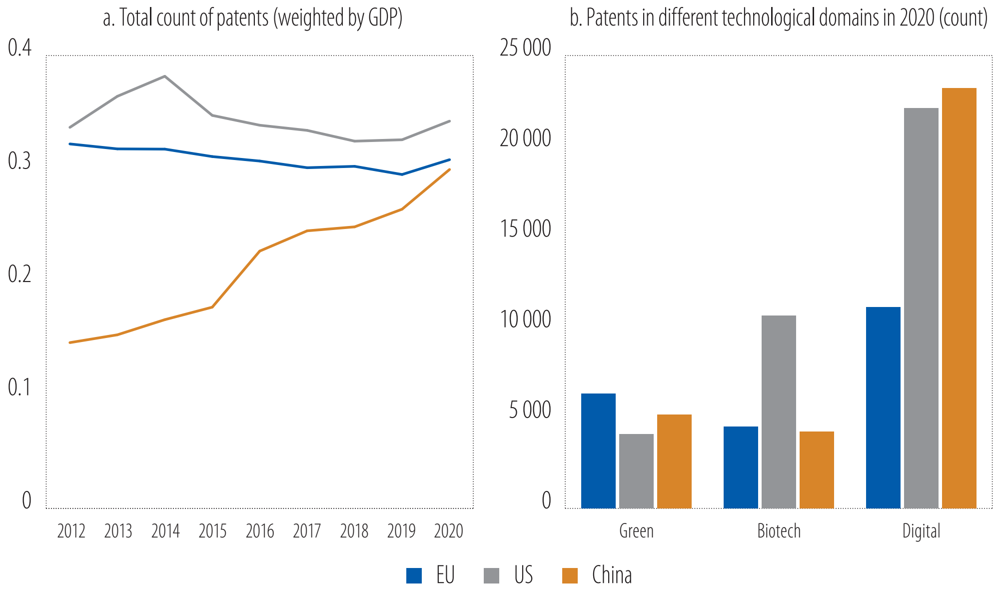
Source: *EIB staff calculations based on the EU Industrial R&D Investment Scoreboard 2022.*
Note: *See Figure 3 for sector definitions.*

Patenting activities in digital technologies, green technologies and biotechnologies

The European Union is at the forefront of the development of new technologies – together with the United States – but China is catching up. This is reflected in innovation measures other than R&D, such as the stock of international patents. Patents protect novel inventions and technologies used in industries. They are important components of the innovation chain, giving inventors the exclusive rights to their knowledge for a specified period. At the same time, patents foster competition as they support the dissemination of knowledge by mandating the disclosure of technical details, thus promoting further advancements. They are therefore a good indicator of the competitive position of different markets.

Chinese patenting activities are beginning to vie with those of the European Union. While China's R&D spending has been similar to that of the European Union for several years, patent activity lagged until very recently (Figure 5a). The narrower gap indicates that China's competitive position in innovative output is improving as years of increasing R&D expenditure pay off, especially in digital technologies (Figure 5b).

Figure 5
Patenting activities in the European Union, the United States and China



Source: *EIB staff calculations based on Patent Cooperation Treaty (PCT) patents (PATSTAT) in collaboration with the Research and Development Monitoring Research Centre (ECOOM) at KU Leuven university.*

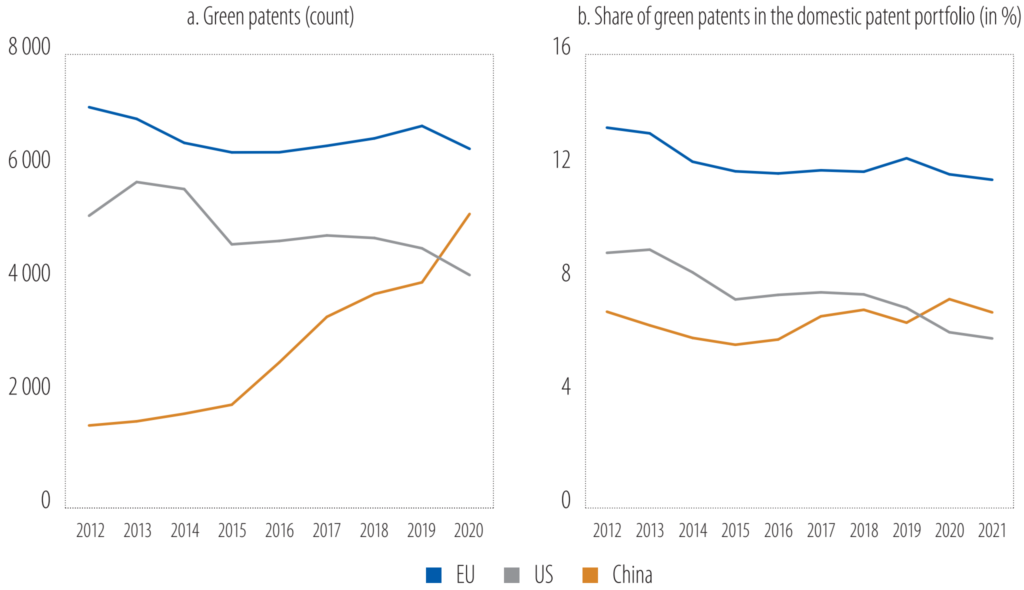
Note: *GDP, USD, constant prices, constant purchasing power parity, reference year 2015, millions (source OECD), count of PCT patents (PATSTAT). Patents weighted by GDP is a common way to measure the innovative activity in a region, correcting for its economic size (OECD, 2009). Patents in green technologies are measured based on the methodology of Haščič and Migotto (2015), with further adjustments implemented by ECOOM. The patent classification in biotechnology is based on the classification established by KU Leuven. The biotechnology domain is the combination of Fraunhofer technology classes 15 (biotechnology) and 16 (pharmaceuticals). The digital patent classification is based on the European Patent Office (EPO) (2017).*

The European Union leads in green technologies. Climate is a key focus of EU policy,[1] and green tech is the only strategic technological area where the European Union is excelling. The European Union has a higher number of patents in green technologies than the United States and China (Figure 6a). It also has a higher share of patents in green technologies, reflecting its specialisation in the development of these technologies (Figure 6b). Box A discusses patenting activities in selected clean and sustainable technologies and the contribution of EU firms.

Venture capital investment in European clean tech, green energy and green tech has increased rapidly in the past few years. These areas benefited from the flow of money to venture capital in 2021, but also remained resilient in 2022. This was a rare exception to the ongoing global contraction in venture capital investment and was enabled by government regulations and subsidies that continued to support these key sectors (Figure 7a). However, the share of venture capital investment in clean tech, green energy and green tech remains small. More investment is needed to achieve Europe's green agenda, especially since EU venture capital flows are expected to be weak in 2024 (Figure 7b).

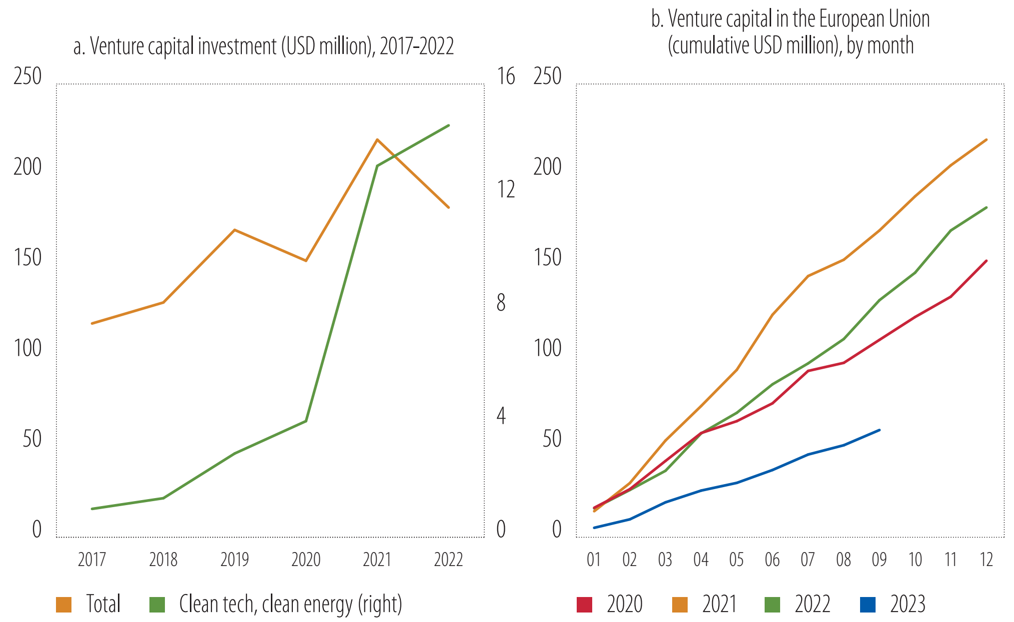
1 For example, the Strategic Technologies for Europe Platform (STEP) is the European Commission's recent proposal for a structural answer to supporting the development and manufacturing of strategic technologies in the European Union. The main technology fields included in this proposal, which will also support investments aimed at reinforcing their values chains, are clean technologies, biotechnologies and digital technologies.

Figure 6
Green tech patents, 2012-2021



Source: *EIB staff calculations based on PCT patents (PATSTAT) in collaboration with ECOOM.*
Note: *Patents in green technologies are measured based on the methodology of Haščič and Migotto (2015), with further adjustments implemented by ECOOM.*

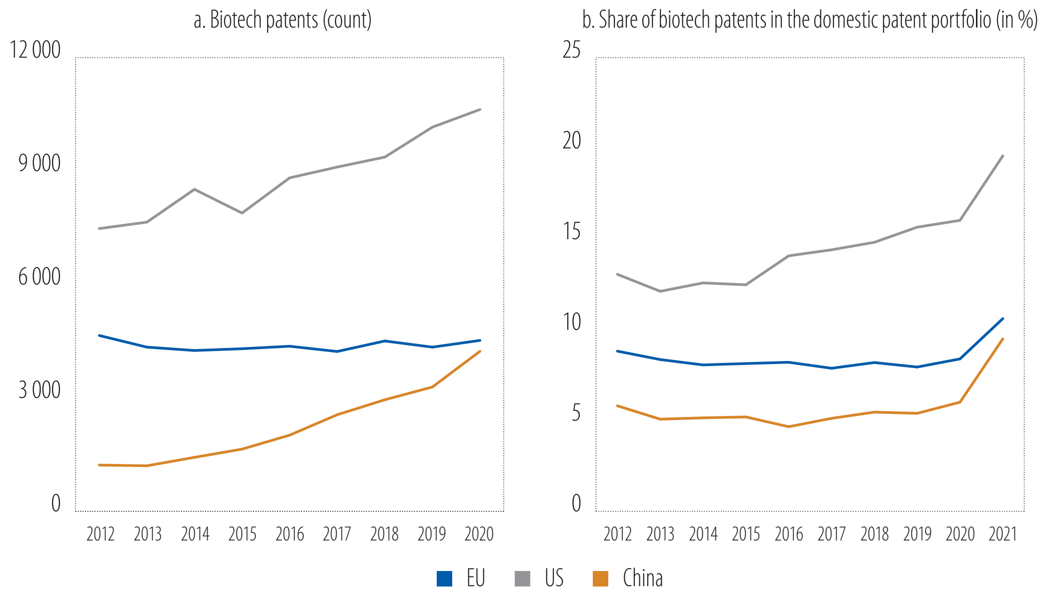
Figure 7
Venture capital investment in clean technologies in the European Union



Source: *EIB staff calculations based on PitchBook data, Inc.*

The United States leads in biotechnology patenting, followed by the European Union and China. The number of biotechnology patents has remained stable in the European Union over the past decade, while it has risen in the United States and China (Figure 8a). China is still lagging the European Union but only marginally, reflecting its increased focus on this domain (Figure 8b).

Figure 8
Biotech patents, 2012-2021



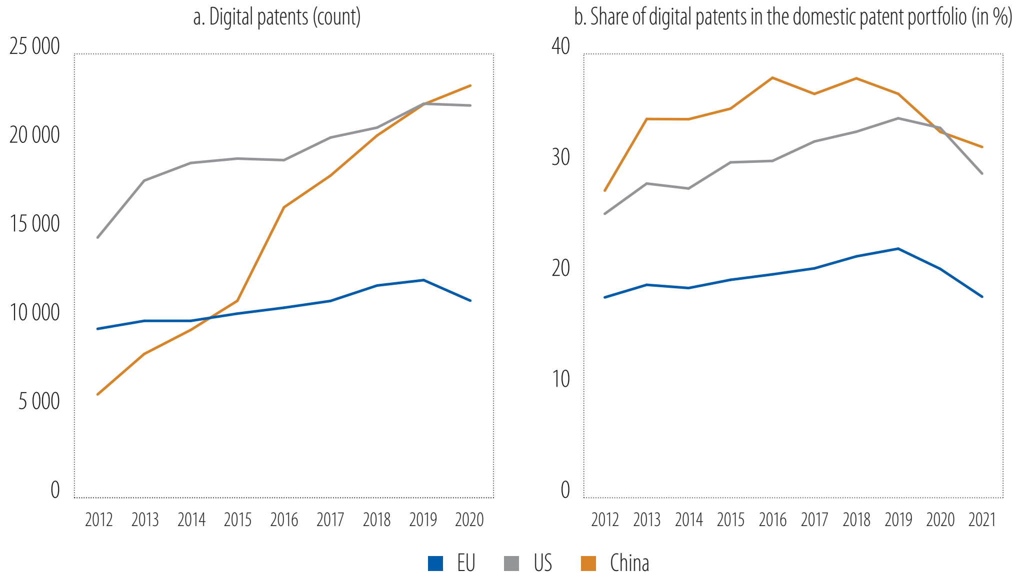
Source: *EIB staff calculations based on PCT patents (PATSTAT) in collaboration with ECOOM.*
Note: *The patent classification in biotechnology is based on the classification established by KU Leuven. The biotechnology domain is the combination of Fraunhofer technology classes 15 (biotechnology) and 16 (pharmaceuticals).*

Compared to the United States and China, the European Union is not well positioned in digital innovation. The number of patented digital innovations has been growing in China more than in the United States and the European Union (Figure 9a), even if the share remains fairly stable (Figure 9b). If Europe wants to remain globally competitive, it must further strengthen and defend its ability to innovate in digital technologies. Box B discusses the position of the European Union, the United States and China in complex technologies.

The European Union is falling behind in innovation in artificial intelligence. Artificial intelligence is increasingly considered a key digital technology, as it has the power to revolutionise various industries. It also could help address pressing global challenges like climate change using data-driven solutions. However, the European Union is behind the United States and China when it comes to patents in this area, especially in recent years (Figure 10). The regulatory framework for artificial intelligence is also a priority for policymakers, as the European Union's AI Act shows.

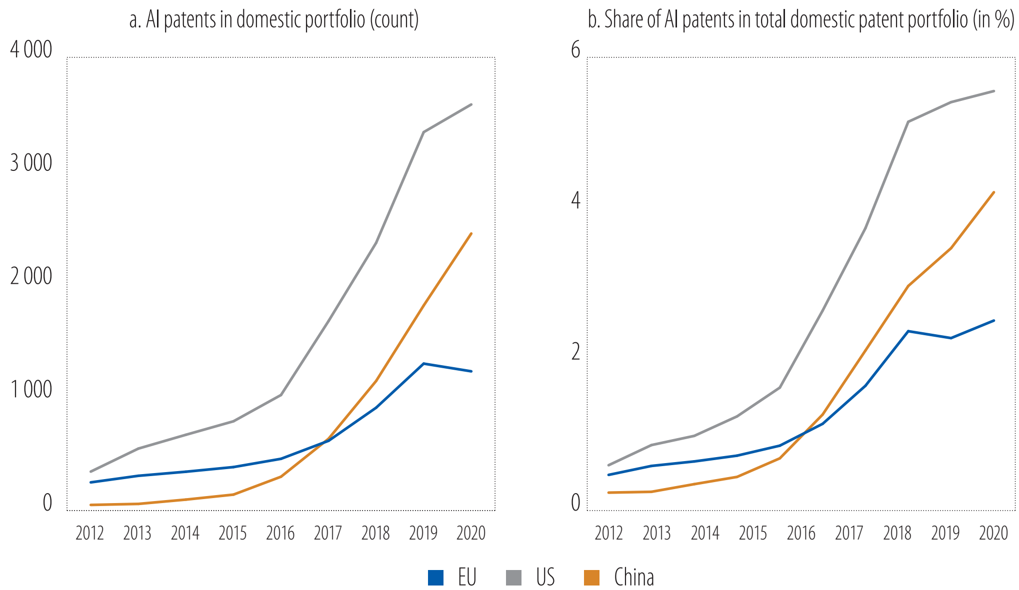
Specialisations in green technology and artificial intelligence seem to reinforce each other in EU countries, particularly in Western and Northern Europe. Green tech and artificial intelligence-related innovation activities in Europe vary significantly depending on the country. Nevertheless, there seems to be a close link between patenting specialisation in these two innovation domains (Figure 11). Combined specialisation could pay off in the future given the growing evidence that artificial intelligence could revolutionise the green transition (Rotman, 2019). The specialisation of the main EU countries in green technologies and artificial intelligence has not changed much over time. The exception to this is Denmark, which has increased its specialisation in green technologies in recent years.

Figure 9
Digital patents, 2012-2021



Source: *EIB staff calculations based on PCT patents (PATSTAT) in collaboration with ECOOM.*
Note: *The digital patent classification is based on EPO (2017).*

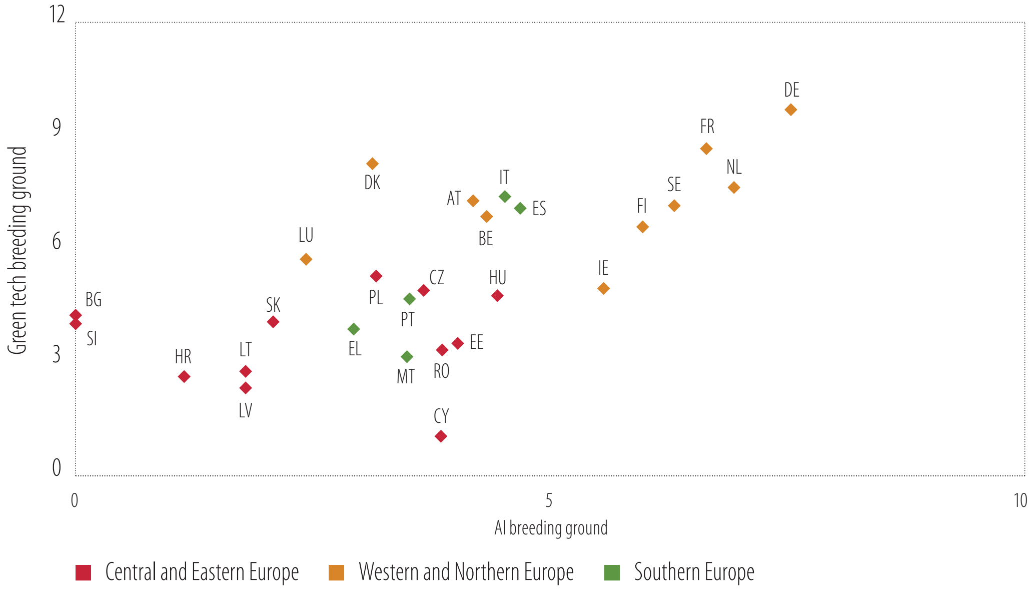
Figure 10
Artificial intelligence patents, 2012-2021



Source: *EIB staff calculations based on PCT patents (PATSTAT) in collaboration with ECOOM.*
Note: *AI patents are a subdomain of the digital patent classification.*

Figure 11

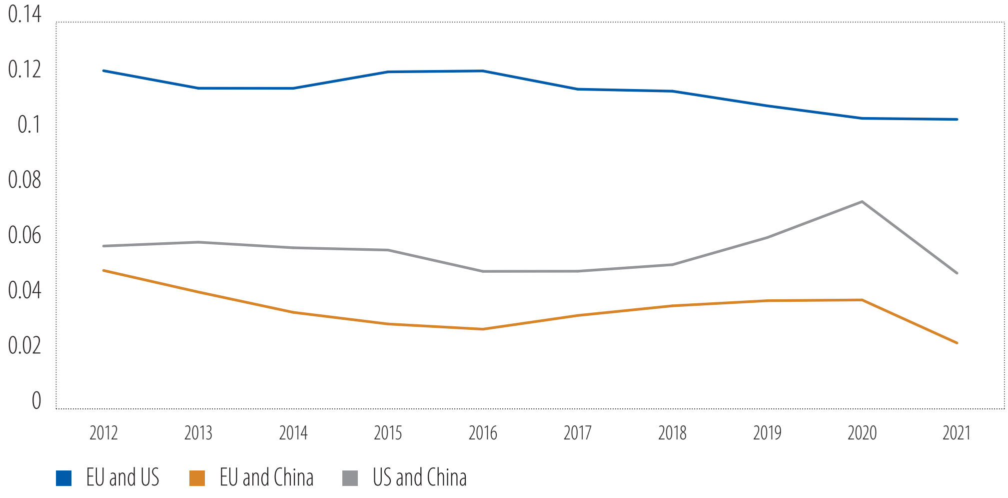
National breeding ground indices of AI and green technologies (logarithm)



Source: *EIB staff calculations based on PCT patents (PATSTAT) in collaboration with ECOOM.*
Note: *Log of National Breeding Ground index (following Leusin et al., 2020), an index multiplying the revealed technological advantage by the number of patents in each domain in a given country.*

Figure 12

Salton index of collaboration between countries



Source: *PCT patents (PATSTAT) in collaboration with ECOOM.*
Note: *The Salton index, r, captures the number of collaborative patents between country i and country j, normalised by the total patent count, n, of both countries:* $r = r_{ij}/\sqrt{n_i n_j}$

The European Union collaborates more closely with the United States than with China. International cooperation plays a pivotal role in driving innovation, paving the way for future advancements with worldwide implications. The European Union and the United States collaborate more closely with each other than with China (Figure 12), but the United States works more closely with China than the European Union does. This is also confirmed by cooperation patterns in green technologies, although EU-China and US-China cooperation is similar in that case.

Box A

Innovation and commercialisation of green and sustainable technologies in Europe

Legally binding since 2021, the European Green Deal delineates Europe's ambitious targets to address major global issues, including climate change, biodiversity loss and pollution. Innovation in clean and sustainable technologies is key to achieving these goals, enabling economies and societies to evolve towards a carbon-neutral future. At the same time, meeting these goals will require substantial investment from the public and private sectors.

Patent data serve as a compelling indicator for tracking advancements in clean and sustainable technologies. The European Patent Office (EPO) examines European patent applications, enabling inventors, researchers and companies from around the world to obtain protection for their inventions in up to 44 countries via a centralised and uniform procedure. The European Patent Office's examiners have devised strategic methods to identify patent documents pertinent to clean and sustainable technologies in various domains, including:

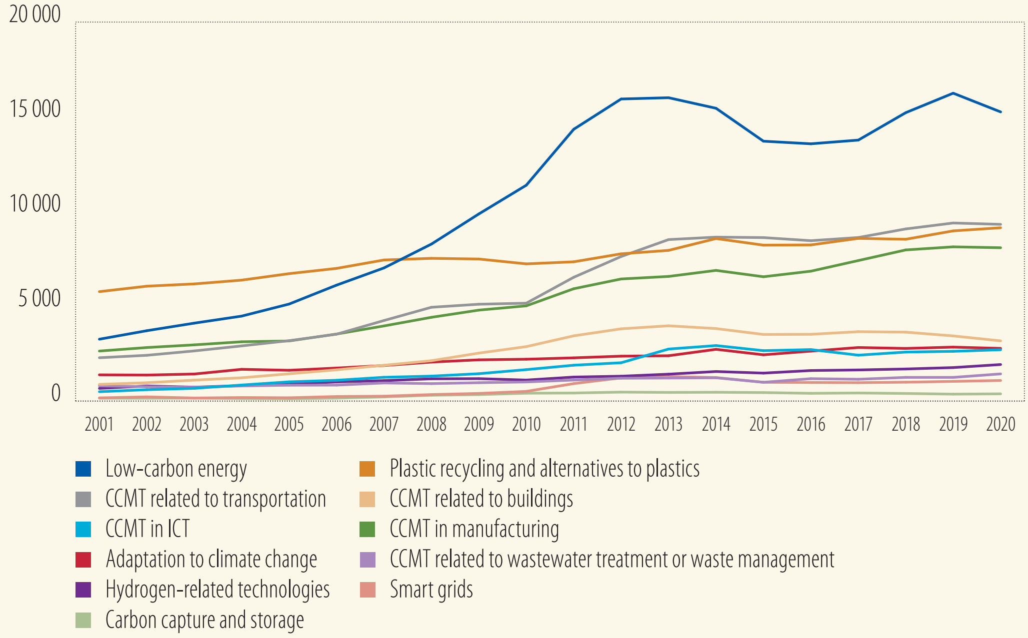
- Low-carbon energy and associated energy storage solutions
- Solutions for plastic recycling and plastic alternatives
- Climate change mitigation technologies (CCMT) in transportation, buildings, information and communication technology (ICT), and manufacturing
- Adaptation strategies for climate change
- Climate-friendly hydrogen-based technologies
- Innovations in waste and wastewater treatment
- Developments in smart grid technology
- Carbon capture and storage methods

Low-carbon energy is the largest technology field with thousands of new inventions per year, encompassing energy supplies such as renewable energy and supporting technologies like electric batteries (Figure A.1). Following a surge in international patent families until the early 2010s, innovation in low-carbon energy remains very active, but with considerable fluctuations in annual numbers. Carbon capture and storage is currently the smallest of the technology fields examined here, with only a few hundred international patent families per year.

Europe was very present in these technologies from 2016 to 2020, albeit to varying degrees (Figure A.2). Europe excels in climate change mitigation technologies related to wastewater treatment and waste management and transportation, but shows relative weakness in those related to information and communication technologies. Further analysis indicates that Europe's strength mostly lies in more established fields, but it lags in newer technological innovations. For instance:

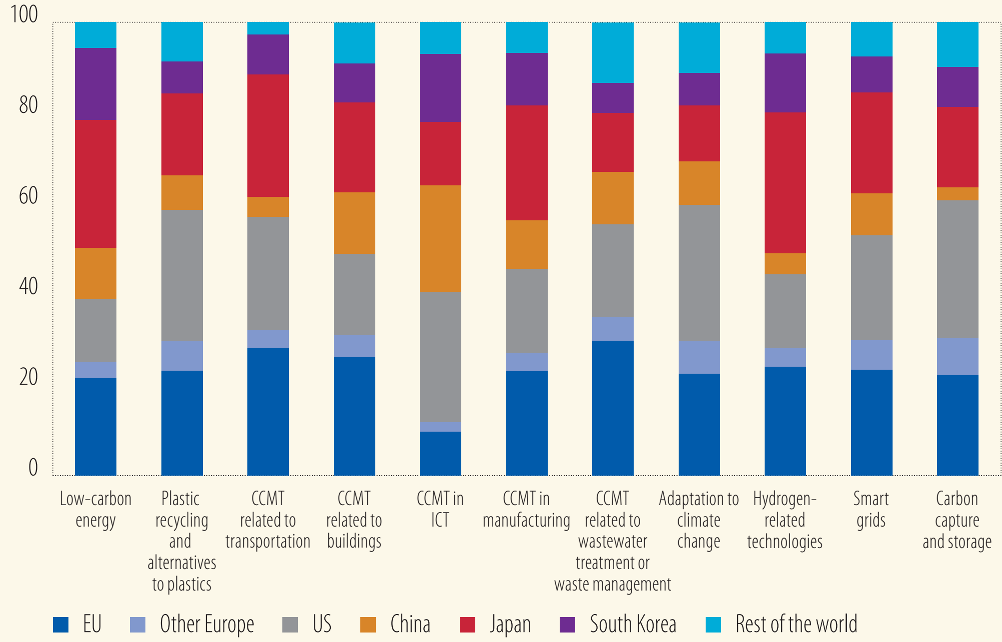
- Europe leads in the mechanical recycling of plastics (EPO, 2021), which is a mainstream solution for transforming plastic with the major breakthroughs made in the 1990s. However, Europe holds a smaller stake in the newer biological and chemical recycling technologies.
- European chemical industries excel in incremental improvements within well-established processes in hydrogen technology (EPO-International Energy Agency (IEA), 2023). However, Asian automotive and chemical companies are at the forefront of emerging technologies in this domain, such as electrolysis and fuel cell technologies.
- While Europe also boasts a strong position in nearly all renewable energy technologies, especially wind energy (EPO-IEA, 2021), it makes less of a contribution to some important enabling technologies such as those related to batteries, which are dominated by Asian countries.

Figure A.1
Trends in international patent families in selected clean and sustainable technologies, 2001-2020



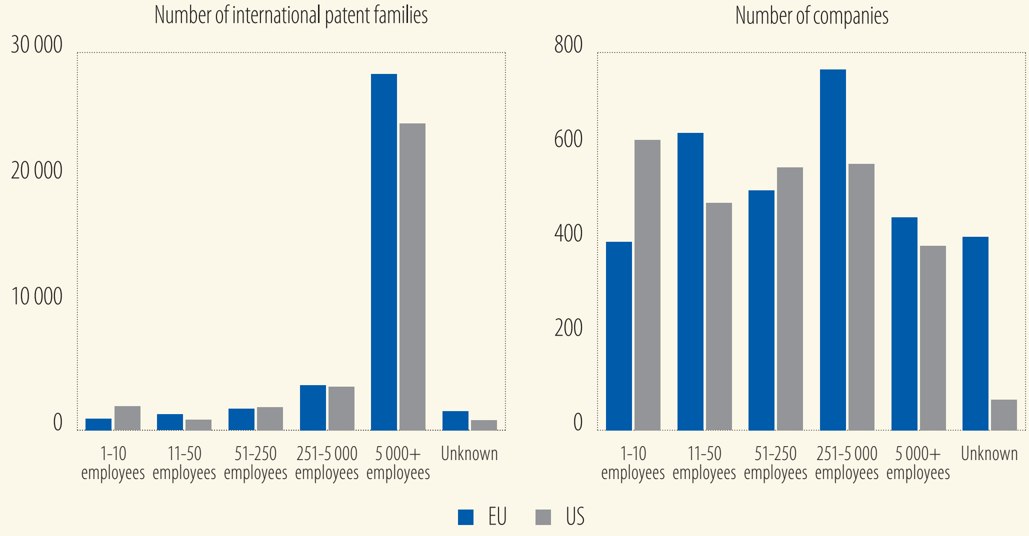
Source: *EPO. CCMT refers to climate change mitigation.*

Figure A.2
Contribution to international patent families in selected clean and sustainable technologies (in %), 2016-2020



Source: *EPO.*

Figure A.3
Distribution of international patent families and applications, by company size 2016-2020



Source: *EPO.*
Note: *Information on the number of employees is based on the matching of patent applicant data with Crunchbase and LinkedIn databases. For international patent families with applicants from EU countries and applicants from other EPO member states, over 79% and 71% respectively were successfully matched. International patent families with universities and public research organisations as applicants are not presented.*

Although protecting new technologies with patents is an important step, it is often only a first step in the development and introduction of new products and services on the market. Companies of all sizes are at the forefront of the transformation needed to make the economy carbon neutral, yet they encounter unique hurdles in the commercialisation of clean and sustainable technologies, meriting significant policy focus. Although very large companies are responsible for most new patent applications in clean and sustainable technologies, smaller companies also seem to be very active in this field (Figure A.3, left-hand column). While smaller companies may not hold most of the patents, they do represent a large share of businesses active in the clean and sustainable technology domain (Figure A.3, right-hand column).

Box B
The position of the European Union, the United States and China in complex technologies

Understanding the global technological landscape is crucial to deploying strategic research and innovation policies. Technologies vastly differ in value and growth potential. Those that are relatively easy to copy and delocalise typically require a lower number of capabilities, thereby conferring a lower competitive advantage on the countries or regions where they are located. On the other hand, more complex technologies combine a higher number of capabilities, are more geographically concentrated and have greater potential for growth and overall competitiveness (Balland & Rigby, 2016).

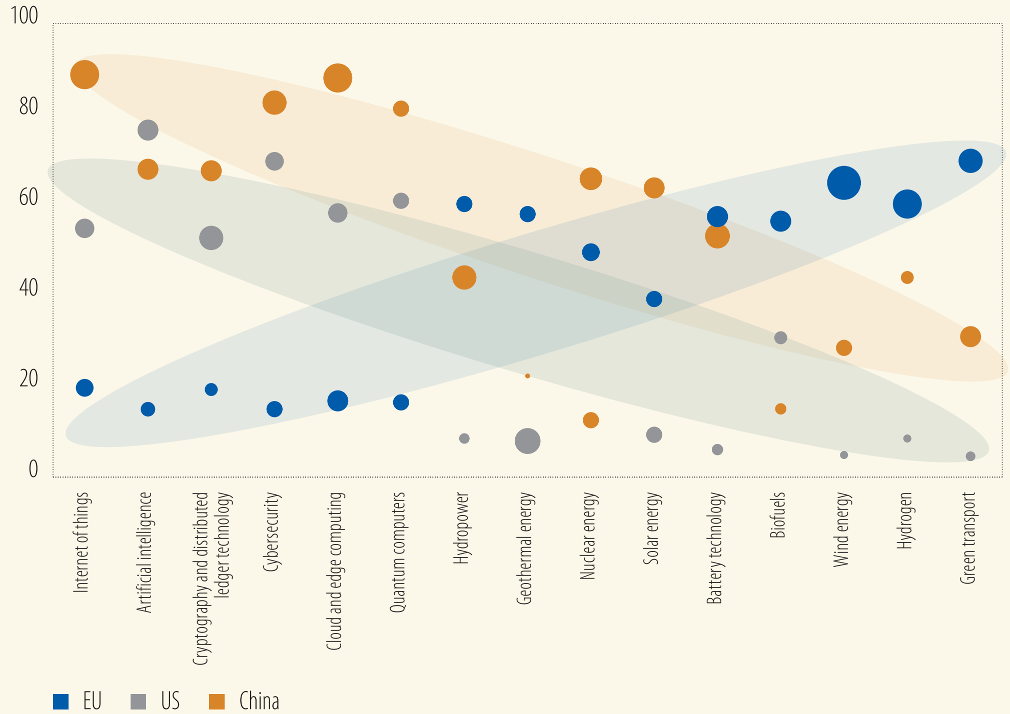
The European Union trails the United States and China in more complex technology fields. Digital technologies emerge as those with the highest technology complexity. Specifically, computer technologies, digital communication, audiovisual technologies, optics, telecommunications and semiconductors rank at the top of the technological complexity scale (Di Girolamo et al., 2023). However, the European Union is in the lead for green technologies, outperforming China and the United States in areas related to climate adaptation, energy technologies and environmental technologies.

Figure B.1 ranks 15 key digital and green technologies based on their level of complexity. The analysis confirms that the European Union is underperforming the United States and China in digital productivity-enhancing technologies such as artificial intelligence, the internet of things, blockchain technologies and quantum computers. This calls for increased EU efforts to narrow the gap with key competitors.

However, the European Union remains ahead in some green fields, outperforming China and the United States in technologies related to wind energy, hydrogen and green transport, while little difference is observed for biofuels (Figure B.1). Furthermore, although it currently has a lower specialisation ranking in nuclear energy, solar energy, hydropower, geothermal energy and battery technologies, the European Union does have high future specialisation potential in these fields, indicating that the cost to further specialise in these types of technologies would be lower.

Figure B.1

EU position in complex technologies vs. the United States and China, 2019-2022



Source: *European Commission Directorate-General for Research and Innovation, Common R&I Strategy and Foresight Service, Chief Economist Unit based on Google patent data.*

Note: *The x-axis indicates the relatedness density in any of the technology fields considered. On the y-axis, technologies are ranked by complexity, 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.*

From a policy standpoint, these results should encourage a more structural approach to strategic funding and technological development, targeting EU research and innovation investments bridging the specialisation gap between the European Union and its main counterparts and focusing on technologies more likely to deliver major productivity gains in the long term. The European Union can also use its international relationships to complement its technological capabilities, defining areas of mutual interest as well as division of knowledge with key partners.

At the same time, the European Union can continue to exploit its comparative advantage in green technologies, while increasing its efforts to reduce its dependency on raw materials and pursue other activities necessary for decarbonisation. The EU single market must also be further strengthened to accelerate the roll-out of strategic technologies and thus reduce strategic dependencies. Efforts are needed to avoid brain drain and promote re-training and lifelong learning initiatives, as innovation remains key to reducing skill gaps and ensuring that humans and cutting-edge technologies complement each other well.

Investment in innovation and the adoption of digital and green technologies

This section focuses on corporate investment in innovation and the adoption of green and digital technologies. The latest results of the EIB Investment Survey (EIBIS) show that investment in innovation is positively associated with a range of firm performance indicators. The section also discusses factors that can support or hamper the investment activities of innovative firms, such as access to finance, digital infrastructure, a dynamic innovation environment, business regulations and the lack of skilled workers.

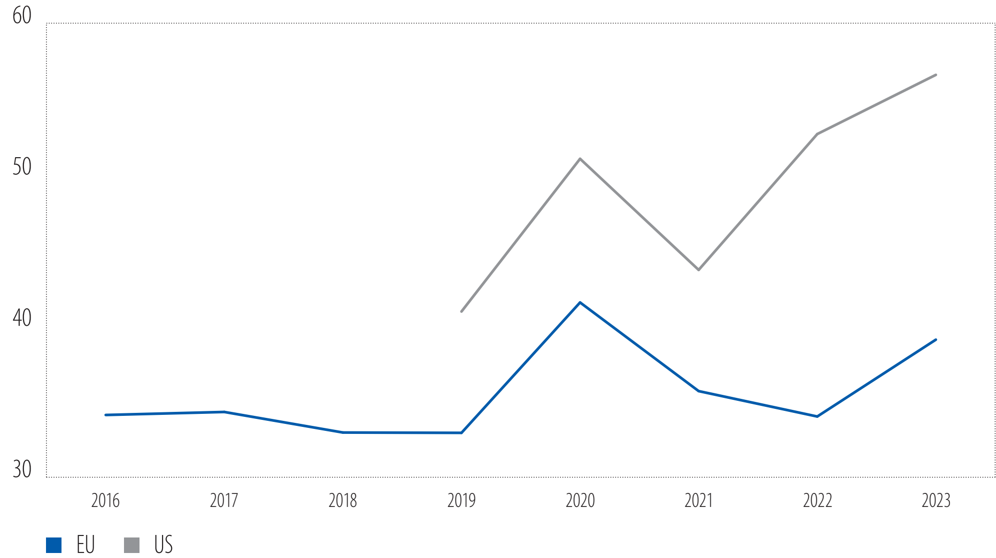
Investment to develop or introduce new products, processes or services

The European Union has a lower share of firms investing to develop or introduce new products, processes or services than the United States. After a slowdown following the COVID-19 crisis, the share of EU firms investing in innovation increased to 39%, compared with 57% in the United States (Figure 13). This evidence from the EIBIS confirms the findings of the European Innovation Scoreboard 2023 (European Commission, 2023) and Organisation for Economic Co-operation and Development (OECD) data, in which the United States scores better than the European Union on several indicators related to R&D and innovation.

Innovation activities are associated with investment in intangible assets. Firms that allocate a greater share of investment to intangibles (R&D, software and data, training of employees and organisational and business process improvements) tend to innovate more (Figure 14). R&D investment is the main driver of this positive correlation between intangible assets and the introduction or development of new products, processes or services.

Figure 13

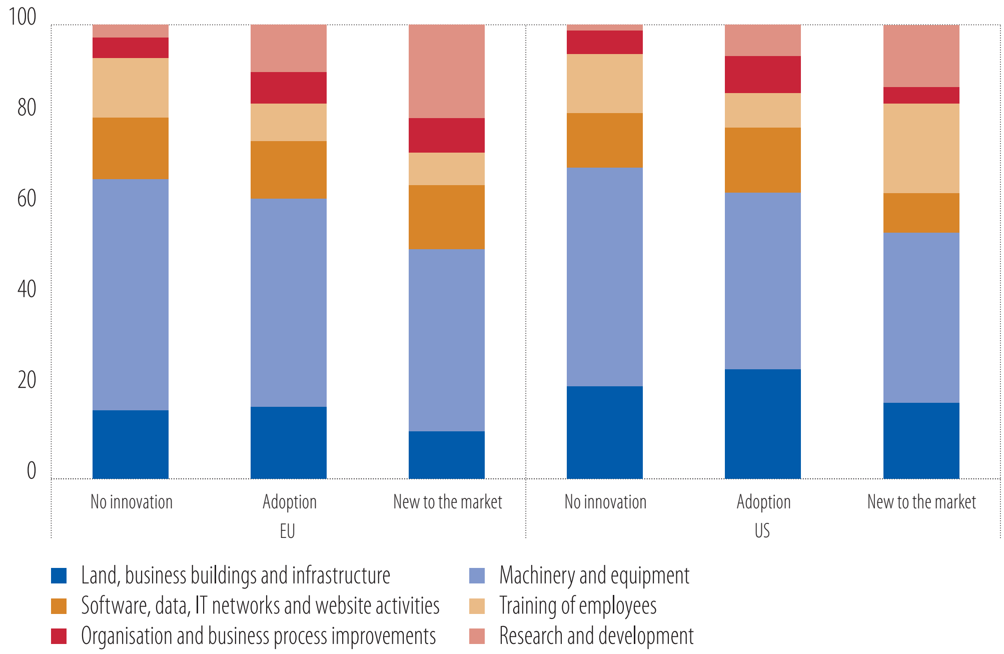
Development or introduction of new products, processes, or services (% of firms)



Source: EIBIS 2016-2023.
Note: Firms are weighted by value added.
Question: What proportion of the total investment in the previous financial year was for developing or introducing new products, processes or services?

Figure 14

Innovation and investment in intangible assets (% of total investment)



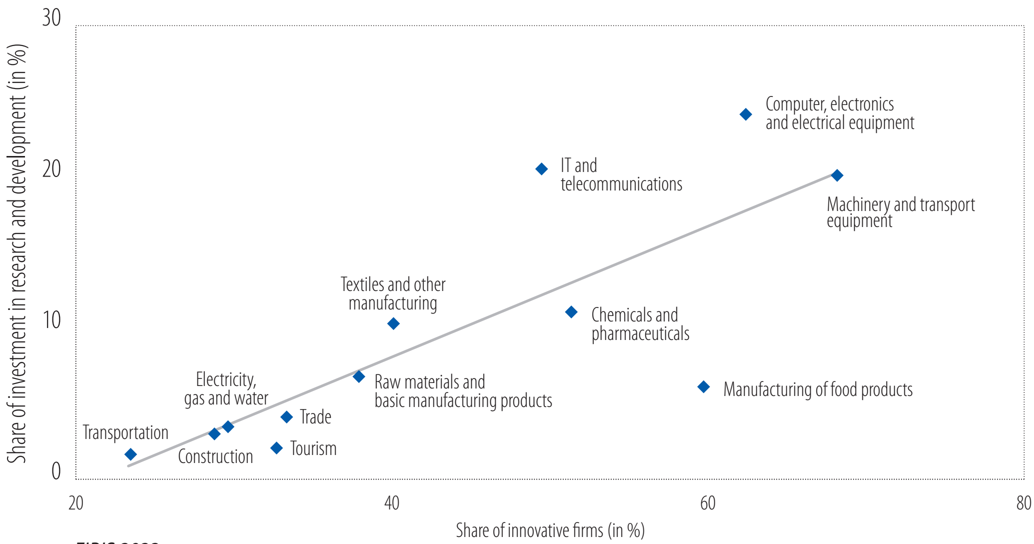
Source: EIBIS 2023.
Note: Firms are weighted by value added.
Question: Were the new products, processes or services that you developed or introduced new to the company or new to the country or global market? In the previous financial year, how much did your business invest in each of the following with the intention of maintaining or increasing your company's future earnings?

Firms in sectors with higher R&D intensity tend to be more innovative. Sectors that invest more intensely in R&D (such as computer, electronics and electrical equipment, machinery and transport equipment, and information technology (IT) and telecommunications) also tend to have a higher share of firms that introduce new products, processes or services (Figure 15). This highlights how different investment needs for supporting innovative firms are, depending on the sector.

Innovative firms tend to perform better. They are more likely to have strong management practices, invest in training their employees, use advanced digital technologies, introduce new green technologies and invest in energy efficiency (Figure 16). They therefore seem more likely to thrive in an environment where investment in all these areas is increasingly important.

Figure 15

Investment in innovation and investment in R&D



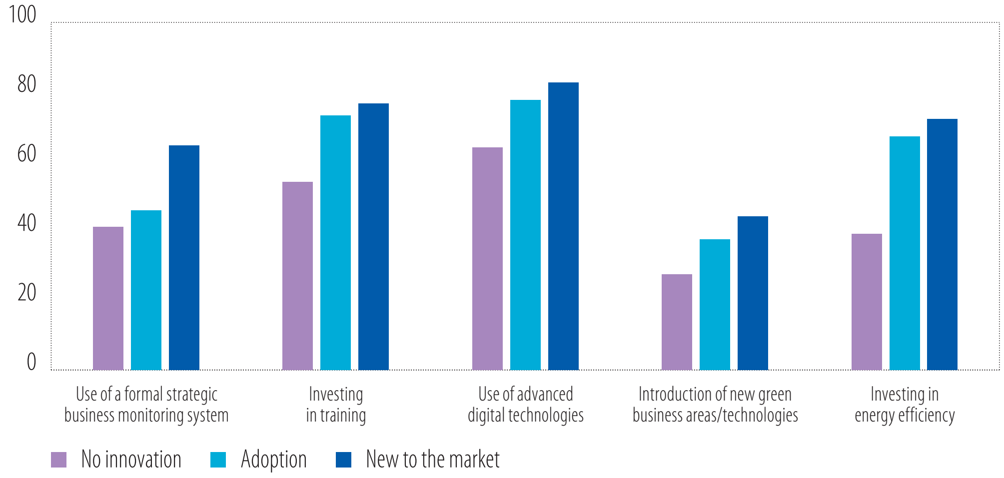
Source: *EIBIS 2023.*
Note: *EU firms. Firms are weighted by value added.*
Question: *What proportion of the total investment in the previous financial year was for developing or introducing new products, processes or services? In the previous financial year, how much did your business invest in research and development (including the acquisition of intellectual property)?*

Highly innovative firms are more pessimistic about the availability of external finance. Over the past two years, there has been a rapid increase in the share of highly innovative firms expecting conditions for external finance to deteriorate (Figure 17a). The current economic context poses several challenges that may negatively affect the investment activities of highly innovative firms. Firms that introduce innovations that are new to the market appear to be the most pessimistic and vulnerable to a cyclical deterioration in financing conditions. This may reflect structurally tighter access to external finance for these firms.

As European policies in 2022 focused on countering the effects of the energy shock, the most innovative companies saw a drop in finance provided by public grants. Even though highly innovative firms saw an uptick in support through grants during COVID-19, they later also experienced a stronger decrease in grant finance (Figure 17b). This could further exacerbate their vulnerability, hindering their ability to weather a difficult external economic environment.

Figure 16

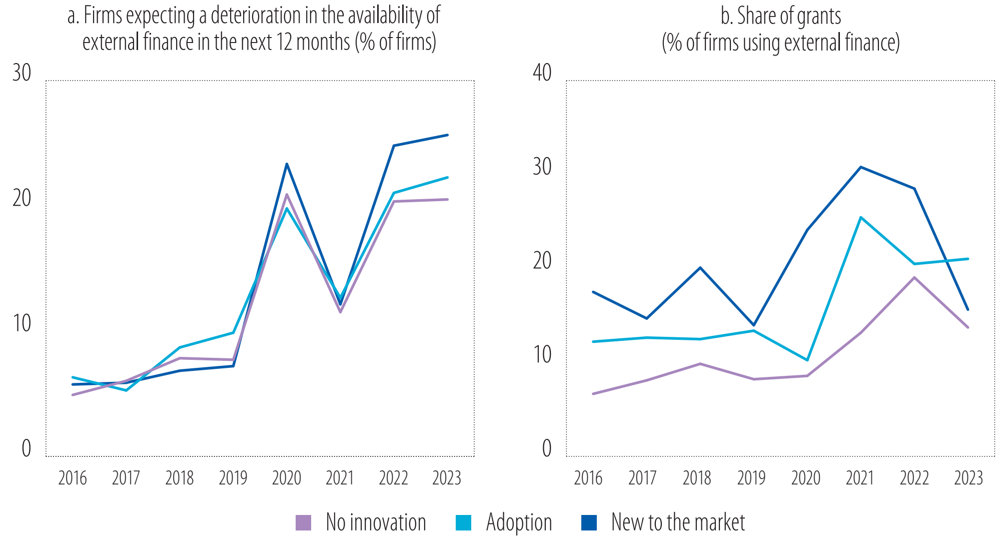
Innovation and firm performance (% of firms)



Source: *EIBIS 2023*
Note: *EU firms. Firms are weighted by value added.*
Question: *Were the new products, processes or services that you developed or introduced new to the company or new to the country or global market? Does your company use a formal strategic business monitoring system that compares the firm's current performance against a series of strategic key performance indicators? In the previous financial year, how much did your business invest in training employees? Are advanced digital technologies used within your business? Is your company investing in new, less polluting, business areas and technologies to reduce greenhouse gas emissions? Is your company investing in energy efficiency (including heating and cooling improvements and energy management (for example, energy smart technologies and Eco-Management and Audit Scheme (EMAS)) to reduce greenhouse gas emissions?*

Figure 17

Innovation and the availability of external finance



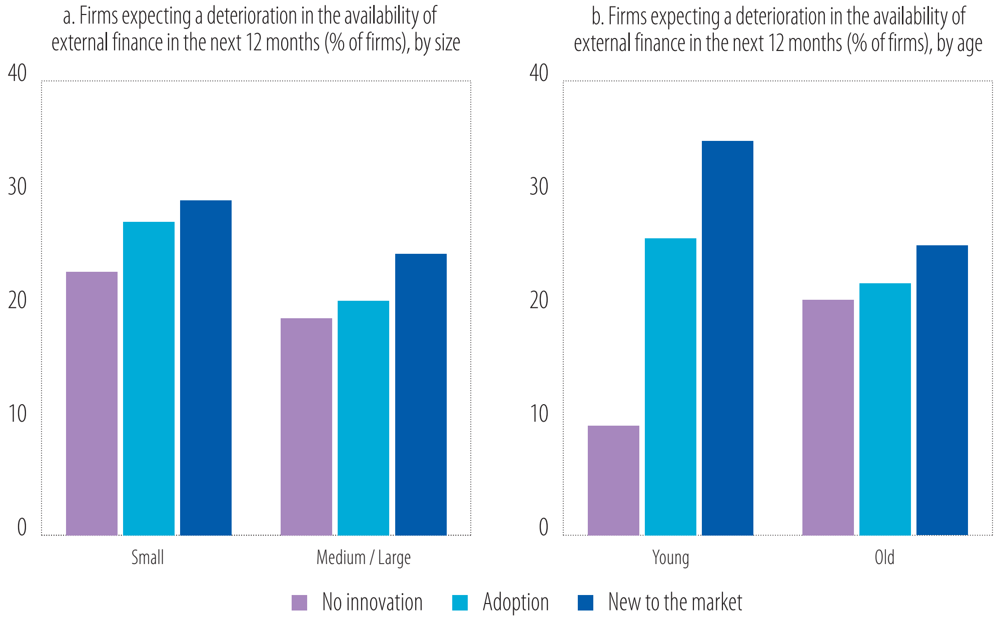
Source: *EIBIS 2016-2023.*
Note: *EU firms. Firms are weighted by value added.*
Question: *Were the new products, processes or services that you developed or introduced new to the company, or new to the country or global market? Do you think that the availability of external finance (such as bank financing, or private or public equity) will improve, stay the same, or get worse over the next 12 months? Did you use grants to finance your investment activities in the previous financial year?*

Investment in innovation could suffer if the prospects of highly innovative companies turn gloomy and their financial buffers deplete. During an economic downturn, tightening financing conditions and financial constraints can have a negative effect on innovation activities, especially for firms in sectors that depend more heavily on external finance (Aghion et al., 2012). In addition to experiencing difficulties tapping into external financing, innovative companies may refrain from investing in innovation, even if they have the financial means to do so. Investments to develop products, processes or services that are new to the market are often risky, with highly uncertain returns. They encompass a large share of sunk costs, and once the investment is made, it is to a large extent irreversible. Innovative firms are also more susceptible to difficulties in accessing finance because of market failures, for example information asymmetries between investors and innovating companies or the inability to appropriate innovation, since knowledge is difficult to own, cannot be protected with insurance, and is not accepted as collateral by banks (Arrow, 1962; Stiglitz & Weiss, 1981; Dixit & Pindyck, 1994).

Small and young firms bringing new innovations to the market seem to be more susceptible to the business cycle. They are more likely to expect a deterioration in the availability of external finance in the next 12 months (Figure 18). Compared to larger and older firms, smaller and younger firms with innovations new to the market are also more likely to report that the demand for their products or services is a major obstacle to investment (Figure 19). During economic downturns, market demand may be strongly affected, thereby weighing on investment in innovation, especially for small and young firms (Fort et al., 2013).

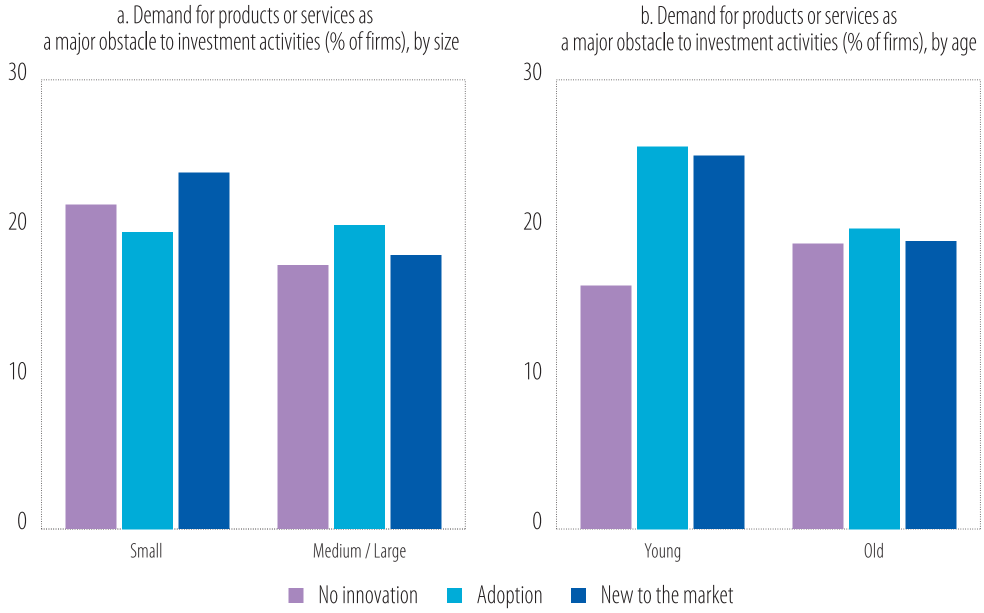
Figure 18

Innovation and the availability of external finance



Source: *EIBIS 2023.*
Note: *EU firms. Firms are weighted by value added.*
Question: *Were the new products, processes or services that you developed or introduced new to the company, or new to the country or global market? Do you think that the availability of external finance (such as bank financing, or private or public equity) will improve, stay the same, or get worse over the next 12 months?*

Figure 19
Innovation and demand for products or services



Source: *EIBIS 2023.*
Note: *EU firms. Firms are weighted by value added.*
Question: *Were the new products, processes or services that you developed or introduced new to the company, or new to the country or global market? Thinking about your investment activities, to what extent is the demand for products and services a major obstacle?*

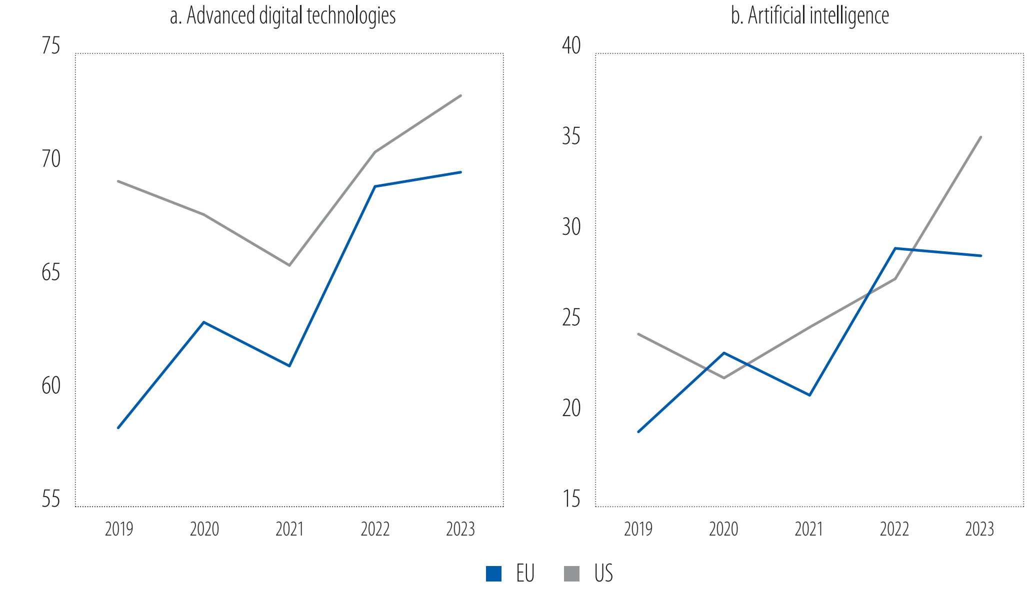
Adopting digital technologies

The digital adoption gap between the United States and the European Union has been narrowing since the pandemic. Strengthening the competitiveness of the European economy through the green and digital transformations will involve cutting-edge innovation and adopting and deploying these technologies more broadly. The latest results from the EIBIS show that EU firms are accelerating the adoption of advanced digital technologies after putting these processes on hold in the first year of the pandemic. The share of EU firms implementing advanced digital technologies reached 70% in 2023, compared with 73% in the United States (Figure 20a). To make sure that no persistent gap is created with their US peers, EU firms need to remain vigilant and increase the use of artificial intelligence, which is a key technology in the digital transformation (Figure 20b).

The sectors that invest more in innovation tend to be more digital. Sectors that invest more in the development of new products, processes or services also tend to have a higher share of firms using advanced digital technologies (Figure 21). This also illustrates the fact that advanced digital technologies – such as big data analytics and artificial intelligence, 3D printing, advanced robotics, drones, the internet of things, digital platform technologies, and augmented or virtual reality – are changing the ways new products and services are developed (Cockburn et al., 2019).

Figure 20

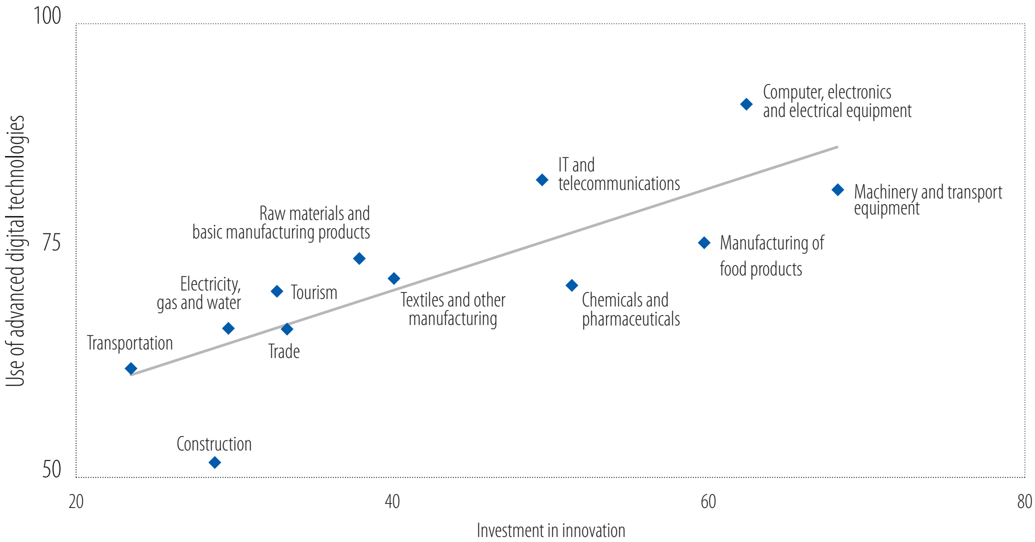
Use of advanced digital technologies and artificial intelligence (% of firms)



Source: *EIBIS 2019-2023.*
Note: *The question on the use of advanced digital technologies was only introduced in EIBIS 2019. Firms are weighted by value added.*
Question: *Are advanced digital technologies used within your business? Are Big Data analytics and artificial intelligence used within your business?*

Figure 21

Investment in innovation and the use of advanced digital technologies (% of firms)

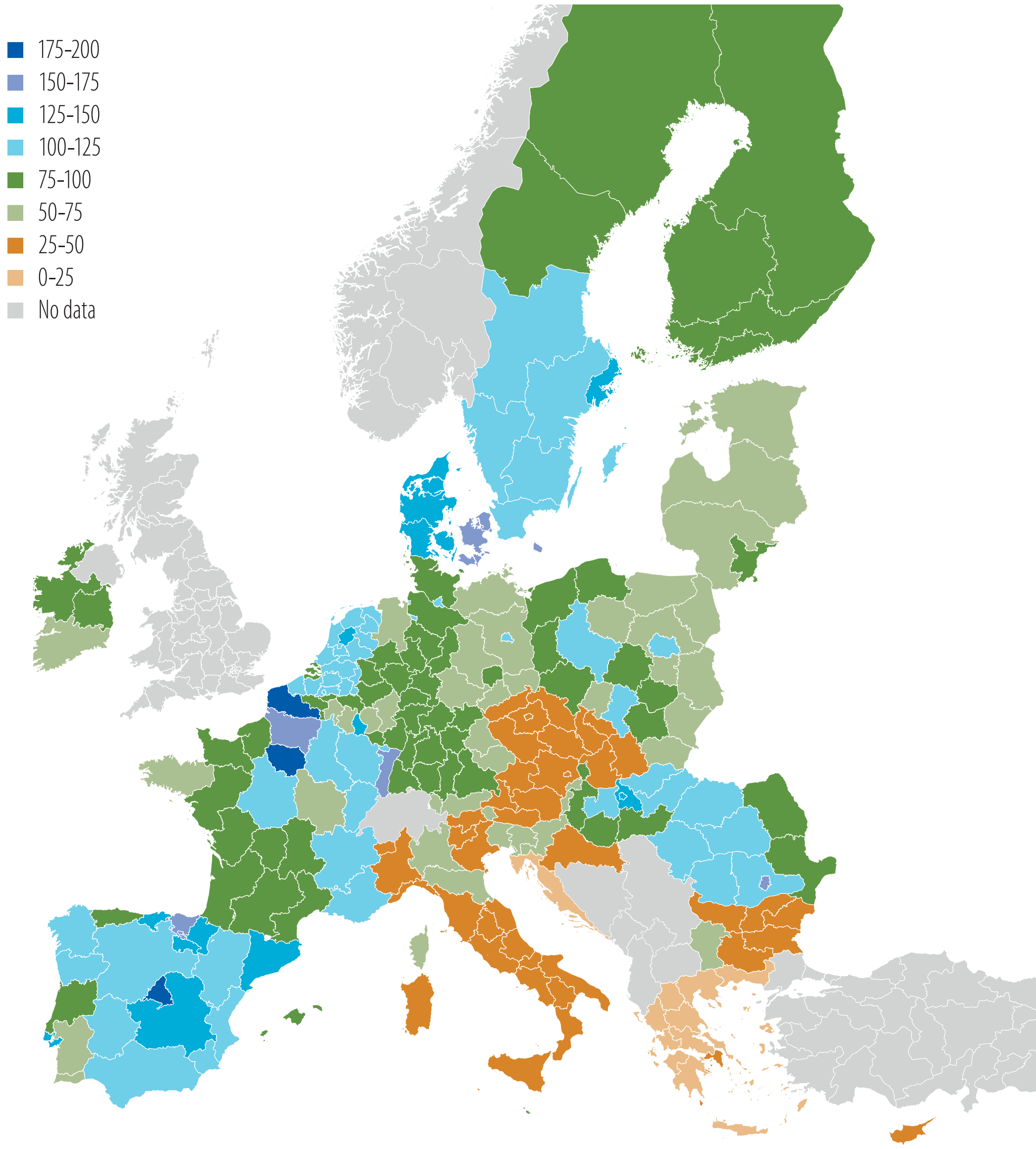


Source: *EIBIS 2023.*
Note: *EU firms. Firms are weighted by value added.*
Question: *What proportion of the total investment in the previous financial year was for developing or introducing new products, processes or services? Are advanced digital technologies used within your business?*

Digital infrastructure plays a critical role for economic activity, particularly for firms using advanced digital technologies. In the latest EIBIS, 12% of EU firms surveyed consider restricted access to digital infrastructure to be a major obstacle to investment. A key problem is internet access and speed. Using data on average internet download speeds, Figure 22 shows that there are significant differences in the quality of digital infrastructure between different EU regions and countries.

Figure 22

Internet download speed in the European Union in 2021 (megabits per second)



Source: *EIB staff calculations based on Ookla.*

Note: *The figure shows data from 2021 and is based on more than 82 million internet speed tests during this period. Average internet download speed in a Nomenclature of Territorial Units for Statistics 2 (NUTS 2) region is based on tests performed using the website Speedtest.net and is measured in megabits per second. The original data is provided at the level of mercator tiles (approximately 610.8 metres by 610.8 metres at the equator), which is aggregated to NUTS 2 level averages, using the number of tests as weights.*

The returns from digitalisation are larger for firms located in regions with better digital infrastructure and faster internet speeds. This is illustrated by the positive interaction between firms' use of advanced digital technologies and high download speeds in a regression analysis (Table 1). These findings illustrate how complementary public and private digital investment can improve firms' performance and economic resilience.

Table 1

Digital adoption, digital infrastructure and firm productivity

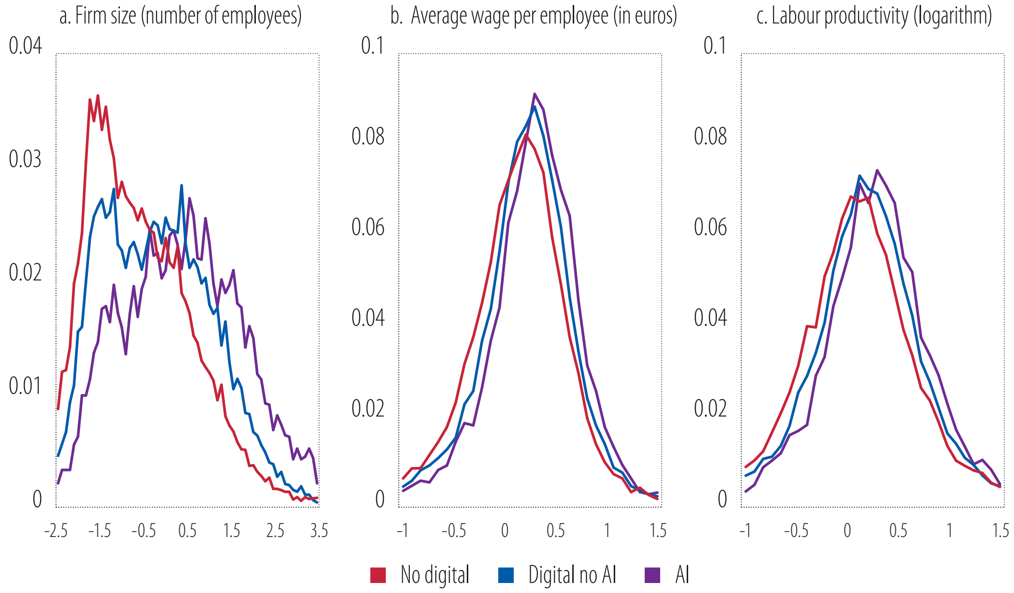
Dependent variable	Labour productivity
Use of advanced digital technologies	0.150***
	(0.013)
Regions with high download speed	0.112***
	(0.014)
Digital x high download speed	**0.032***
	(0.018)
Sample size	42 515
R-squared	0.254

Source: EIB staff calculations based on EIBIS 2019-2023 and Ookla (2021).
*Note: EU firms. Labour productivity is in natural logarithm. The ordinary least square (OLS) regression controls for firm size, firm age, country and sector (three groups of EU countries and four macroeconomic sectors). Regions with high download speed: NUTS 2 regions with average download speed higher than the median download speed for all regions (based on Ookla data). Robust standard errors are in parentheses. Statistical significance: *** p-value<0.01, ** p-value<0.05, * p-value<0.1.*

Firms using artificial intelligence tend to perform better than firms using other advanced digital technologies on a number of different performance metrics. Firms that have adopted big data and artificial intelligence technologies are on average larger, pay higher wages to their employees and have higher productivity. Figure 23 compares the distribution of firm size, average wage per employee and total factor productivity for three groups of firms: (i) firms that have not adopted any digital technologies; (ii) firms that use advanced digital technologies (but not artificial intelligence); and (iii) firms that use artificial intelligence. The distribution for firms using artificial intelligence is shifted to the right, which illustrates the benefits for firm performance.

Using artificial intelligence positively affects firm performance. The causal relationship between the adoption of digital technologies and firm performance is identified using propensity score weighting, where the propensity of using artificial intelligence or other advanced digital technologies is modelled based on past firm performance and firm characteristics, such as the capital intensity and the share of intangible investment. The estimates are reported in Table 2 with two panels. The top panel is for firms that used digital technologies but do not use artificial intelligence, and the bottom panel is for firms that use artificial intelligence. The results underline the positive benefits of using advanced digital technologies on firm performance. They also show that firms using artificial intelligence tend to perform even better than firms using other advanced digital technologies, but not artificial intelligence. Overall, this supports previous empirical evidence on the positive effect of digital adoption and the use of artificial intelligence on innovation and firm productivity (Gal et al.; 2019; Acemoglu et al., 2022a; Rammer et al., 2022; EIB, 2023).

Figure 23
Distribution of firm size, average wage per employee and firm productivity



Source: *EIB staff calculations based on EIBIS 2016-2023.*
Note: *EU firms. The graph shows distributions net of country and sector fixed effects.*

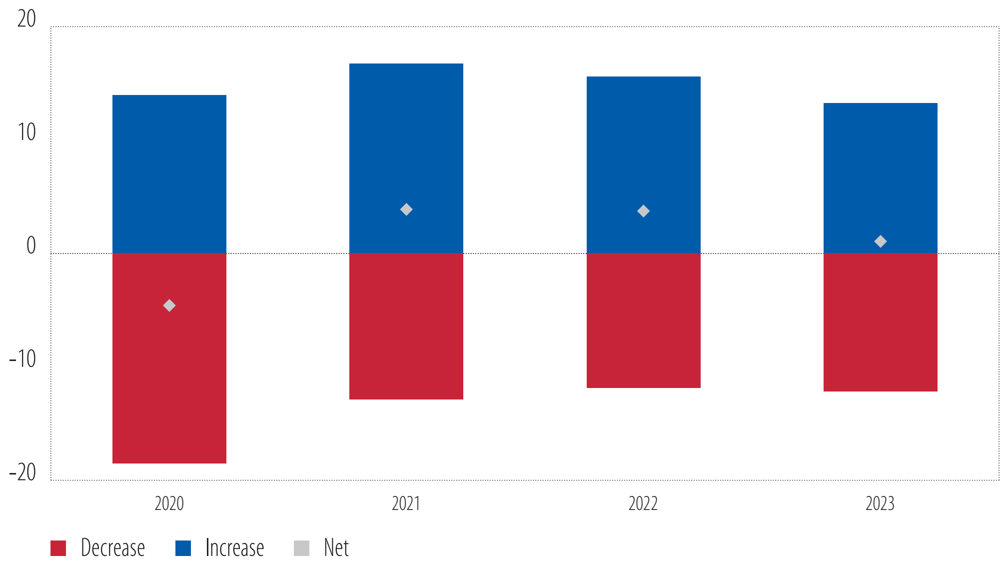
Table 2
Higher performance of firms using digital technologies and artificial intelligence, compared to non-digital firms

	Binary outcomes			Continuous outcomes			
	Training of employees	Strategic management systems	Innovation (share of firms)	Innovation (share of investment)	Labour productivity	Total factor productivity	Average wage per employee
Digital but not AI	0.276***	0.371***	0.270***	0.033***	0.055***	0.021*	0.032***
	(0.019)	(0.016)	(0.021)	(0.004)	(0.013)	(0.013)	(0.012)
Sample size	32 634	35 846	30 278	30 282	31 694	30 534	34 308
AI	0.269***	0.538***	0.320***	0.056***	0.124***	0.086***	0.095***
	(0.028)	(0.027)	(0.024)	(0.006)	(0.017)	(0.015)	(0.014)
Sample size	30 085	33 267	28 525	28 525	29 660	28 722	31 939

Source: *EIB staff calculations based on EIBIS 2016-2023.*
Note: *EU firms. The upper panel compares non-digital firms to firms using advanced digital technologies but not artificial intelligence. The lower panel compares non-digital firms to firms using artificial intelligence. Robust standard errors are in parentheses. The regressions control for firm size, country, sector and year (27 EU countries and four macroeconomic sectors). Statistical significance: *** p-value<0.01, ** p-value<0.05, * p-value<0.1.*

Many digital firms expect that using digital technologies will result in hiring more employees. The share of firms using digital technologies expecting a positive impact on job creation is higher than the share of digital firms believing that digital technologies will lead to a decrease in employee numbers (Figure 24). However, most firms do not expect the use of digital technologies to have any impact on the number of people they employ.

Figure 24
Expected net effect of digitalisation on employment (% of firms)



Source: *EIBIS 2020-2023.*
Note: *EU firms. Firms are weighted by value added. Net is the share of firms expecting an increase minus the share of firms anticipating a decrease in employment.*
Question: *Over the next three years, what impact do you expect your business's use of digital technology(ies) to have on the number of people your company employs?*

Digitalisation goes hand in hand with a reallocation of resources that can improve productivity. Digital firms tend to be more productive than non-digital firms, especially if they use artificial intelligence. Among digital firms, those in the top quartiles of the productivity distribution are also more likely to expect digital technologies to have a positive impact on the number of people they employ (Figure 25). At the same time, firms that expect a decrease in employment are more likely to be at the bottom of the productivity distribution. These results suggest a reallocation of labour resulting from employment flowing from low to high productivity firms, which can increase the productivity of the economy overall.[2]

Digital technologies and artificial intelligence affect employment differently. On the one hand, digitalisation can reduce demand for labour and push down wages for jobs involving tasks performed by the technology. At the same time, it can increase demand for labour needed to perform other tasks (Acemoglu & Restrepo, 2020; Aghion et al., 2020). Automation does not have negative aggregate effects on employment, but firms adopting digital technologies do shift their new hiring towards digital skills (Acemoglu et al., 2022b; Babina et al., 2022; Grossman & Gene, 2022).

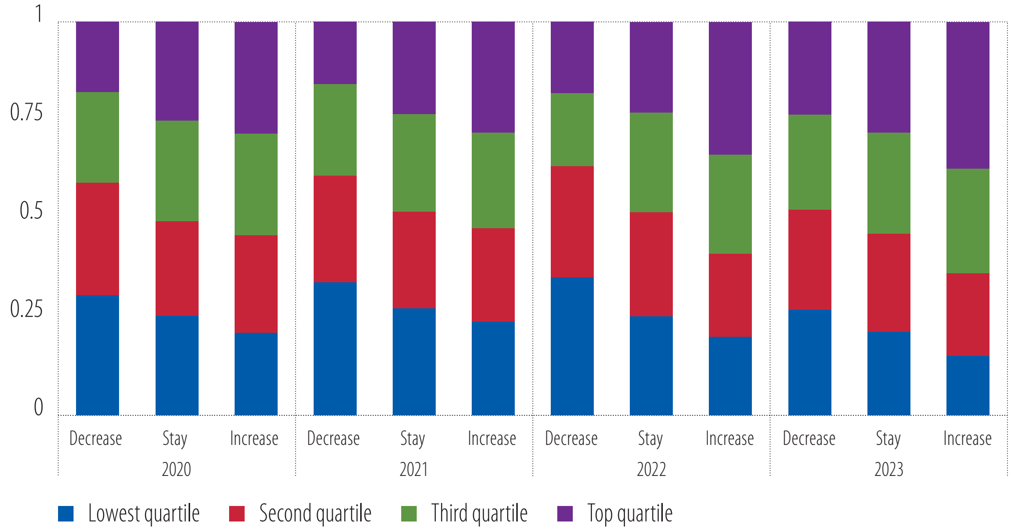
Firms that adopt advanced digital technologies grow faster than non-digital firms. Firms that adopted digital technologies before the COVID-19 crisis have expanded faster than non-digital firms (Figure 26). But these firms were already growing faster than their non-digital peers even before digital adoption – possibly reflecting a selection effect, where fast-growing firms are also firms that decide to adopt digital

2 The results are also supported by the positive correlation between the expectations and reality of digital firms' employment growth. The use of panel data shows that the digital firms that expect to grow are also those that do grow.

technologies. A cohort of firms started using advanced digital technologies in 2020, possibly as a response to the COVID-19 crisis. These new digital adopters began growing faster than non-digital firms only after their digital transformation (Figure 26). Overall, this causal evidence on the positive effect of digitalisation on employment for EU firms corroborates the findings of Acemoglu et al. (2022a) for the United States.

Figure 25

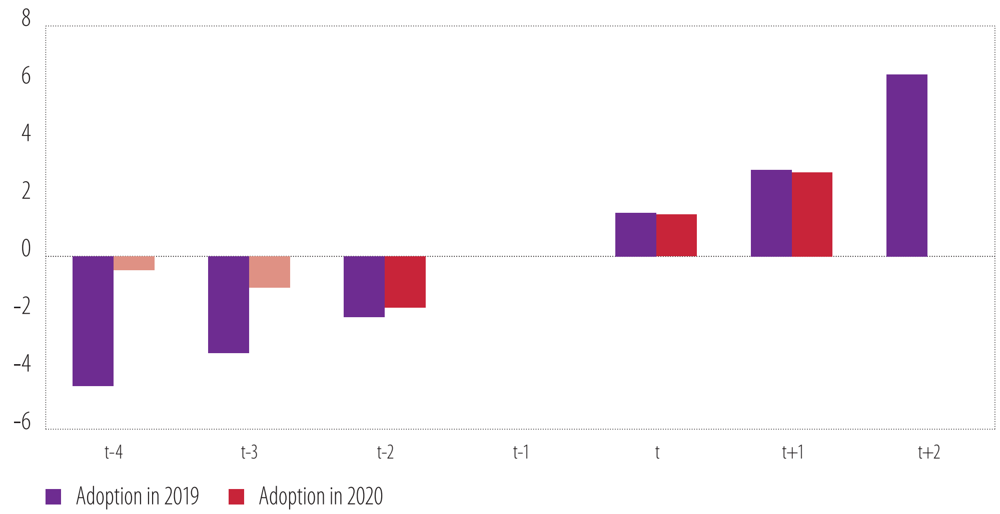
Expected effect of digitalisation on employment (% of firms)**, by productivity quartiles**



Source: *EIB staff calculations based on EIBIS 2020-2023.*
Note: *EU firms. Productivity is measured as the logarithm of total factor productivity. Firms are weighted with value added.*
Question: *Over the next three years, what impact do you expect your business's use of digital technolog(ies) to have on the number of people your company employs?*

Figure 26

Employment growth before and after digital adoption (in %)



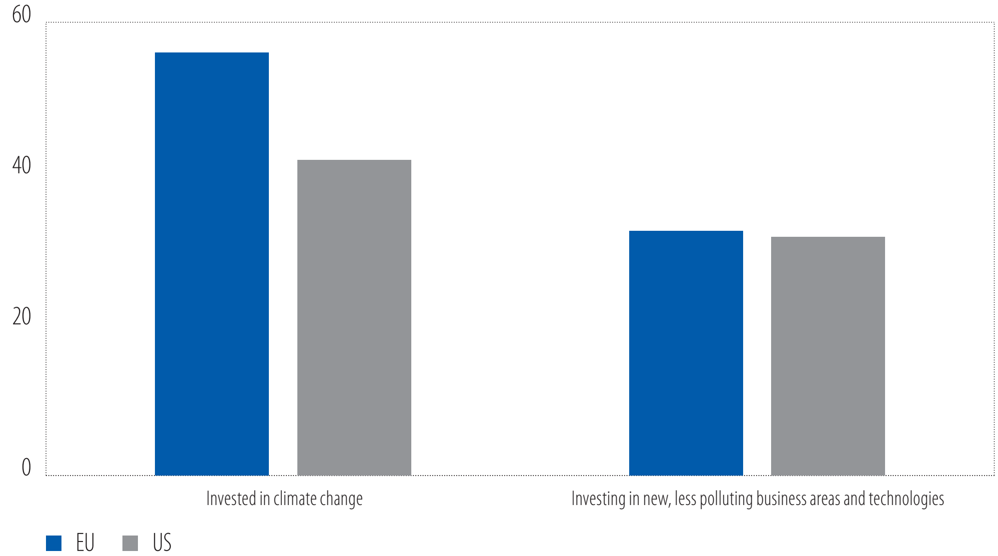
Source: *EIB staff calculations based on EIBIS and ORBIS data.*
Note: *EU firms. The bars show the estimated employment of firms relative to the level of employment in the year just before digital adoption. Only firms that adopt a single digital technology are considered in the estimation. Employment in t+2 is not available for 2020 adopters. Light coloured bars are not significant at the 5% confidence level.*

Adopting green technologies

The European Union has a higher share of firms that invest in tackling the fallout of extreme weather and in helping to reduce carbon emissions than the United States. However, the share of EU and US firms that invest in new, less polluting business areas and technologies is similar (Figure 27). Investing in new green technologies is especially important if the European Union wants to maintain a competitive advantage in this area. The previous section showed that Europe is excelling in patenting green technologies. While this is encouraging, it is critical that firms invest in adopting these new green innovations more broadly.

Figure 27

Investment to tackle the effects of weather events and to help reduce carbon emissions, and investment in new, less polluting business areas and technologies (% of firms)



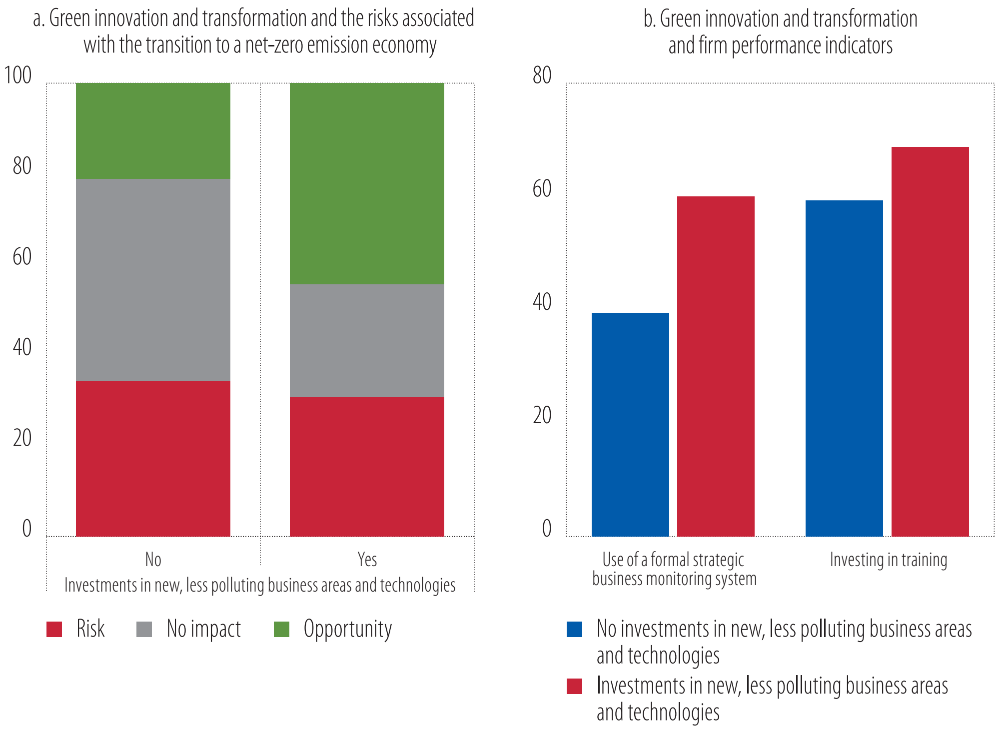
Source: *EIBIS 2023.*
Note: *Firms are weighted by value added.*
Question: *Has your company already made investments to tackle the impacts of weather events and to help reduce carbon emissions? Is your company investing in new, less polluting business areas and technologies to reduce greenhouse gas emissions?*

Firms investing in green innovation and transformation are more likely to see the challenges associated with moving to a net-zero emission economy as an opportunity. Almost half of firms that invest in less polluting business areas and technologies see the transition to stricter climate standards as an opportunity (more than 20 percentage points above firms not making such investments) (Figure 28a). Investing in green innovation also fosters firm performance, resulting in greater use of advanced management practices and more investment in employee training (Figure 28b).

An innovative environment can play a critical role in encouraging firms to invest in innovation and thereby foster economic activity and performance. A wide range of literature highlights the role of knowledge spillovers in innovation by firms and the importance of environments that support innovation (Audretsch et al., 2022; European Commission, 2022a). The intensity of green innovation in a region (as measured by patents in green technologies) can be used as a proxy for the innovative quality of a green ecosystem. Figure 29 shows that significant differences exist in the green innovative intensity of different EU regions and countries.

Figure 28

Green innovation and transformation, transition risks and firm performance (% of firms)



Source: *EIBIS 2023.*
Note: *EU firms. Firms are weighted by value added.*
Question: *Is your company investing in new, less polluting business areas and technologies to reduce greenhouse gas emissions? Thinking about your company, what impact do you expect this transition to stricter climate standards and regulations will have on your company over the next five years? Does your company use a formal strategic business monitoring system that compares the firm's current performance against a series of strategic key performance indicators? In the previous financial year, how much did your business invest in training employees?*

Table 3

Green innovation, regional green innovation and firm productivity

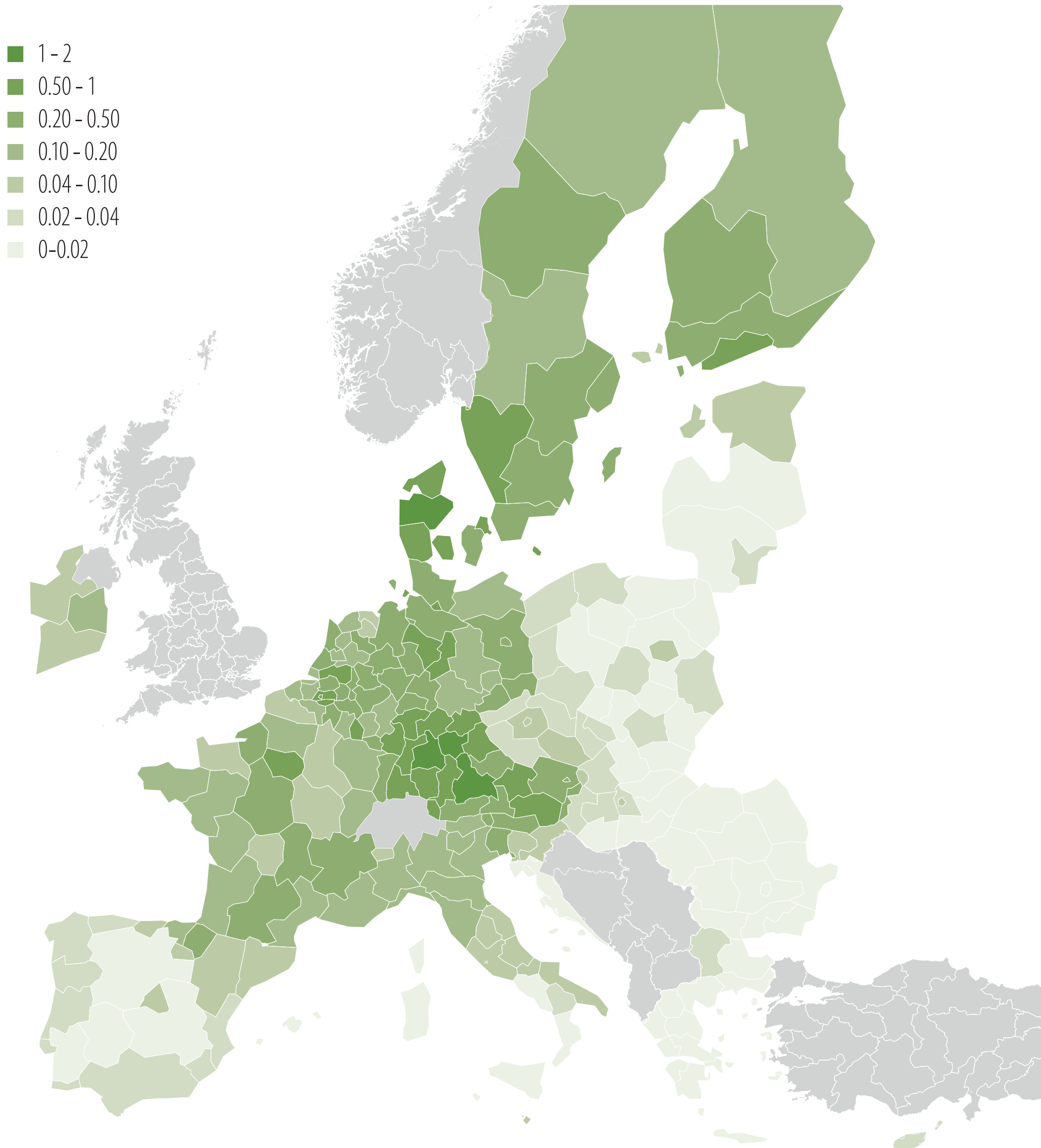
Dependent variable	Labour productivity		
Investing in new, less polluting business areas and technologies	0.139*** (0.017)		0.093*** (0.026)
Region with a high share of green innovation (relative to total population)		0.451*** (0.024)	0.426*** (0.026)
Invest in green tech x green innovative region			0.083** (0.033)
Sample size	23 422	21 469	21 356
R-squared	0.149	0.187	0.189

Source: *EIB staff calculations based on EIBIS 2022-2023 and PATSTAT.*
Note: *EU firms. Labour productivity is expressed in natural logarithms. The ordinary least squares (OLS) regressions control for firm size, country and sector (three groups of EU countries and four macroeconomic sectors). Robust standard errors in parentheses. Statistical significance: *** p-value<0.01, ** p-value<0.05, * p-value<0.1.*

The returns from green innovation and transformation are greater for firms located in regions with a stronger environment for green innovation. Being located in a region with a higher-than-average intensity of green innovation provides additional productivity gains to companies that invest in green innovation and transformation. This is illustrated by the regression output in Table 3. Table 3 also shows that investments in new, less polluting business areas and technologies are associated with higher labour productivity, even without considering the region's level of green innovation. This also holds when assessing the impact of climate change-related investment in general and its impact on productivity. The evidence is well aligned with an emerging body of literature (Stern & Stiglitz, 2023).

Figure 29

Green tech patents (% of total patents in the region)



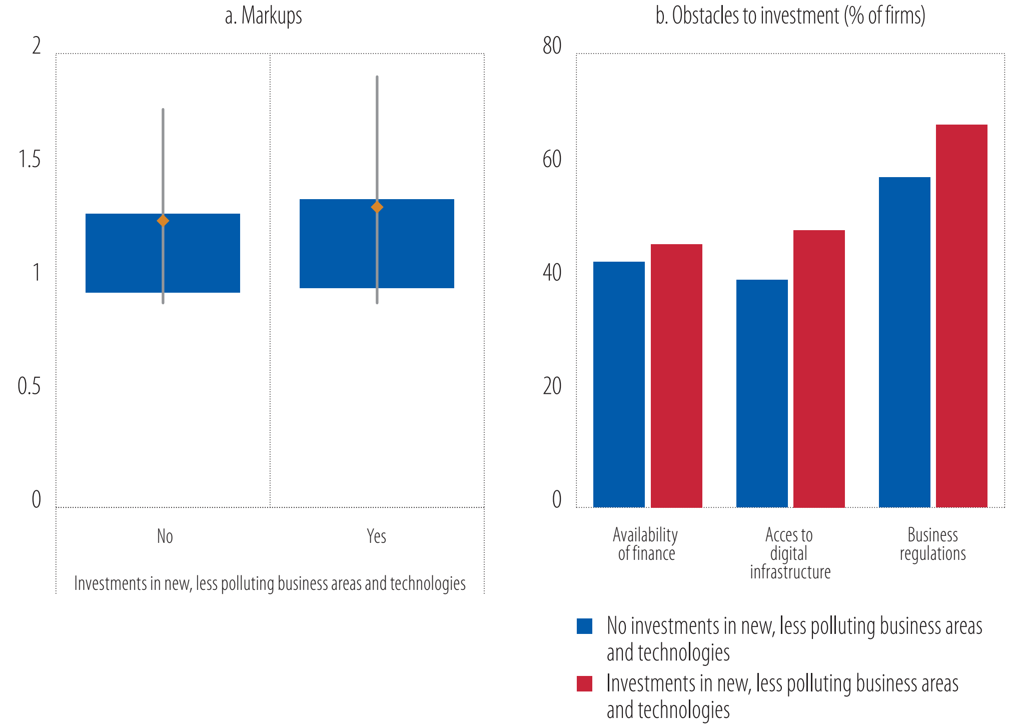
Source: EIB staff calculations based on PCT patents (PATSTAT), in collaboration with ECOOM and Eurostat.
Note: Green tech patents are measured as the cumulative patent from 2011 to 2020. Population is the regional population in 2020, divided by 1 000. The values should thus be interpreted as a ranking, and not interpreted at face value.

Investment in green innovation and transformation is associated with higher markups. Firms that invest in green innovation and transformation are not only more productive on average, but also tend to have higher markups for their products (Figure 30a). Markups can indicate market power, and they show that investing in green innovation and transformation currently pays for firms. However, it could at the same time indicate that there is too little competition on the markets in which these firms operate. Higher upfront investment costs, especially in new technologies, may also explain the higher markups, meaning that they may not necessarily show a lack of competitive pressure or excessively high market power.

Firms investing in green innovation and transformation report that business regulations are an obstacle to investment. Overall, firms investing in new, less polluting business areas and technologies complain slightly more about almost all obstacles to investments than other firms. The main difference is for business regulations and digital infrastructure, with firms investing in green innovation and transformation complaining almost 10 percentage points more than other firms (Figure 30b). This points to a need for policymakers to alleviate regulatory uncertainty for businesses willing to undertake green investments. Access to digital infrastructure also deserves attention, since the use of digital technologies could play a major role in tackling environmental challenges (Intergovernmental Panel on Climate Change (IPCC), 2022).

Figure 30

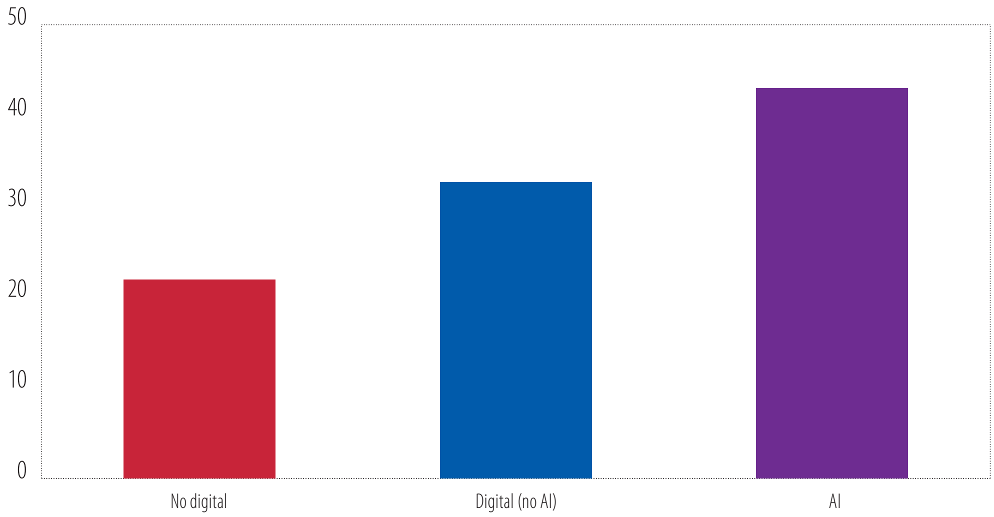
Markups and obstacles to investment, by whether a firm invests in new, less polluting business areas and technologies



Source: *EIBIS 2023.*
Note: *EU firms. Firms are weighted by value added. In the left panel, the bar represents the range between the markup at the 25th percentile of the distribution (bottom of the bar) and the 75th percentile (top of the bar). The vertical line shows the range between the lowest and the highest value and the diamond shows the mean (average value). Markup calculations are based on the approach of De Loecker et al. (2020). The results on markups also hold in a regression framework controlling for firm size, country and sector (three groups of EU countries and four macroeconomic sectors).*
Question: *Is your company investing in new, less polluting business areas and technologies to reduce greenhouse gas emissions? Thinking about your investment activities, to what extent is each of the following an obstacle? The availability of finance; access to digital infrastructure; availability of adequate transport infrastructure; business regulations (such as licenses, permits, or bankruptcy) and taxation.*

Digital technologies, and especially artificial intelligence, could catalyse green innovation and economic transformation. Firms adopting artificial intelligence are more likely to invest in green innovation and transformation (Figure 31). This suggests that the contribution of digital technologies to a firm's innovation is driven to a large extent by investment in areas of AI applications (Rotman, 2019; Montresor & Vezzani, 2023).

Figure 31
Green innovation and transformation and the use of advanced digital technologies

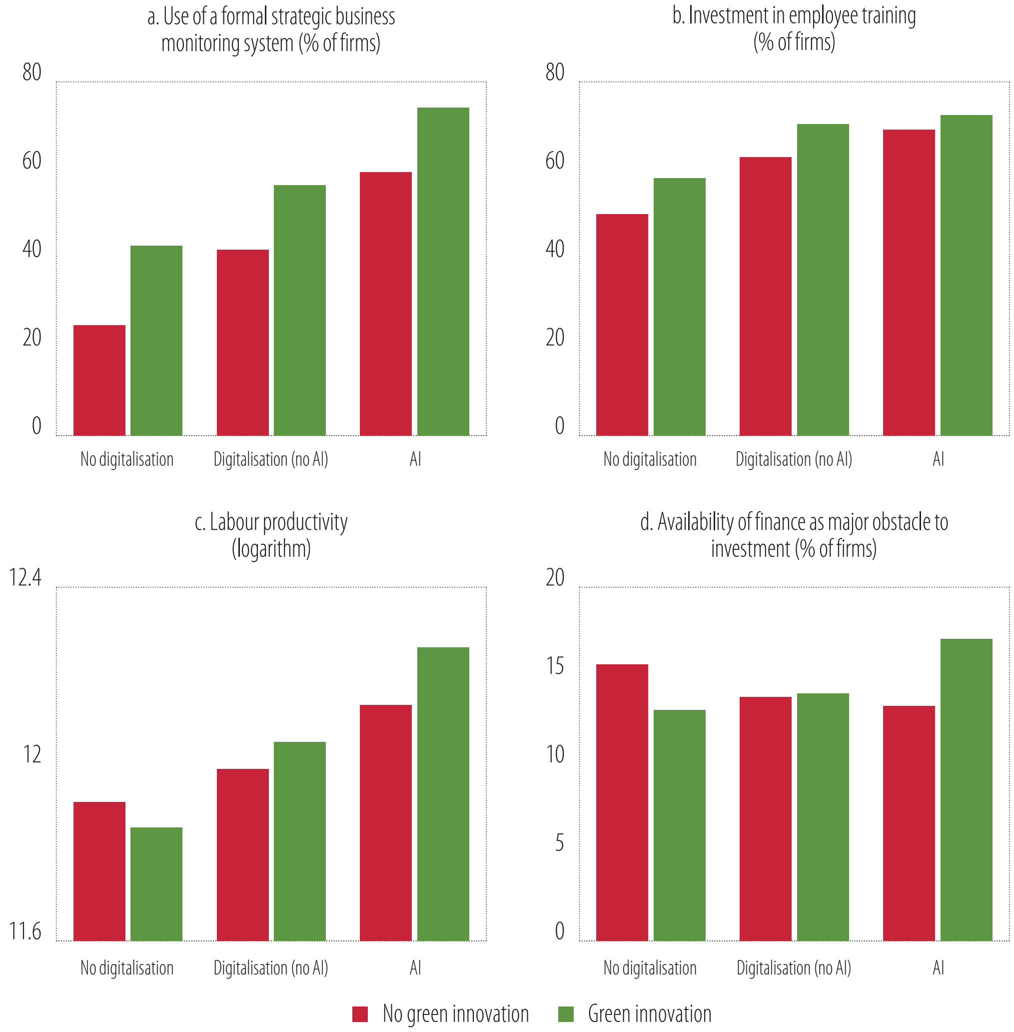


Source: *EIBIS 2023.*
Note: *EU firms. Firms are weighted by value added.*
Question: *Is your company investing in new, less polluting business areas and technologies to reduce greenhouse gas (GHG) emissions? Are advanced digital technologies used within your business? Are Big Data analytics and artificial intelligence used within your business?*

Firms that invest in green innovation and use artificial intelligence tend to perform better. The firms embracing the twin transition by combining artificial intelligence with green innovation are more likely to report the use of strategic business monitoring systems (Figure 32a) and investment in employee training (Figure 32b). This is associated with firm-level output and growth, as these firms also tend to be more productive (Figure 32c). Embracing both digitalisation and green innovation and transformation not only leads to returns for society, but it also seems to pay off for firms.

Firms implementing advanced digital technologies and green innovation and transformation are more likely to report a lack of available finance as a major obstacle to investment (Figure 32d). Given the potential benefits of combining digital and green technologies for structural transformation, it is important for these companies to be able to invest to take full advantage of the twin transition. If problems with the availability of finance are hampering progress in these areas, which are typically plagued by various market failures, then policymakers could have an important role to play in offering solutions.

Figure 32
The impact of green innovation and transformation on firm characteristics and investment



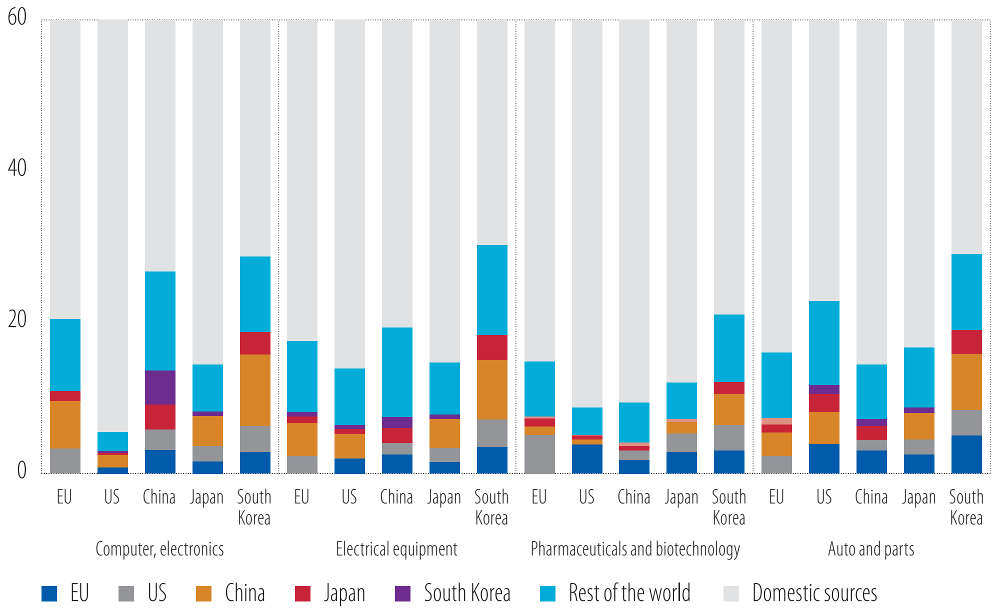
Source: *EIBIS 2023.*
Note: *EU firms. Firms are weighted by value added.*
Question: *Is your company investing in new, less polluting business areas and technologies to reduce greenhouse gas emissions? Are advanced digital technologies used within your business? Are big data analytics and artificial intelligence used within your business? Does your company use a formal strategic business monitoring system that compares the firm's current performance against a series of strategic key performance indicators? In the previous financial year, how much did your business invest in training employees? Thinking about your investment activities, to what extent for each is the availability of finance a major obstacle?*

EU exposure to the global economy

The European Union is well integrated in the global economy, enabling it to carry out some of the production of the goods and services it sells abroad. Over the past three decades, trade liberalisation and advances in digital technologies have allowed firms to reap the benefits of specialisation by producing parts or obtaining resources in different locations and parts of the supply chain (World Trade Organization (WTO), 2019; Alfaro & Chor, 2023). However, recent crises such as the COVID-19 crisis, the war in Ukraine and geopolitical tensions have shown that fragile supply chains can expose firms and countries to trade disruption risks.

Depending on the sector, the European Union imports 15% to 20% of the resources used to create the goods it exports. The remaining resources originate from within the European Union. The European Union is also an important source for its trading partners. For example, in pharmaceuticals and biotechnologies, the United States, China and Japan buy a higher share of resources from the European Union than from other countries (Figure 33).

Figure 33
Value added by foreign sources in the exports of selected countries (in %)**, by sector**



Source: *EIB staff calculations based on OECD Trade in value added 2022.*
Note: *Calculations based on Belotti et al. (2021).*

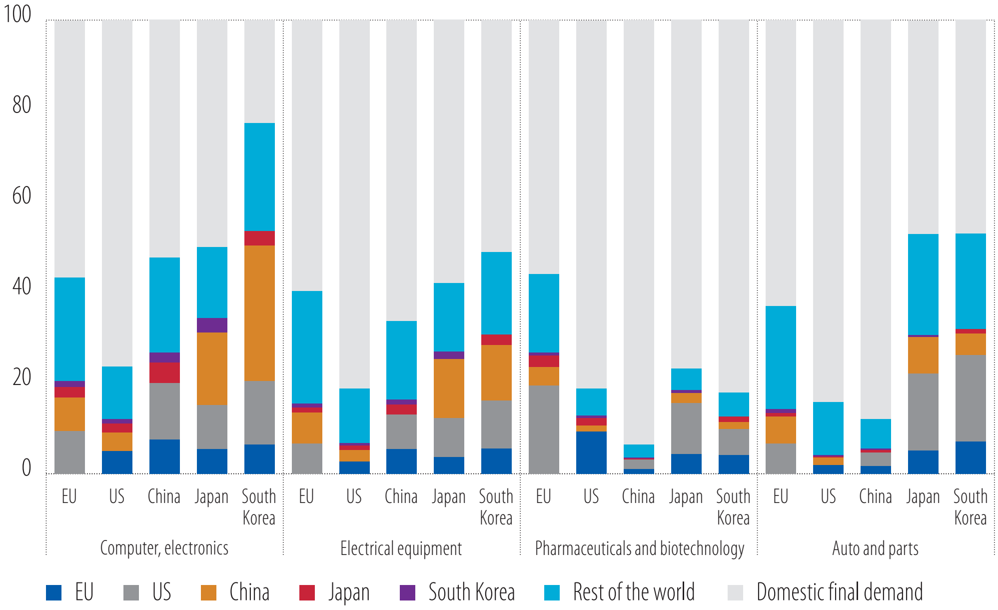
The United States and China are significant markets for the final products and services exported by the European Union. Other countries (including Switzerland and the United Kingdom, for example) are also important trading partners for the European Union. Close to 40% of EU products and services are consumed abroad, while the remainder are sold within the European Union (Figure 34). This share is lower in the United States (around 20%), reflecting the importance of the domestic market for the US economy.

The majority of EU firms have faced obstacles related to their supply chains in recent years, but the challenges differ depending on the sector. Access to commodities or raw materials was cited as an obstacle by 32% of EU firms, while disruptions of logistics and transport were mentioned by 29% of them. Access to raw materials is more likely to be an obstacle for firms in manufacturing. Machinery and transport equipment and computer, electronics and electrical equipment are the two sectors most affected by semiconductor and microchip shortages (Figure 35). Compared to other sectors, firms in the chemicals and pharmaceuticals industries were also hit particularly hard by logistics and transport disruptions.

Importing firms often respond to supply chain obstacles by building stocks and expanding inventories. This is the case even in service industries, where inventories and stocks do not play as significant a role as they do in manufacturing. For most industries, the second most common strategy is investing in digital inventory and resource tracking that allows firms to follow goods through the supply chain. For other industries, such as chemicals and pharmaceuticals and machinery and transport equipment, trade diversification (increasing or diversifying the number of countries from which firms import their resources) is the second most common way companies ensured adequate supplies (Figure 36).

Figure 34

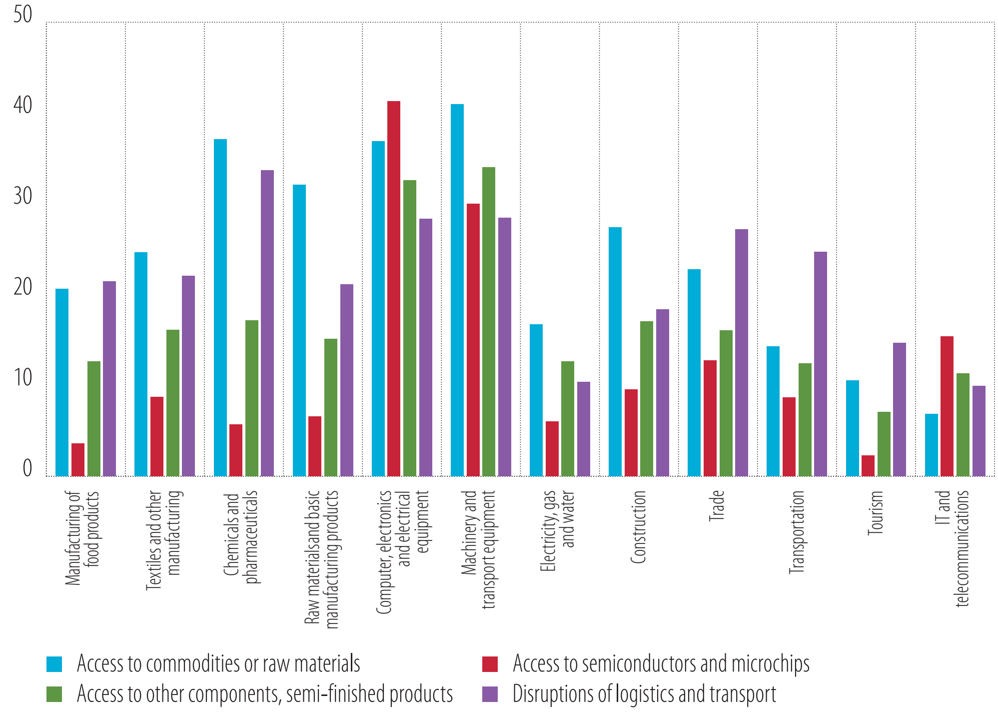
Location of the final demand for the production of selected countries (in %)**, by sector**



Source: *EIB staff calculations based on OECD Trade in Value Added 2022.*
Note: *Calculations based on Belotti et al. (2021).*

Figure 35

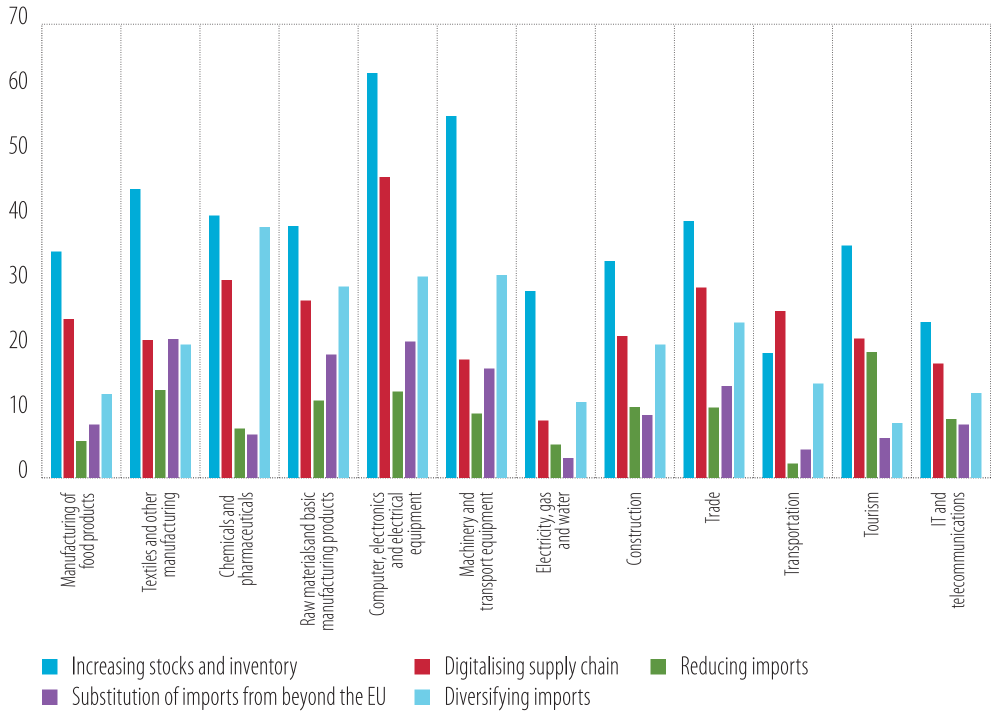
Major obstacles to supply chains (% of firms)



Source: *EIBIS 2023.*
Note: *EU firms. Firms are weighted by value added.*
Question: *Since the beginning of 2022, were any of the following an obstacle to your business's activities?*

Figure 36

Changes in the strategy to source inputs (% of importing firms)



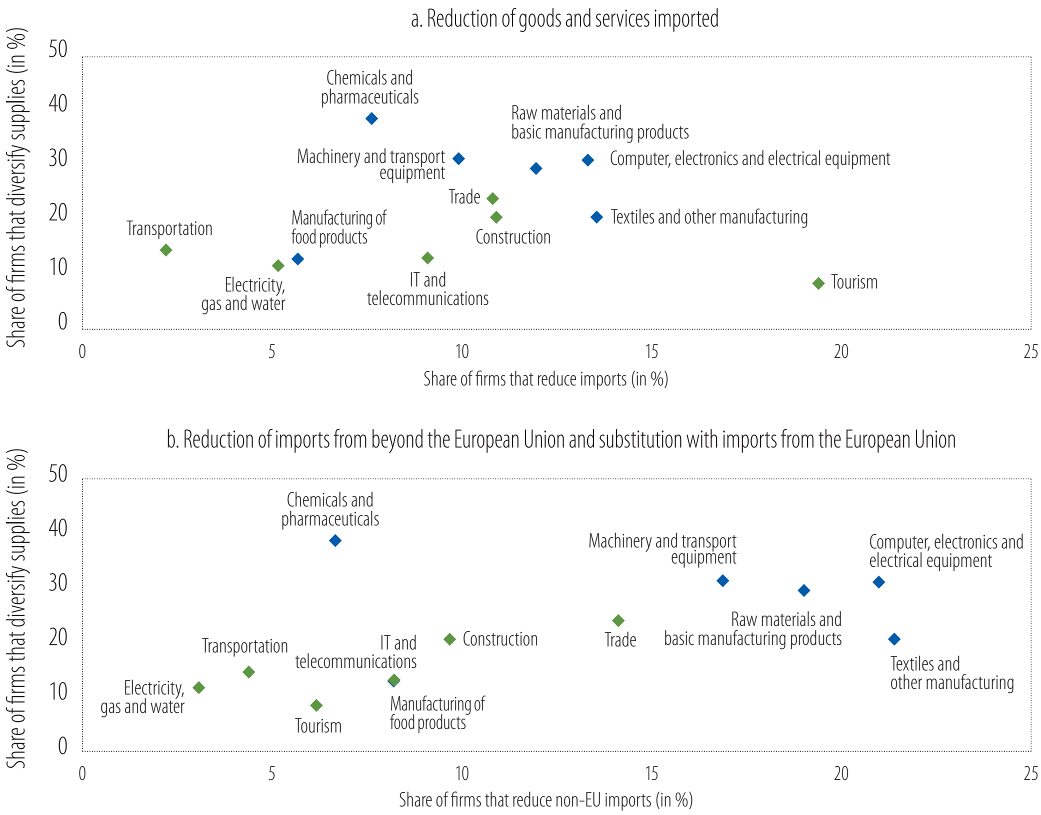
Source: *EIBIS 2023.*
Note: *EU importing firms. Firms are weighted by value added.*
Question: *Since the beginning of 2022, has your company made or are you planning to make any of the following changes to your sourcing strategy?*

Most EU firms are more likely to prioritise the diversification of their supplies than reduce the share of goods and services imported from abroad. Changing sources and import partners can be more difficult and takes more time than stockpiling or improving efficiency by investing in digital inventory and resource tracking. Overall, EU companies remain open to world trade and only one in ten EU importers has responded by reducing imports. At the same time, about one in five EU importers is diversifying their supply chain. These strategies may be key to improving the competitiveness and ensuring the long-term resilience of EU industries.

Diversification and import substitution strategies vary widely by sector. Firms in manufacturing are more exposed to trade than firms in other sectors and are more likely to make adjustments to their sourcing strategy. For example, firms in machinery and transport equipment, computer, electronics and electrical equipment, and textiles and other manufacturing are among those most likely to diversify import partners and reduce imports at the same time (Figure 37). These same sectors are also moving away from partners beyond the European Union to favour those within the European Union. In contrast, firms in food production are less likely respond to supply chain disruptions by either reducing imports or adopting strategies to diversify supplies. While firms in the chemicals and pharmaceuticals sector are more likely to diversify their imports for all trade partners, they are less likely to reduce imports or find trade partners within the European Union to substitute segments of their supply chain that depend on non-EU partners.

Figure 37

Responses to supply chain disruption (% of importing firms)



Source: *EIBIS 2023.*
Note: *EU importing firms. Firms are weighted by value added. Blue diamonds indicate manufacturing sectors (tradeables) and in green diamonds indicate other sectors.*

Table 4

Digital firms' response to supply chain disruptions

	Increasing stocks and inventory	Digitalising supply chain	Reducing imports	Substituting non-EU imports with EU imports	Diversifying trade partners
Digital firms	6.338***	12.29***	1.840**	2.755***	8.727***
	(1.282)	(1.103)	(0.796)	(0.951)	(1.159)
Sample size	6 076	6 076	6 076	6 076	6 076
R-squared	0.067	0.069	0.030	0.051	0.055

Source: *EIB staff calculations based on EIBIS 2023.*
Note: *Importing firms in EU members. The coefficient values express percentage point difference in the probability of taking action for digital vs. non-digital firms. The ordinary least squares (OLS) regressions control country and the 12 sectors. Robust standard errors in parentheses. Statistical significance: *** p-value<0.01, ** p-value<0.05, * p-value<0.1.*

Firms that use advanced digital technologies, such as artificial intelligence, are also more likely to actively manage supply chain shocks. On the one hand, digital firms are more likely to report that trade disruptions have affected their business activities since the beginning of 2022. In particular, firms using digital technologies are more likely than their non-digital peers to consider disruptions related to logistics and transport, access to semiconductors and microchips, and access to other components, semi-finished products, services or equipment to be a major obstacle to their activities. On the other hand, digital firms are more likely to act to counter the adverse effects of trade disruptions and make changes to their sourcing strategy, to increase stocks and inventories, to invest in digital inventory and resource tracking, and to diversify or increase the number of countries from which they import (Table 4). These findings suggest that digitalisation can increase resilience and the ability to adapt to large, unexpected economic or trade shocks.

The role of policy

The green and digital transition will require major investment in research and innovation. Investment is vital for economic resilience, sustained and sustainable growth and delivering on the European Green Deal. It must also be accompanied by reforms and regulations that create the right incentives for businesses to fully contribute to the structural transformation (European Commission, 2022b; OECD, 2023).

The European Union may be leading the way in clean technology, but it is not well positioned in digital innovation compared to the United States and China. Global uncertainty, an economic downturn and tightening financing conditions may have further adverse effects on investment in innovation activities, especially those that are ground-breaking (Aghion et al., 2012). This may also hamper the structural investment required in areas where Europe needs to maintain or step up its competitiveness.

In the European Union, highly innovative firms tend to suffer from a lack of suitable finance, which becomes particularly severe as companies grow. The financing gap of high-growth companies is associated with a domestic market that is more resistant to disruptive innovation than the United States and lacks the appropriate instruments, scale, risk appetite and skills. The recent tightening of financing conditions has exacerbated these problems and affected scale-up companies disproportionately. The public sector has recognised the need to intervene in the startup and scale-up market. In this context, EU instruments are being put in place, which should ensure a level playing field across the single market. At the same time, many countries are working to consolidate their finances, and EU resources are limited. That means that incentives and direct support will have to become more targeted.

Direct policies such as targeted R&D grants can be useful to foster innovation in certain technology domains that have not yet reached cost competitiveness. Policies are needed to help bridge the gap between R&D and the offering of new products on the market, especially for early-stage technologies and smaller firms (Howell, 2017; European Commission, 2022a). Furthermore, the complementary nature of different technologies (for example, through the combination of green innovation with artificial intelligence) may hold greater potential for breakthrough innovations.

The way in which instruments to support R&D and innovation are deployed matters. While R&D grants have a positive impact on innovation, a selection problem could emerge given that the funding agency must choose the best-suited projects. Conversely, R&D tax credit programmes do not have the same selection problem, but mostly target profitable companies, which often excludes smaller and especially younger firms (Czarnitzki & Giebel, 2021). In addition, tax credits do not necessarily incentivise firms to invest in technologies that are further from the market, since they are most likely prioritise the projects that are most profitable in the short run (Cervantes et al., 2023). Equity incentives, venture capital, tax breaks or public loan guarantees may more effectively address obstacles to investment in R&D and innovation, especially for younger and smaller companies. Finally, carbon pricing, often called the backbone of the EU decarbonisation strategy, pushes the development and deployment of technologies. It also provides a revenue source to the government, which can be used to further support innovation.

Given the size of the financing gap for innovation in the European Union, public support needs to be highly targeted and effectively catalyse private finance. It should focus on early support to kickstart new risky technologies and the patient capital needed to scale up large new projects and invest in key enabling infrastructure. Deepening the EU single market and advancing the capital markets union remain key priorities, as they would provide the market scale and depth needed for firms to take advantage of growth opportunities. A strategy to reduce barriers to investment and integrate capital markets would further crowd in private investment and support entrepreneurs.

Policymakers must also address the potential detrimental effects new technologies may have on the economy, the labour market and inequality. For example, despite the potential productivity gains and sizeable risks of not keeping up with advanced digital technologies, digitalisation may have a negative impact on unemployment and inequality. New digital technologies tend to reinforce the need for skilled workers (although recent evidence finds that artificial intelligence can have larger productivity gains for low-skilled workers (Brynjolfsson et al., 2023)). These issues will need to be closely monitored, as they have implications for policies aiming to retrain low-skilled workers lacking the digital literacy needed in the labour market (see Box C for a discussion of employee training and lack of skilled staff). Addressing the lack of digital skills (especially in small EU firms) and ensuring younger generations are digitally literate will be crucial.

Bringing down barriers to investment and fostering an innovation-enhancing environment could provide powerful momentum for change. It is important to address direct obstacles to investment (such as a lack of access to external finance) and structural barriers in the operating environment (such as regulatory barriers or difficulties in accessing the necessary infrastructure). In addition, the EU market's highly fragmented nature may further complicate cooperation on and the dissemination of innovations. Preserving a competitive environment goes hand in hand with reinforcing the EU single market and a level playing field across the European Union.

The European Union will have to make a judicious compromise between maintaining openness while being challenged by increasing geopolitical risks. While it is crucial for the European Union to coordinate better within its borders, there are trade-offs on how it should position itself in the global landscape. On the one hand, the current technological developments required for a successful green transition closely depend on global cooperation and knowledge exchange. On the other hand, the European Union should ensure it remains a competitive player.

Box C
Skills for a changing environment

A rapidly changing work environment requires an equally rapid shift in skills. A skilled workforce that can swiftly adapt to a changing needs is incredibly important for Europe's transition to a greener, more digital and more resilient economy. At the same time, EU labour markets have become historically tight, resulting in persistent skill shortages for firms. Effective training of workers and the improvement of their skills are key to addressing these challenges and maintaining companies' performance and profitability in the future.

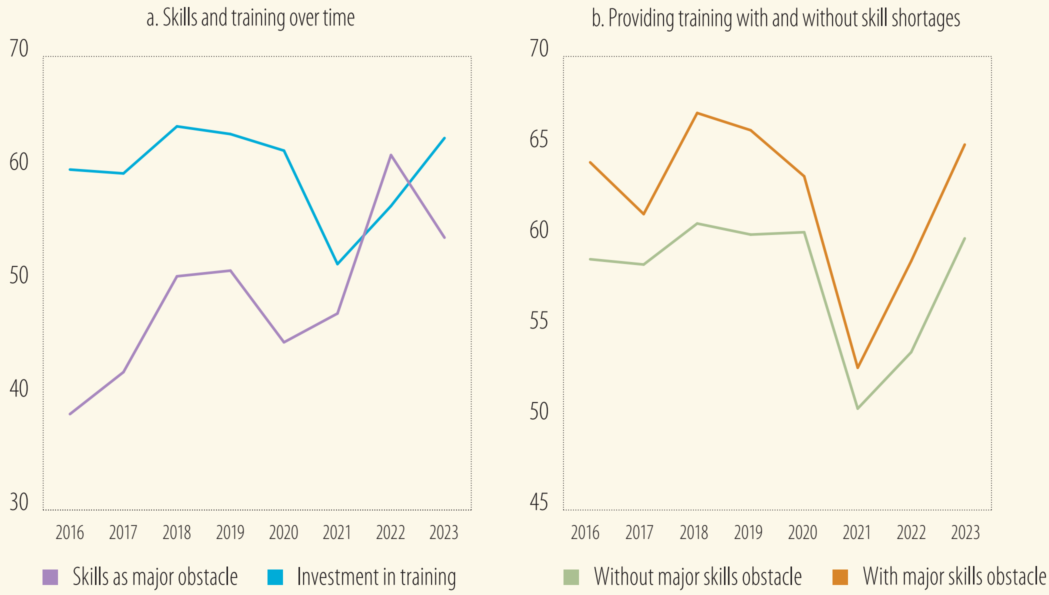
European firms increasingly suffer from a shortage of skilled staff but tend not to train sufficiently. Over time, the share of EU firms reporting a lack of staff with the right skills as a major barrier to investment has increased to 54% in 2023, from about 38% in 2016 (Figure C.1a). However, training provided, in terms of the percentage of firms and average amount invested, remained relatively constant. This encompasses the recovery period following the COVID-19 crisis, which brought training back to pre-pandemic levels. However, of the firms reporting a significant shortage of skilled staff, only a marginally higher percentage provided training, compared to firms that did not declare skills a major investment barrier (Figure C.1b).[3]

3 These developments are observable independent of firm size.

At the regional level, firms experienced a similar dynamic of skill shortages and training provided. Since the pandemic, the shortage of skilled staff has mainly intensified in Northern and Western Europe and Southern Europe (although at comparatively lower levels), but has receded in Central and Eastern Europe. Investments in training, which were most widespread in Northern and Western Europe (with around 65% of firms on average making these investments since 2016), have not yet fully recovered to pre-pandemic levels across the board. Firms indicating a lack of skilled staff as a major barrier were slower to reinitiate training than firms not reporting skills as a major obstacle.

Figure C.1

Aggregate reporting of major skills obstacles and training (% of firms)



Source: *EIBIS 2016-2023.*
Note: *EU firms. Firms are weighted by value added.*

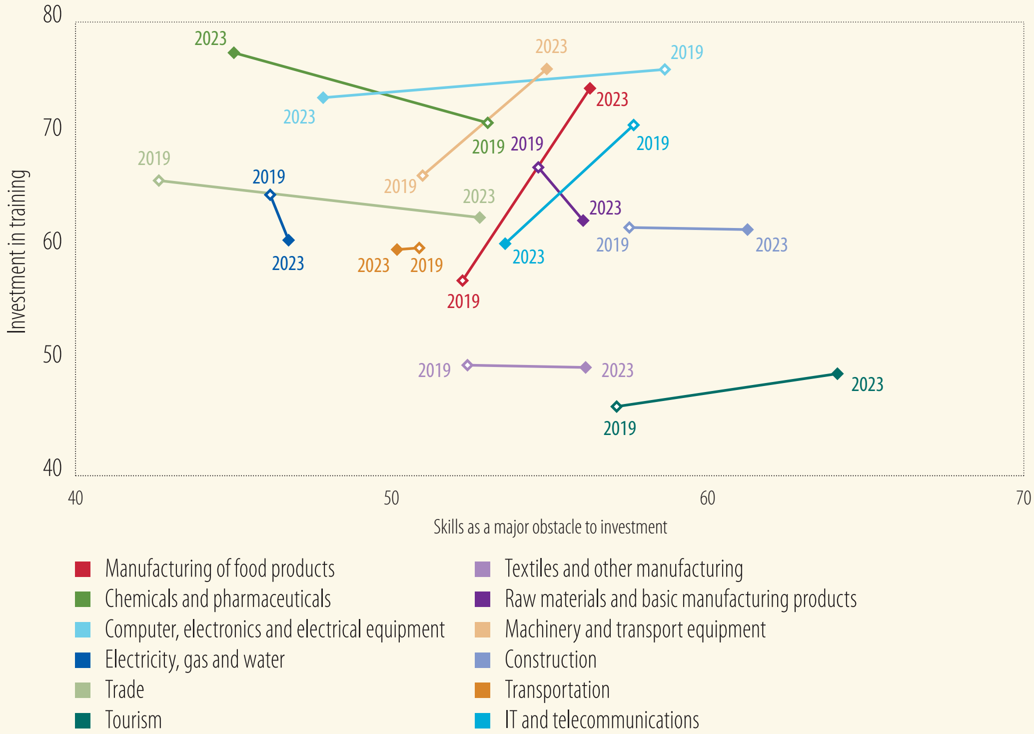
Firms in innovative sectors face the highest skill shortages but also invest more in training on average. The share of firms reporting skill shortages increased by an average of 9 percentage points between 2019 and 2023 (Figure C.2). Sectors found to be the most innovative in using advanced digital technologies (such as IT and telecommunications and manufacture of machinery and transport equipment) seem to face bigger challenges in finding skilled staff and filling open vacancies than other sectors. While firms in these sectors tend to train more on average, they also exhibit the biggest gap in training provided relative to demand for skilled staff. For instance, IT and telecommunications experienced one of the steepest increases in skill scarcity, but also a bigger drop in the share of firms providing training from 2019 to 2023 than any other sector (with a decrease of 10 percentage points). In contrast, firms providing training in machinery and transport equipment during the same period increased by 10 percentage points.

On average, this pattern continues to hold at a regional level and over time, with more innovative sectors reporting a higher prevalence of firms investing in training. This includes sectors like food production and IT and telecommunications in Northern and Western Europe, the manufacturing of machinery and transport equipment in Southern Europe, and (to a lesser extent) food production in Central and Eastern Europe. Firms in other sectors often trimmed their training expenses amid intensifying skill shortages.

While most EU firms face significant challenges in finding skilled staff, firms in more innovative sectors seem to be adapting better to an environment demanding increasingly skilled work. Major discrepancies remain, however, despite investment in training stepping up as firms looked for more skilled workers. All firms need to increase their efforts not only to better train their staff, but also to attract qualified external candidates more easily. Making firms more attractive to external candidates may also require improvements to more structural elements such as flexibility within firms, offering childcare to attract workers, and providing employees with the support they need to engage in training.

Figure C.2

Investment in training and skills as a major barrier to investment (% of firms), **by sector**



Source: *EIBIS 2019 and 2023.*
Note: *EU firms. Firms are weighted by value added.*

Conclusion and policy implications

EU policies increasingly emphasise the need to enhance and preserve the global competitiveness of European firms, with a renewed focus on innovation, the spread of innovation and the resilience of global supply chains, particularly as firms find themselves dependent on critical sectors. The ability of Europe's economy to adjust and transform itself during the green and digital transition will also depend on the support of an effective operating environment.

Europe's position in global innovation is being challenged. While it is at the forefront of clean technologies, the European Union's digital technology performance remains lacklustre compared to the United States and China. It should therefore strengthen its ability to innovate in key strategic technologies.

A successful transition to a more digital and green EU economy will require the widespread uptake of new technologies, as they will drive competitiveness and improve resilience to economic disruption and climate change. While EU firms are catching up with their US peers in the use of digital technologies, they should remain vigilant and invest more, particularly in the adoption of big data analytics and artificial intelligence, which are positively associated with firm performance and job creation and can be a catalyst for green innovation and transformation.

Amid global uncertainty, geopolitical tensions and strategic dependencies, pressure on EU competitiveness may increase. Europe is committed to a model of open strategic autonomy where the benefits of trade remain, but diversification, resilience and innovation are enhanced. Improving the competitiveness of EU firms will also help maintain the efficiency of the economic environment and strengthen the single market, ensuring there is an equal playing field across the European Union.

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