CHAPTER 11

INNOVATION AND ADOPTION OF DIGITAL AND GREEN TECHNOLOGIES

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1 The views expressed in this chapter are those of the authors, and do not necessarily reflect the views of the European Investment Bank.

Abstract

This chapter focuses on corporate investment in innovation and the adoption of green and digital technologies. Based on the latest results of the EIB Investment Survey (EIBIS), it compares the performance of EU firms relative to their US peers and also looks at differences across the different cohesion regions within the EU. First, the analysis finds that the EU has a lower share of firms that invest in innovation than the US. Second, it shows that EU firms are closing the gap in the adoption of advanced digital technologies with their US peers, a trend mainly driven by firms in more developed regions. Third, the chapter argues that investment in climate change is an area in which the EU has been able to keep its competitive edge over the US. To better assess Europe's position in the innovative landscape, the chapter also discusses factors that can support or hamper firms' investment in the structural transformation, such as digital infrastructure, a dynamic innovation environment, business regulations and access to finance.

1. Introduction

Europe's future prosperity and competitiveness depend on investing in innovation and addressing the challenges of climate change. While the current policy debate mainly rotates around global competition and resilience, the flexibility of Europe's economy to adjust and transform will also rely on the efficiency of the operating environment. The aim is to foster a smarter, more competitive Europe by creating an inclusive environment that incentivises EU firms to accelerate the twin green and digital transition.

Against this background, this chapter focuses on corporate investment in innovation and the adoption of green and digital technologies. Based on the latest results of the EIB Investment Survey (EIBIS), we compare the performance of EU firms relative to their US peers in the adoption of technologies. We also examine differences between the different cohesion regions within the EU and how to create an environment that enhances the adoption of innovation. This chapter does not discuss how to enhance the frontier of innovation or the global innovation leadership race.

First, we find that the EU has a lower share of firms investing in innovation than the US. We also highlight the differences in innovation activities across different EU regions. Second, we show that EU firms are closing the gap in the adoption of advanced digital technologies with their US peers, a trend mainly driven by firms in more developed regions. Third, we argue that investment in climate change is an area in which the EU has been able to keep its competitive edge over that of the US. Finally, to better assess Europe's position in the innovative landscape, the chapter discusses factors that can support or hamper firms' investment in the structural transformation, such as digital infrastructure, a dynamic innovation environment, business regulations and access to finance.

2. Data

The evidence reported in this chapter is based on EIBIS: an annual survey that gathers qualitative and quantitative information on investment activities by non-financial corporates, their financing requirements, and the difficulties they face. Every year since 2016, the survey has collected data from more than 12,000 businesses in all EU countries, and 800 businesses in the US since 2019. Using a stratified sampling methodology, the survey is designed to be representative at the levels of country, sector (manufacturing, construction, services and infrastructure) and firm-size class (micro, small, medium and large).[2]

EIBIS data are collected in a consistent manner and with the same methodology for a large number of firms across all EU countries

2 The sector classification in EIBIS is based on the NACE classification of economic activities: manufacturing: group C; construction: group F; services: group G (wholesale and retail trade) and group I (accommodation and food services activities); infrastructure: groups D and E (utilities), group H (transportation and storage) and group J (information and communication). The firm size classes in EIBIS are: micro (5-9 employees); small (10-49 employees); medium-sized (50-249 employees); and large (250 employees). Using various administrative databases, Brutscher et al. (2020) provide evidence on the representativeness of EIBIS for the business population of interest.

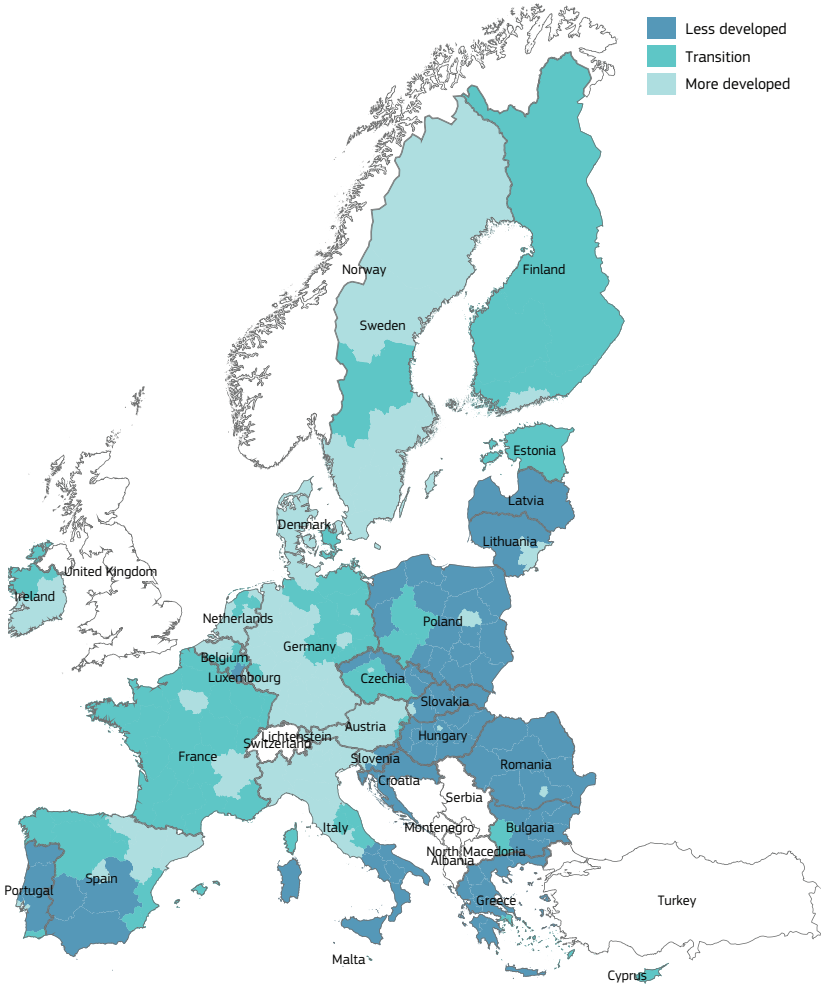
and the US, thus allowing a comprehensive comparative analysis of investment activities in diverse institutional settings. EIBIS also gathers qualitative information on firms' investment in the development or introduction of new products, processes or services, the use of advanced digital technologies, and their investments to tackle the physical and transition risks associated with climate change.

This chapter aims to compare both the performance of EU firms relative to their US peers and the performance across different EU regions, as economic convergence lies at the heart of EU policy. The analysis focuses on investment in innovation, the use of advanced digital technologies, and investments to tackle climate change.

In the following discussion, we refer to NUTS2 regions with GDP per capita above the EU average as 'more developed' or 'non-cohesion' regions; to those with GDP per capita between 100 % and 75 % of the EU average as 'transition' regions; and to those with incomes below 75 % of the EU average as 'less developed'.[3] Figure 11-1 shows an overview of this classification of regions.

3 NUTS2 refers to the Nomenclature of Territorial Units for Statistics. NUTS2 regions are the basic regions for EU regional policies. According to regions' income classification, the availability of co-financing from EU funds differs, with poorer regions having the possibility to receive more financial support.

Figure 11-1 Classification of EU regions based on EU cohesion policy



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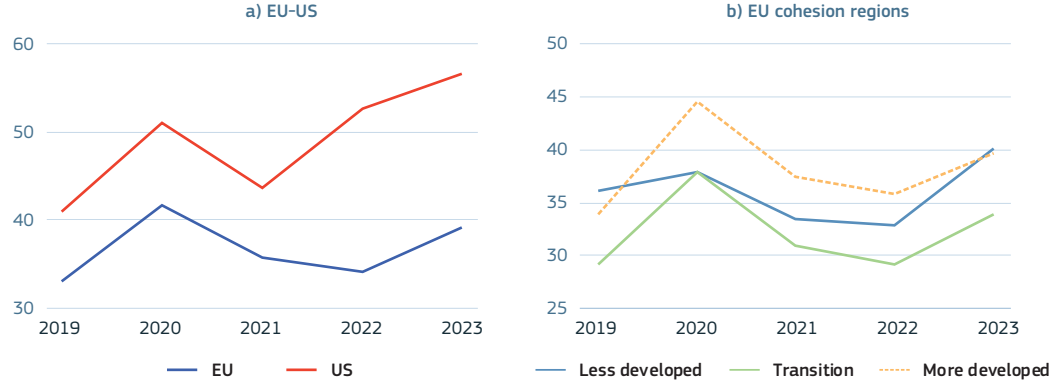
Source: European Commission's Directorate-General for EU Regional and Urban Policy.

3. Investment to develop or introduce new products, processes or services

The EU has a lower share of firms that invest in developing or introducing new products, processes or services than the US. After a slowdown following the COVID-19 crisis, the share of EU firms investing in innovation increased to 39% in 2022, compared to 57% in the US (Figure 11-2a). This evidence from EIBIS confirms the findings of the European Innovation Scoreboard 2023 (European Commission, 2023) and OECD data, in which the US scores better than the EU on several indicators related to R&D and innovation.

There is also a sizeable persistent innovation gap between transition regions and more developed regions. In transition regions, only 34% of firms report investing in the development or introduction of new products, processes or services, while this share is as high as 40% in more developed regions (Figure 11-2b). This recent uptake of investment in innovation in less developed regions is a positive signal, and could be a key contributor for these regions to alleviate the innovation divide across the EU (European Commission, 2022a).

Figure 11-2 Development or introduction of new products, processes or services (% of firms)



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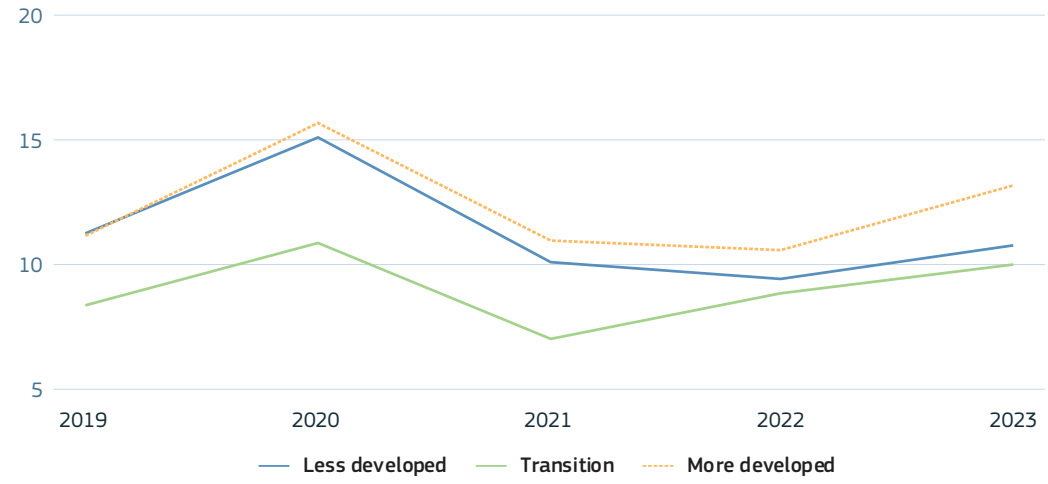
Source: EIBIS 2019-2023.
Note: Firms are weighted by value added.

The share of firms investing in innovation in Figure 11-2 measures a combination of two types of innovation: firms can invest to develop innovations that are new to their market, or adopt and adapt technologies that already exist in their market and are used by other companies. The difference between the innovation activities of firms in less developed regions and transition regions is mainly driven by this latter type of innovation; namely, the adoption of innovation that is new to their company. When focusing on the share of firms that invest in innovations new to the market, the recent increase in investment in less developed regions is absent. Instead, more developed regions seem to have increased their gap with the less developed regions (Figure 11-3).

Figure 11-3 Development or introduction of new products, processes or services that are new to the market (% of firms), for cohesion regions



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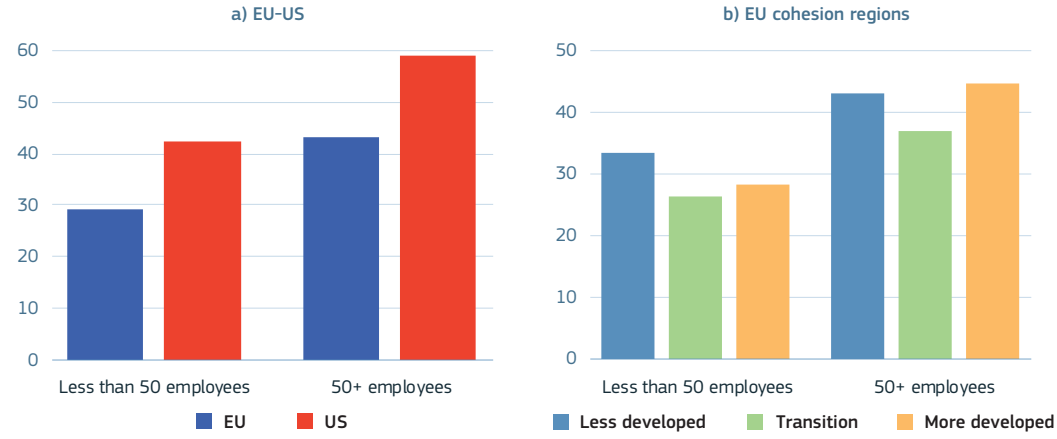
Source: EIBIS 2019-2023.
Note: Firms are weighted by value added.

Larger firms tend to be more innovative. The share of EU small firms (with less than 50 employees) that invest in innovation is only 30%, compared to 43% in the US (Figure 11-4a). The positive relationship between firm size and investment in innovation is also apparent across different cohesion regions (Figure 11-4b). Small firms in less developed regions are making a strong effort to invest in the adoption of innovation.

Figure 11-4 Development or introduction of new products, processes or services (% of firms), by firm size



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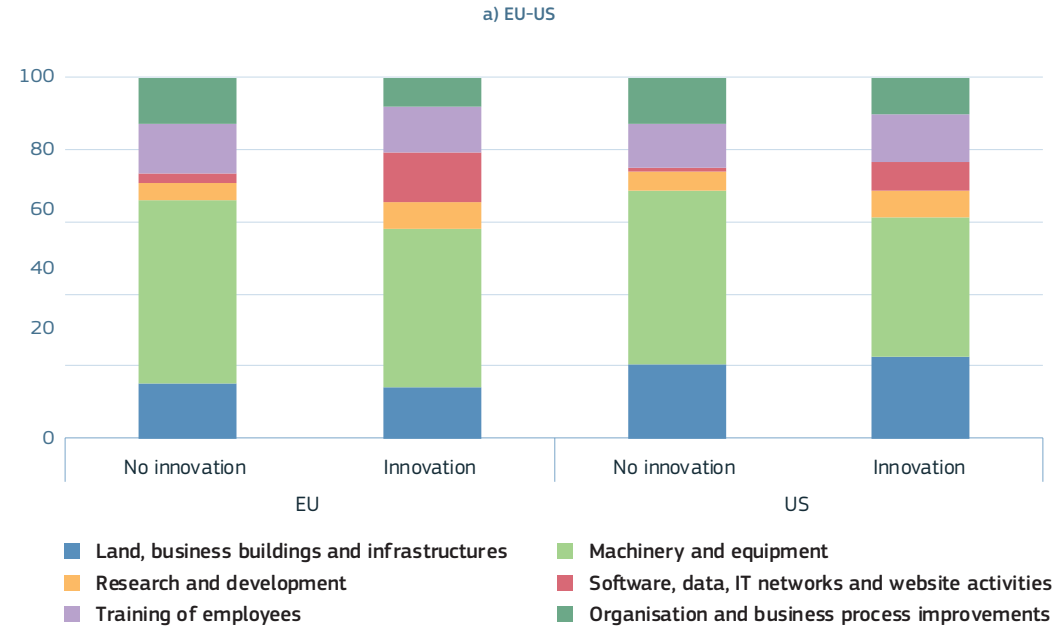
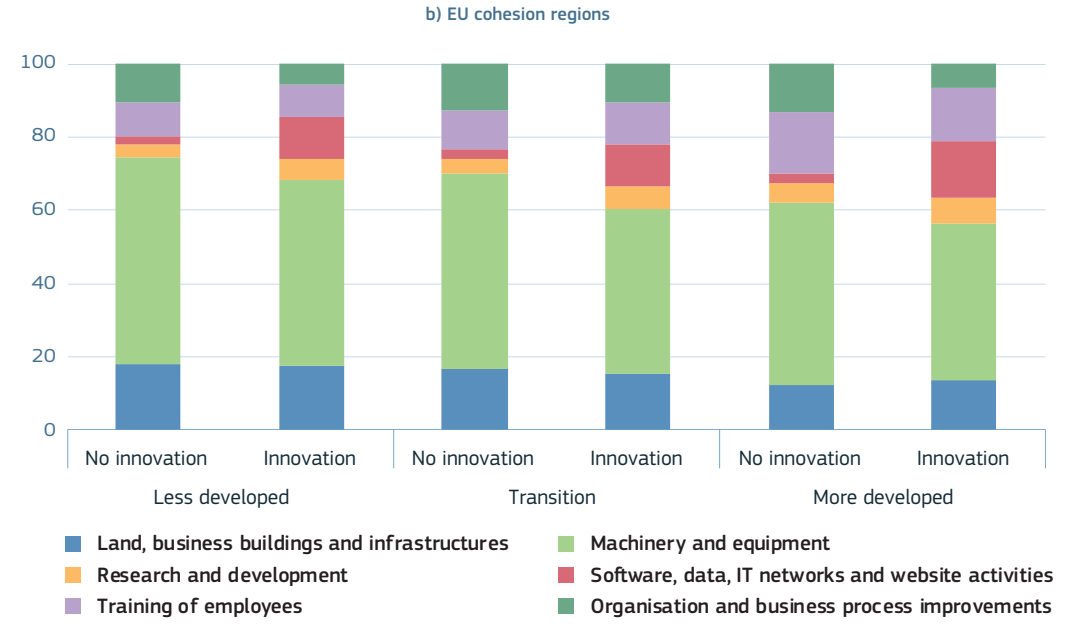
Source: EIBIS 2023.
Note: Firms are weighted by value added.

Innovation activities are associated with investment in intangibles. Firms that allocate a greater share of investment to intangibles (R&D, software and data, training of employees, organisational and business process improvements) tend to innovate more (Figure 11-5). R&D investment appears to be the key driver of this positive correlation between intangible assets and the introduction or development of new products, processes or services. For example, innovative EU firms allocate about 14% of total investment to R&D, compared to only 3% for non-innovative firms. This pattern is visible when comparing the US and the EU, and across the different EU regions.

Investments to develop products, processes or services new to the market are often risky, with highly uncertain returns. They encompass a large share of sunk costs; once the investment is effectuated, it is, to a large extent, irreversible. Innovative firms are also more susceptible to difficulties in access to finance due to market failures; for example, information asymmetries between investors and innovating companies, or the lack of appropriability of innovation (Arrow, 1962; Stiglitz and Weiss, 1981; Dixit and Pindyck, 1994). Based upon this rationale, innovation is therefore often supported by public authorities. In addition, 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).

Figure 11-5 Innovation and investment in intangible assets (% of total investment)





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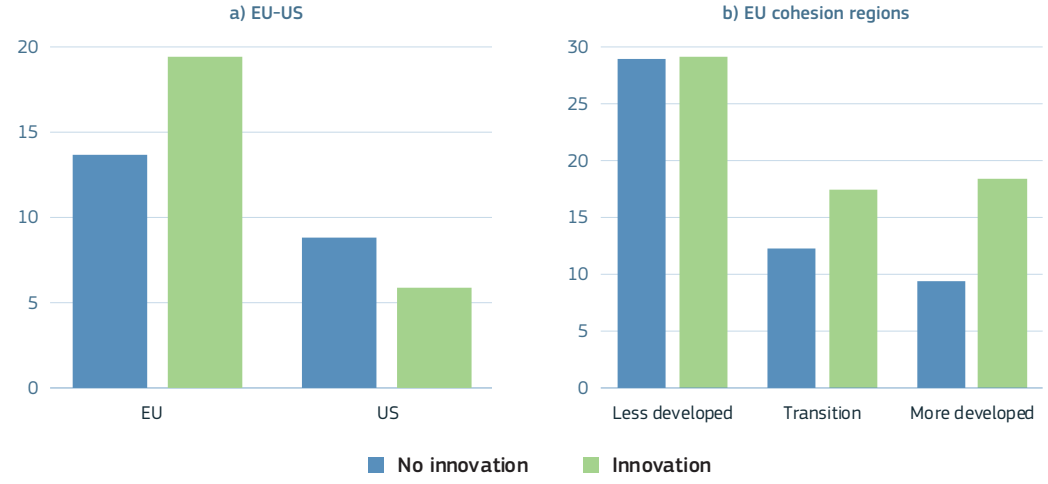
Source: EIBIS 2023.
Note: Firms are weighted by value added.

Innovative EU firms using external finance are more likely than non-innovative firms to use grants to finance their investments. This differs from the US, where the opposite pattern can be observed (Figure 11-6a). This suggests that EU grants tend to be more targeted to innovation than in the US. In addition, firms using external finance in less developed regions were more likely to receive grants, independent of their innovation status (Figure 11-6b). This is in line with the availability of co-financing differing across regions, with poorer regions having the possibility to receive more financial support overall, which also target non-innovative firms.

Figure 11-6 Share of grants (% of firms using external finance)



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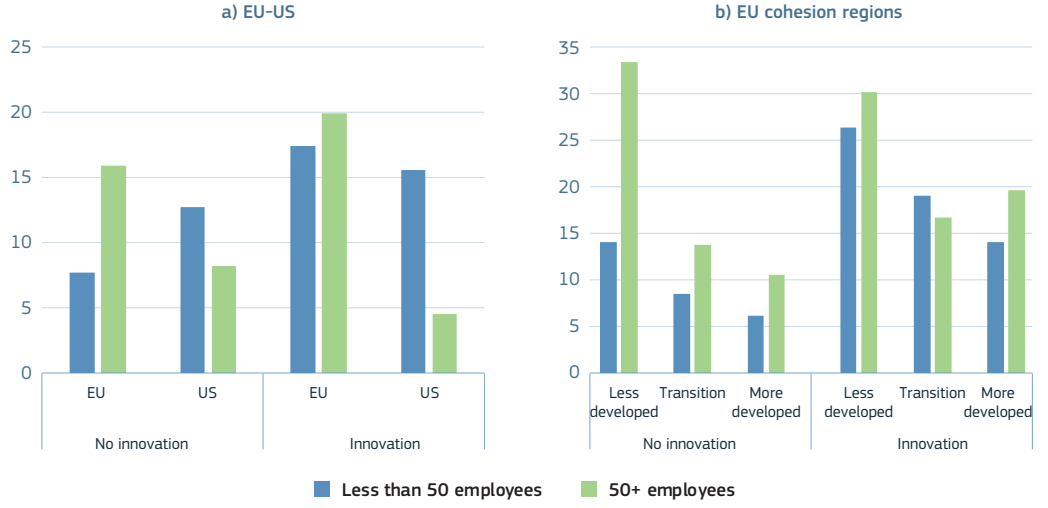
Source: EIBIS 2023.
Note: Firms are weighted by value added.

In the EU, large firms using external finance are more likely to report that they received grants than small firms. In the US, the opposite pattern is observed, as smaller firms are more likely to use grants than large firms. In addition, among EU innovators, small and large firms are almost equally likely to receive grants. In the US, small innovators are much more likely to use grants than large innovators (Figure 11-7a). In the US, the policy support through grants focuses on small firms, in particular small innovators. Focusing on the different cohesion regions shows that, among non-innovators, large firms are more likely to receive grants than small firms, especially in less developed regions (Figure 11-7b).

Figure 11-7 Share of grants (% of firms using external finance), by firm size and innovation status



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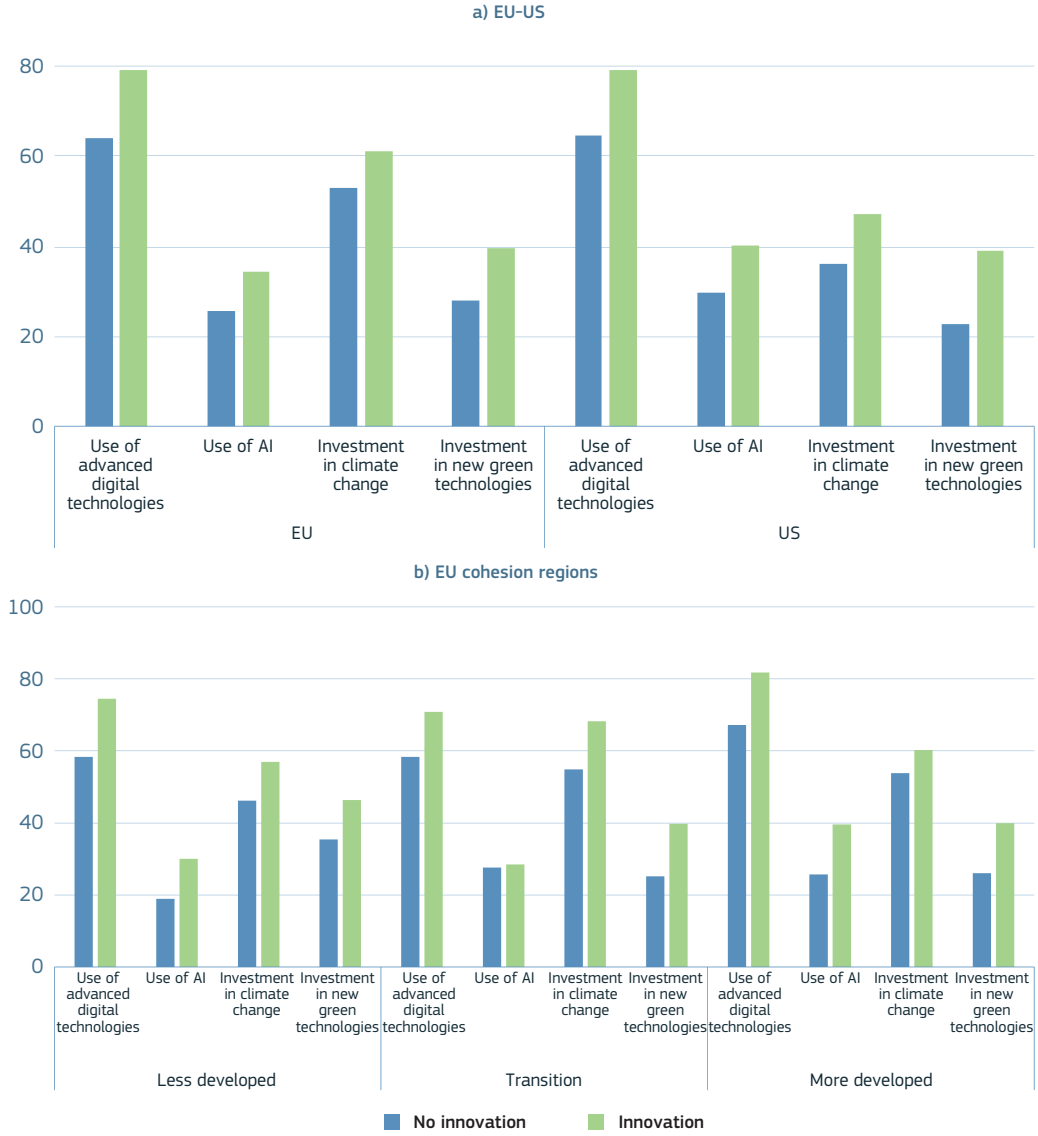
Source: EIBIS 2023.
Note: Firms are weighted by value added.

Innovation, digitalisation and the green transition go hand in hand. Innovative firms are also those that digitalise more and invest more in climate change (Figure 11-8a). This confirms the role these companies can play in the future resilience and competitiveness of the EU and the criticality of supporting innovation. Indeed, innovative companies can better thrive in an environment where investment in these areas is increasingly important. This relationship between innovation and the twin digital and green transition is also strong across cohesion regions (Figure 11-8b).

Figure 11-8 Innovation and firm performance (% of firms)



Science, research and innovation performance of the EU 2024

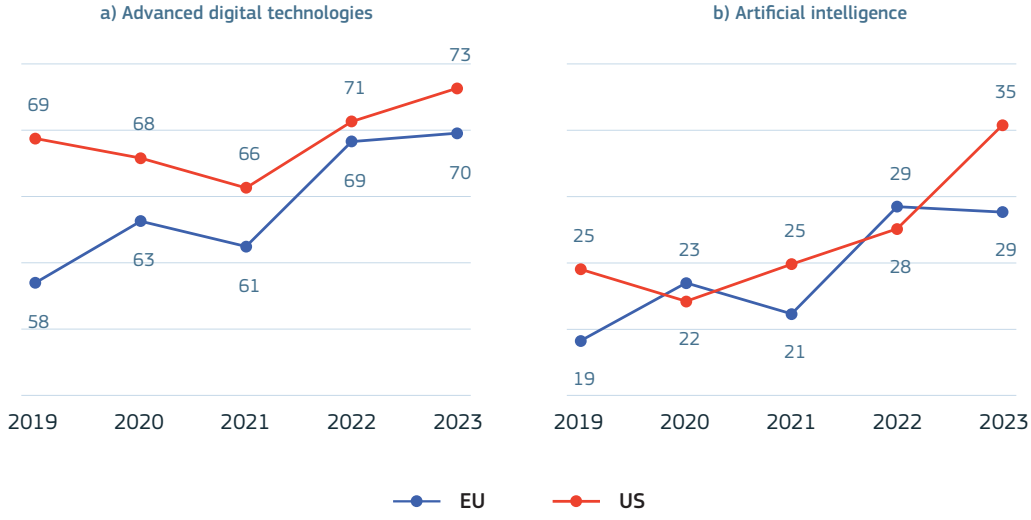
Source: EIBIS 2023.

Note: Firms are weighted by value added.

4. Adoption of digital technologies

Strengthening the competitiveness of the European economy through the twin green and digital transition is not only about innovation at the technological frontier, but also the adoption and deployment of these technologies more broadly. The latest results from 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 US (Figure 9a). To ensure no persistent gap is created with their US peers, EU firms must remain vigilant and reinforce the use of artificial intelligence (AI), which is a key digital technology (Figure 11-9b).

Figure 11-9 Use of advanced digital technologies and artificial intelligence (% of firms)

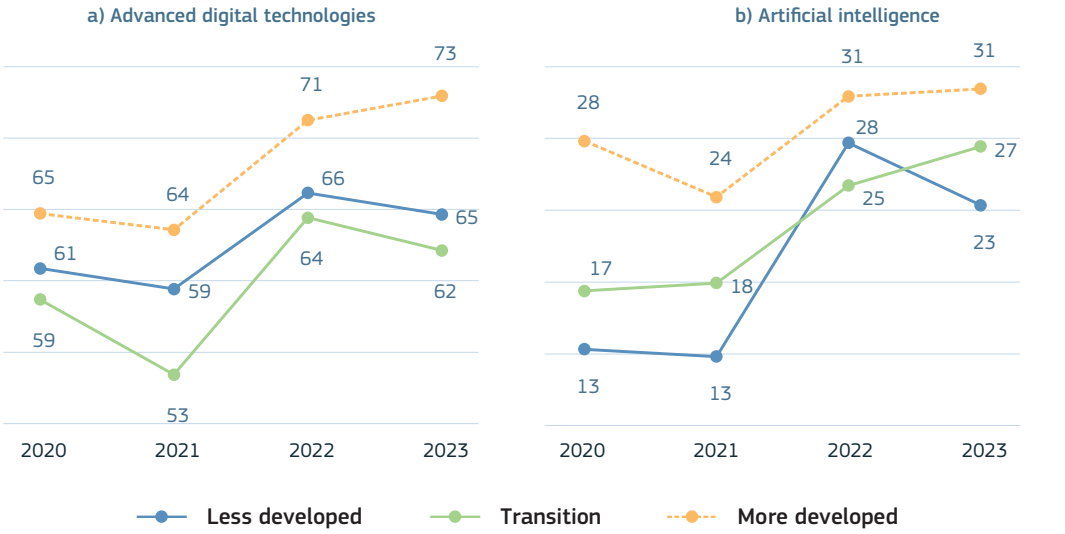


Science, research and innovation performance of the EU 2024

Source: EIBIS 2023.
Note: Firms are weighted by value added.

Digital adoption rates are higher in more developed regions. Technology adoption patterns reflect industrial specialisation and depend on digital infrastructure, and the availability of human capital. The transition and less developed regions consistently lag behind the more developed regions over time. In addition, Figure 11-10 shows that firms in the more developed regions mainly drive the digital technology adoption in the EU. More developed regions lead in adopting AI, a digital area that has also been increasingly embraced by transition and less developed regions.

Figure 11-10 Use of advanced digital technologies and artificial intelligence (% of firms)



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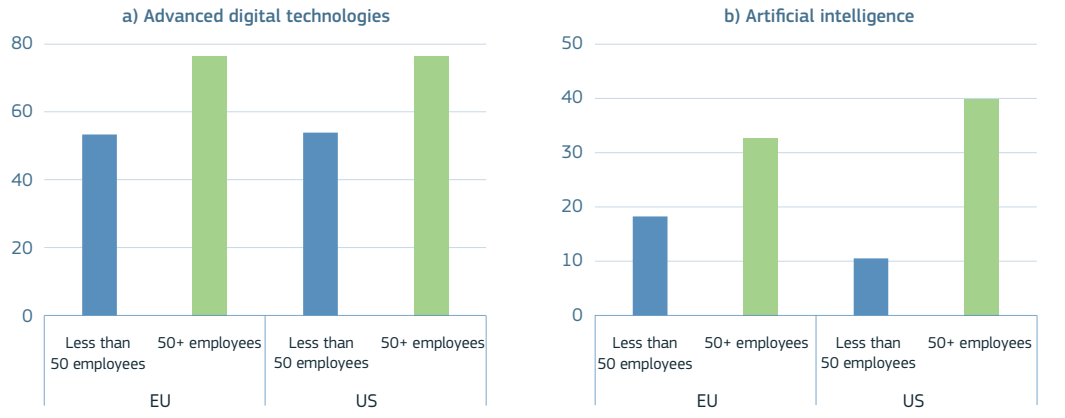
Source: EIBIS 2023.

Note: Firms are weighted by value added.

Figure 11-11a shows that large firms are more likely to make use of digital technologies. When focusing on AI, the gap in adoption rates between small and large firms is wider in the US than in the EU (Figure 11-11b). The same relationship between the use of digital technologies and firm size holds across the different regions across the EU (Figure 11-12).

Figure 11-11 Use of advanced digital technologies and artificial intelligence (% of firms), by firm size, EU-US

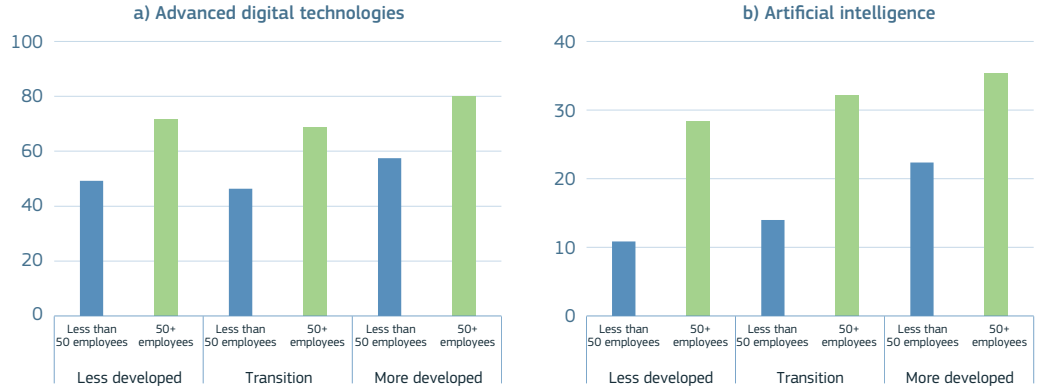


Science, research and innovation performance of the EU 2024

Source: EIBIS 2023.

Note: Firms are weighted by value added.

Figure 11-12 Use of advanced digital technologies and artificial intelligence (% of firms), by firm size



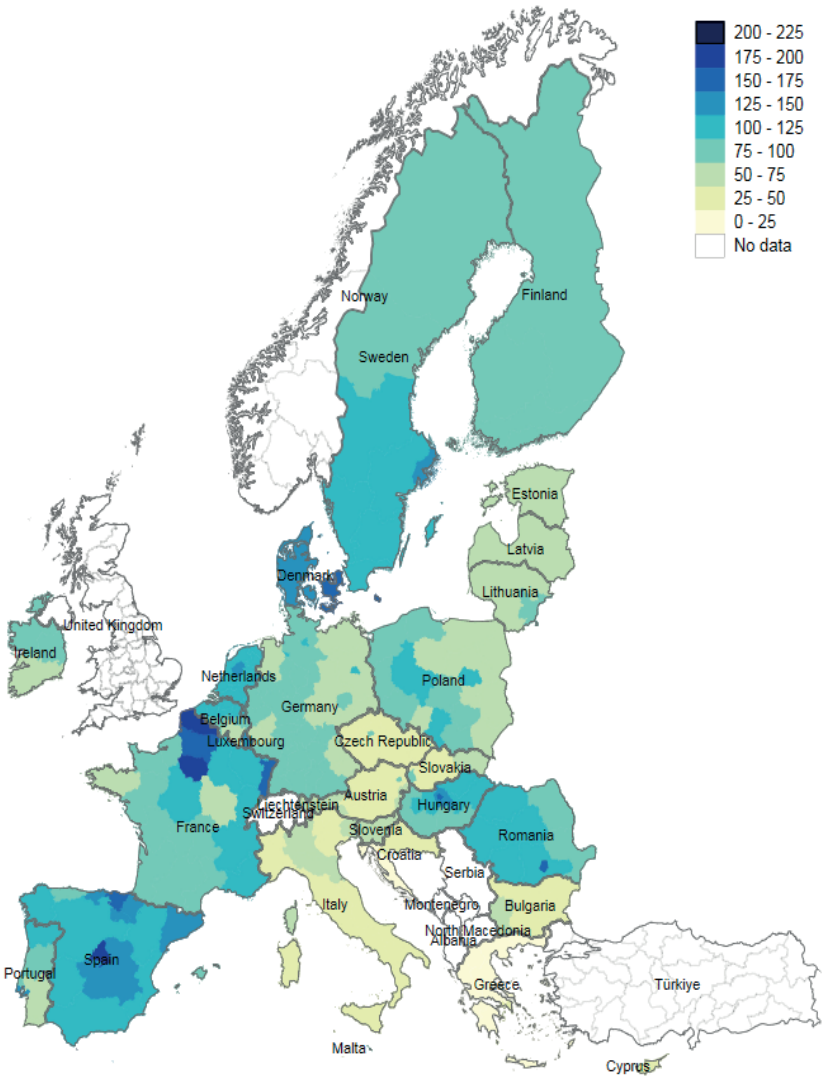
Science, research and innovation performance of the EU 2024

Source: EIBIS 2023.

Note: Firms are weighted by value added.

Digital infrastructure plays a critical role in economic activity, particularly for firms using advanced digital technologies. 12 % of EU firms surveyed in the latest EIBIS consider access to digital infrastructure as a major obstacle to investment. A key consideration here is internet access and speed. Using data on average internet download speeds, Figure 11-13 shows that significant differences exist in the quality of digital infrastructure between different EU regions and countries.

Figure 11-13 Internet download speed in the EU in 2021 (megabits per second)



Science, research and innovation performance of the EU 2024

Source: Authors' 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 NUTS2 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 meters by 610.8 meters at the equator), which is aggregated to NUTS2 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 speed. This is illustrated by the positive interaction between firms' use of advanced digital technologies and high download speed in a regression analysis (Table 11-1). This underpins how complementary public and private digital investment can improve firm performance and economic resilience.

Additionally, several different performance metrics confirm that adopting digital technologies pays off at the firm level. Firms that have embraced Big Data and AI technologies are, on average, larger and pay higher wages to their employees. These effects are even stronger for firms using AI, thereby highlighting the benefits of using advanced digital technologies in terms of firm performance. Overall, this also supports previous empirical evidence on the positive effect of digital adoption and the use of AI on innovation and firm productivity (Gal et al.; 2019; Acemoglu et al., 2022; Rammer et al., 2022; EIB, 2023).

Table 11-1 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

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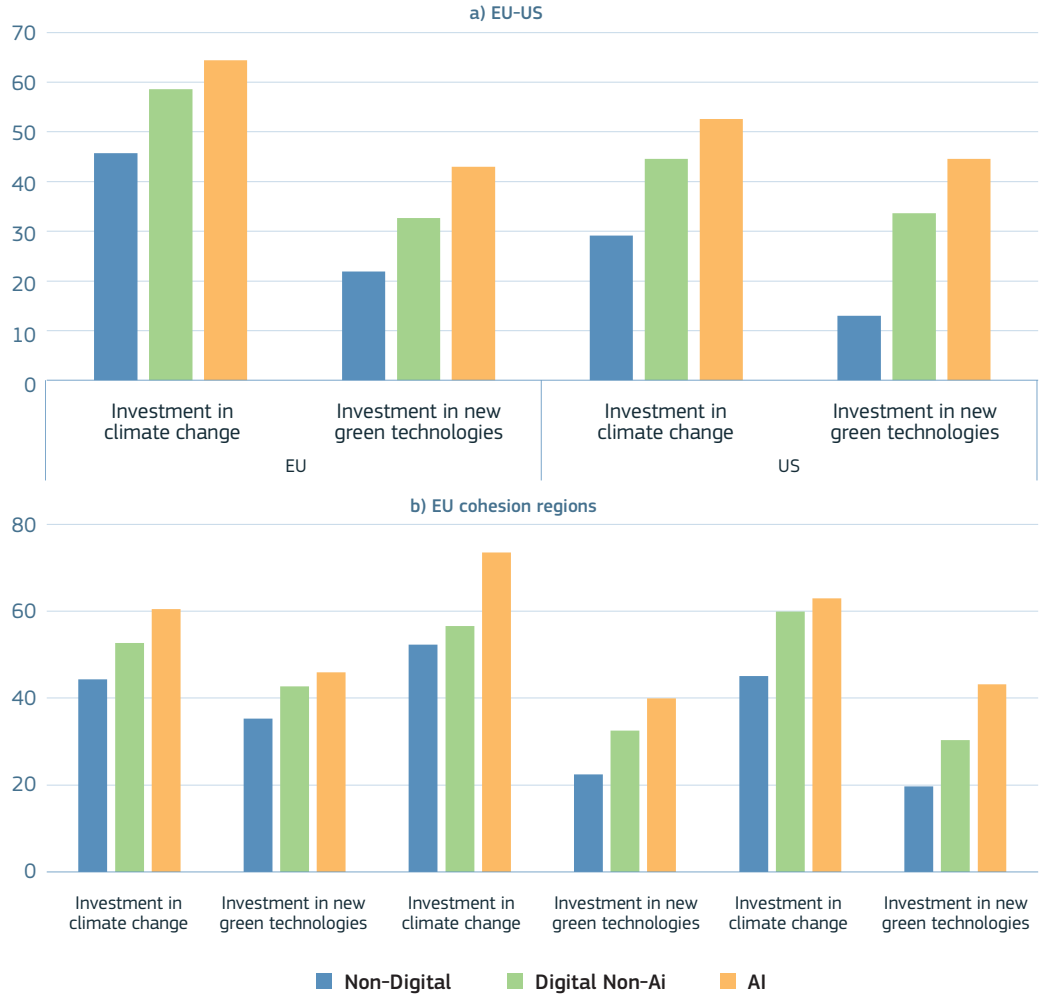
Source: Authors' calculations based on EIBIS (2019-2023) and Ookla (2021).

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 speeds: NUTS 2 region, with average download speeds higher than the median download speed across 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.

Digital technologies –especially AI – could catalyse green innovation and transformation. Indeed, as shown in Figure 11-14, firms adopting AI technologies are more likely to invest in green innovation and transformation. This suggests that the contribution of digital technologies to a firm's eco-innovation is mainly driven by investment in AI application areas (Rotman, 2019; Montresor and Vezzani, 2023). As such, the next section concentrates on investment in the green transition – another key structural transformation challenge for the EU.

Figure 11-14 Digitalisation and investment to tackle climate change (% of firms)



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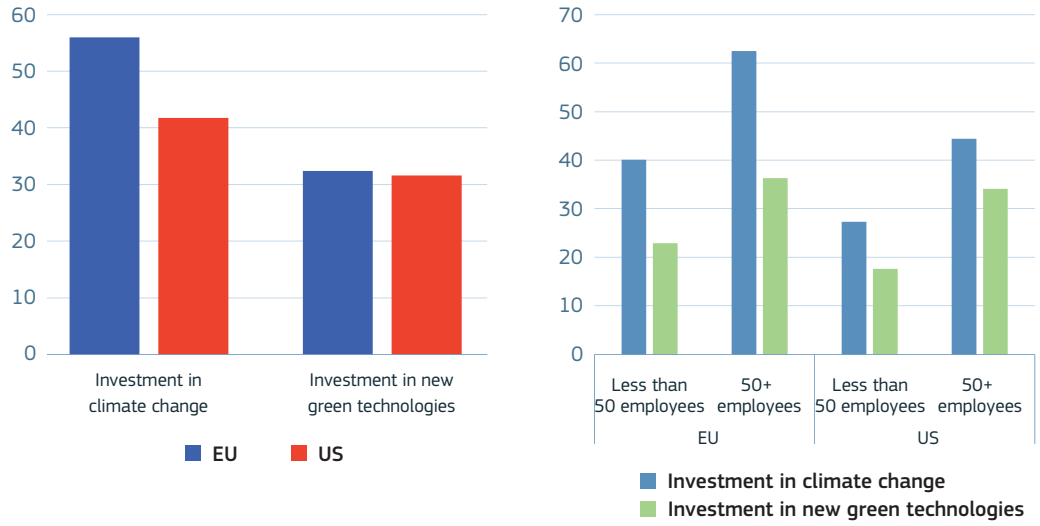
Source: EIBIS 2023.
Note: Firms are weighted by value added.

5. Adoption of green technologies

The EU has a higher share of firms that invest in tackling the impacts of weather events and reducing carbon emissions than the US. However, the share of EU and US firms that invest in new, less polluting business areas and technologies are similar (Figure 11-15a). As such, investing in new green technologies is especially important if the EU wants to maintain a competitive edge in this area. Previous evidence has shown that Europe excels in patenting green technologies, unlike its position in digital technology innovation (EIB, 2024); while this is encouraging news, EU firms must invest to adopt these new green innovations more broadly.

Large companies mainly drive investments in climate change and digital innovation and transformation. Figure 11-15b indicates that, just like in the case of digitalisation, there is a positive relationship between firm size and investment in the green transition. This relationship also holds across the different cohesion regions across the EU (Figure 11-16).

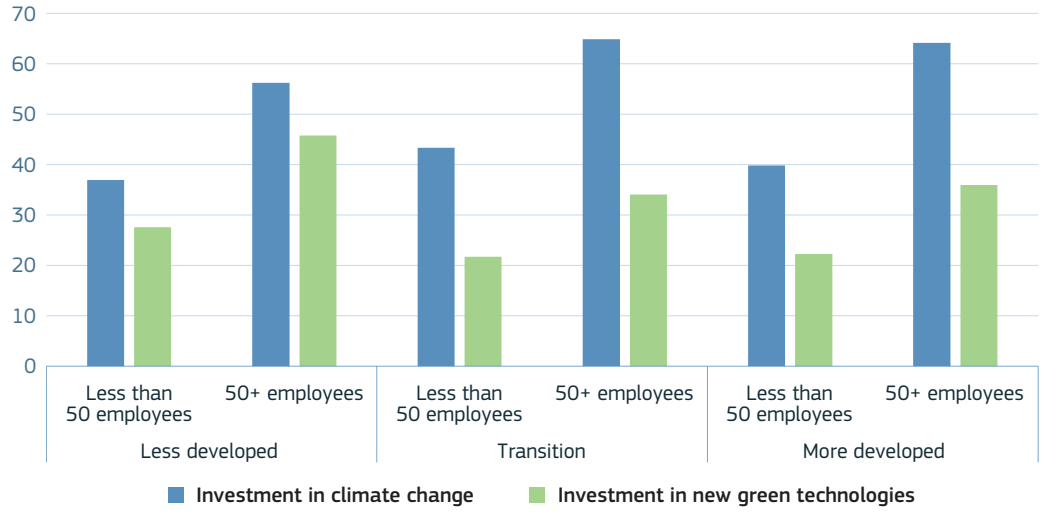
Figure 11-15 Investment to tackle climate change (% of firms)



Science, research and innovation performance of the EU 2024

Source: EIBIS 2023.
Note: Firms are weighted by value added.

Figure 11-16 Investment to tackle climate change (% of firms), by firm size, cohesion regions

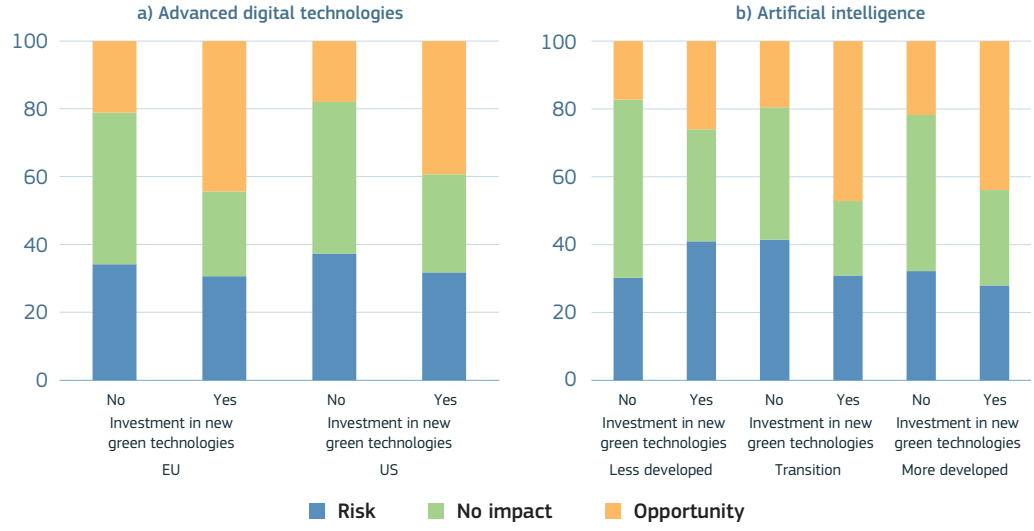


Science, research and innovation performance of the EU 2024

Source: EIBIS 2023.
Note: Firms are weighted by value added.

Firms investing in green innovation and transformation are more likely to see the transition risk 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, a difference of 20 percentage points compared to firms not making such investments (Figure 11-17a). This supports the view that investing in green innovation and transformation is an important driver of a successful climate change transition. The same pattern holds across the different cohesion regions, even if the firms investing in new green technologies in less developed regions are more likely to consider the transition a risk than firms in transition and more developed regions (Figure 11-17b).

Figure 11-17 Green innovation and transition risk (% of firms)



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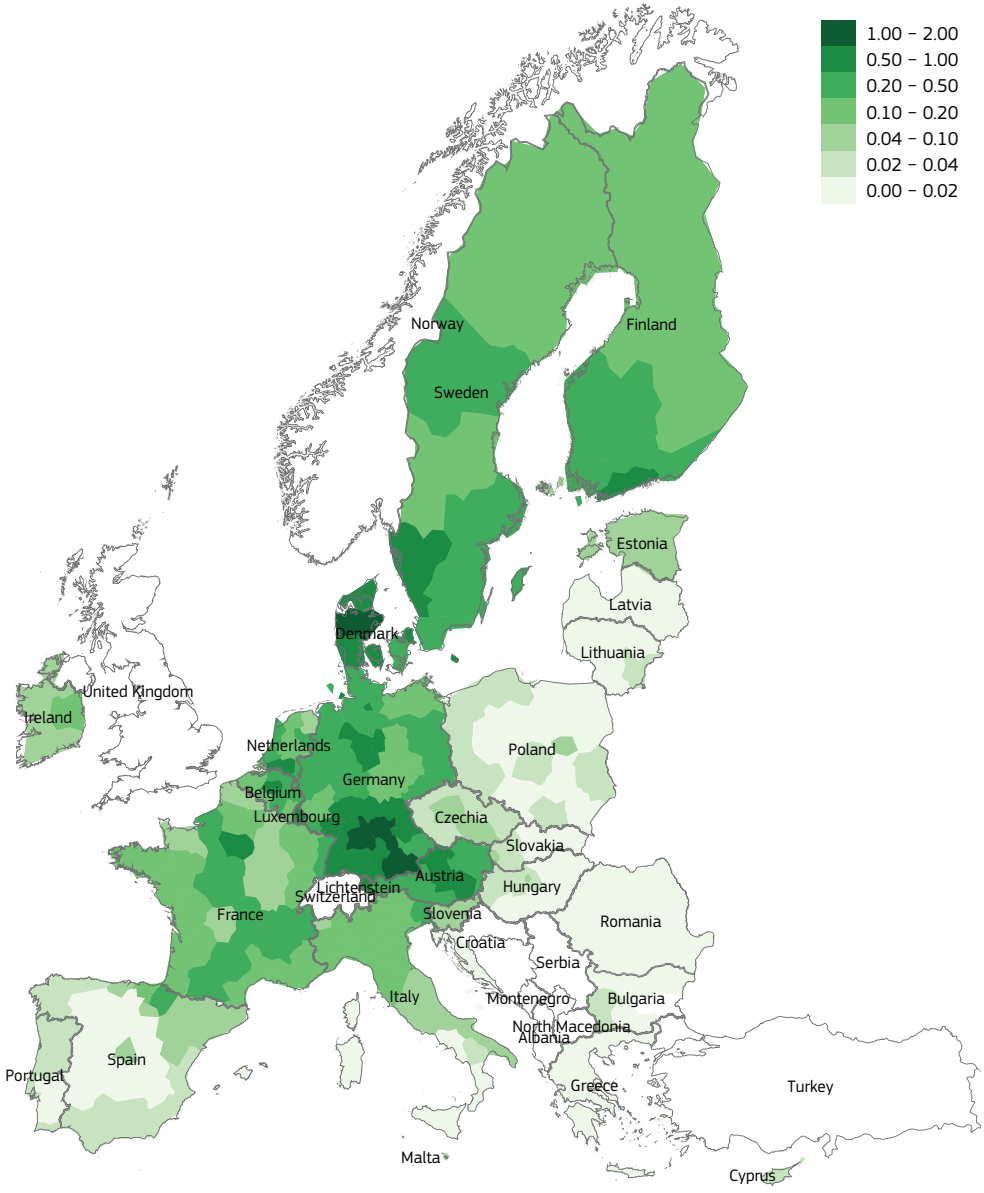
Source: EIBIS 2023.
Note: Firms are weighted by value added.

The innovative environment can play a critical role in firms' investment in innovation, as well as local and aggregate economic activity. A vast literature supports this, highlighting the role of knowledge spillovers on firm-level innovation and the importance of ecosystems inducing innovation (Audretsch et al., 2022; European Commission, 2022b). The green innovation intensity of a region – as measured by patents in green technologies – can be used as a proxy for the innovative quality of a green ecosystem. Figure 11-18 illustrates significant differences in green innovative intensity across different EU regions and countries.

Figure 11-18 Green tech patents (% of population in the region)



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Source: Authors' calculations are based on PCT patents (PATSTAT), in collaboration with ECOOM, KU Leuven, and Eurostat.
Note: Green tech patents are measured as the cumulative patent count across 2011-2020. 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.

The returns from green innovation and transformation are greater for firms located in regions with a more robust green innovative environment. Being embedded in a region with a higher intensity of green innovation relative to the total population provides additional productivity gains to those that invest in green innovation and transformation. This is illustrated by the regression output in Table 11-2, showing a positive interaction effect between investing in new, less polluting business areas and technologies and a greener innovative environment, which further underlines the importance of the broader ecosystem for innovation performance. Table 11-2 also shows that investments in new, less polluting business areas and technologies are associated with higher labour productivity, even when the green innovativeness of the region is not taken into account. This also holds when assessing the impact of investment in climate change at large and its impact on productivity. This evidence is well aligned with an emerging body of literature, emphasising the productivity-enhancing effects of investments in climate (Stern and Stiglitz, 2023).

Table 11-2 Green innovation, regional green innovation and firm productivity

Dependent variable:	**Labour productivity**		
Investment in new green technologies	0.139***		0.093***
	(0.017)		(0.026)
Region with a high share of green innovation (relative to total population)		0.451***	0.426***
		(0.024)	(0.026)
Investment 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

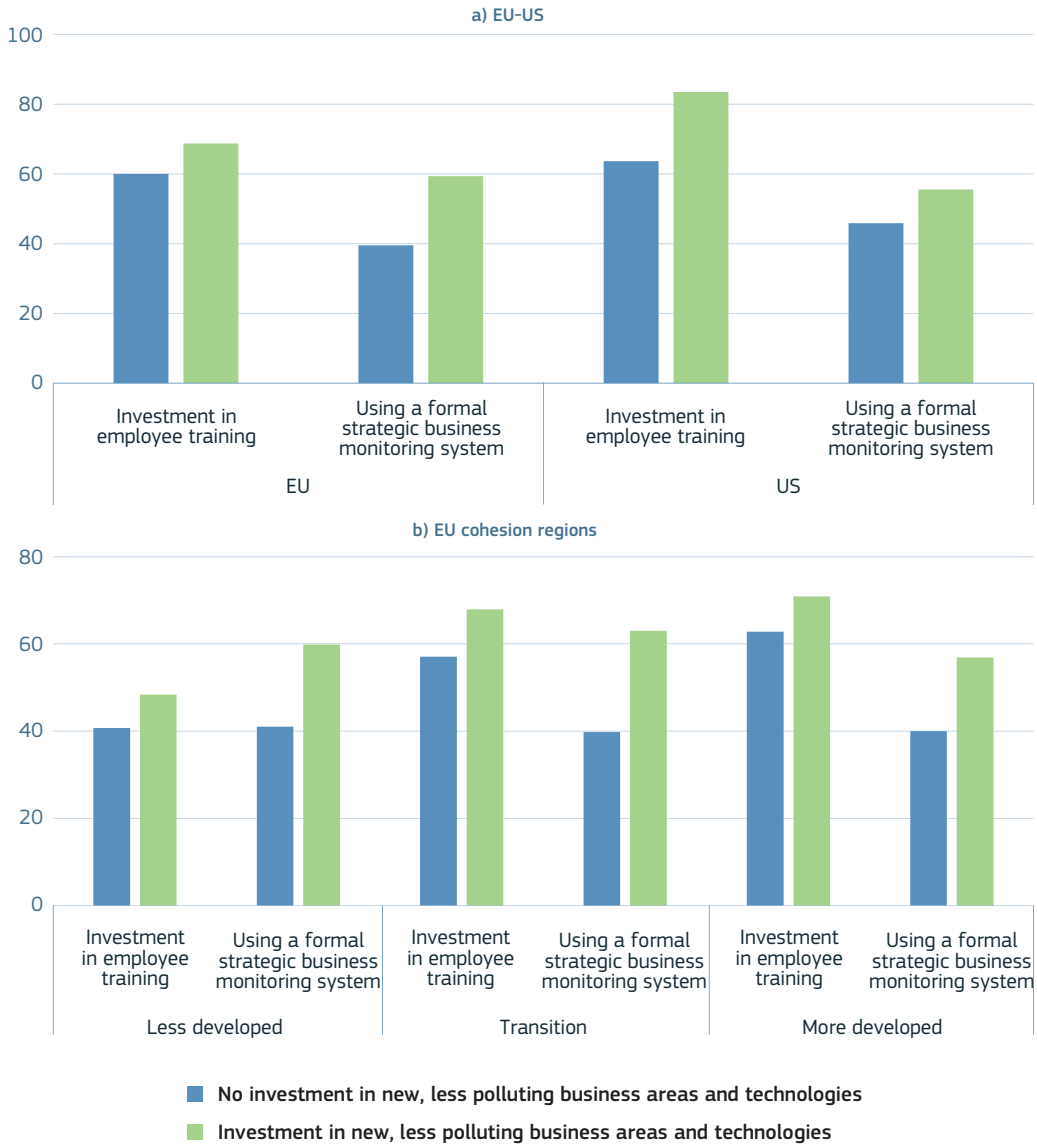
Science, research and innovation performance of the EU 2024

Source: Authors' 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 are in parentheses. Statistical significance: *** p-value<0.01, ** p-value<0.05, * p-value<0.1.

Next to having a positive impact on productivity, investing in green innovation also fosters other firm performance metrics. For example, investment in green innovation and transformation consistently results in a higher use of advanced management practices and more investment in employee training, both in the EU and the US (Figure 11-19a), as well across the different European cohesion regions (Figure 11-19b).

Figure 11-19 Green innovation and firm performance indicators (% of firms)



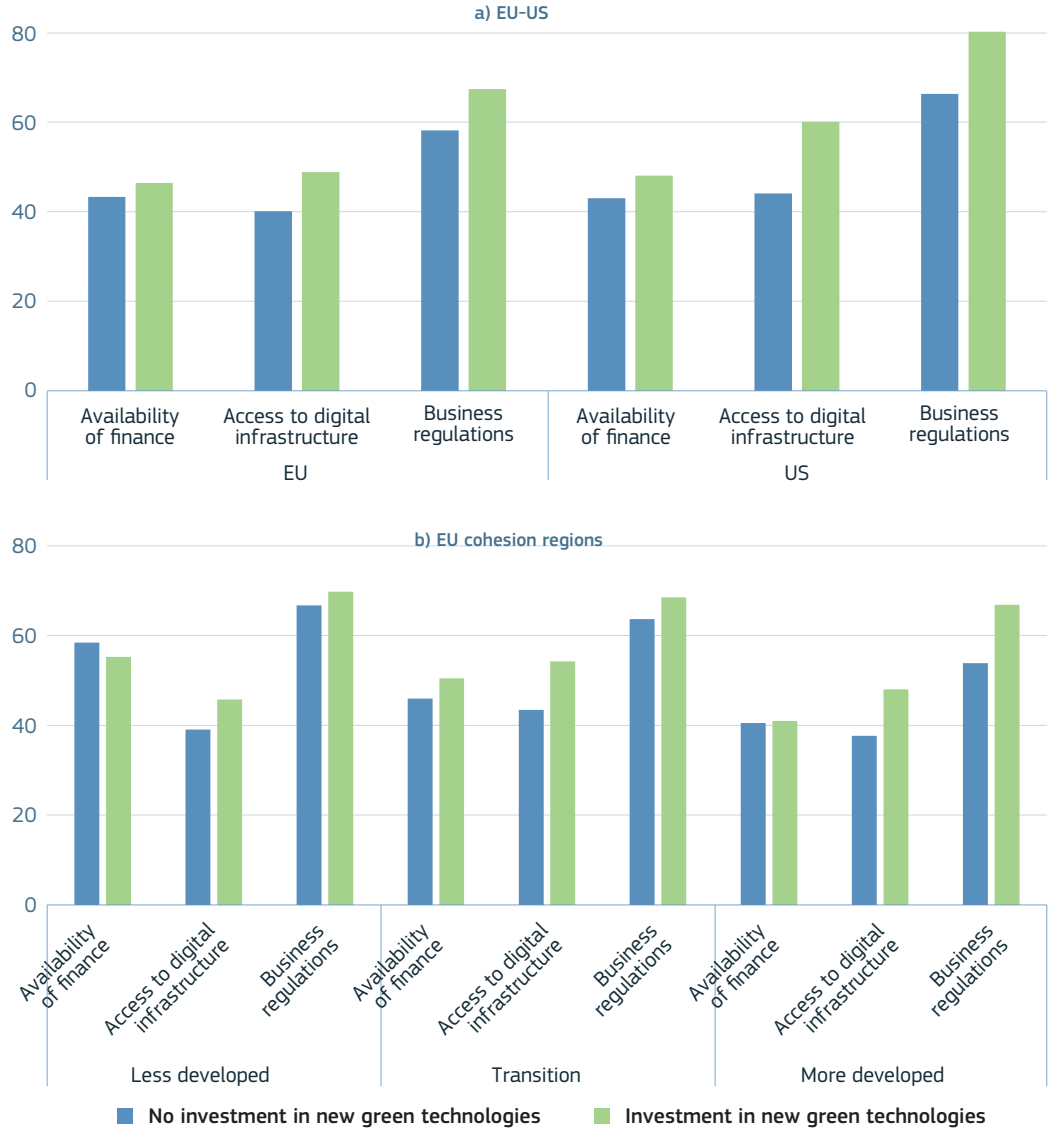
Science, research and innovation performance of the EU 2024

Source: EIBIS 2023.

Note: Firms are weighted by value added.

Firms investing in new, less polluting business areas and technologies object slightly more to almost all obstacles related to their investments than other firms. The main difference is seen within business regulations and digital infrastructure, with firms investing in green innovation and transformation complaining almost ten percentage points more than other firms (Figure 11-20). This points to a need for policymakers to alleviate regulatory uncertainty for businesses willing to undertake green investments. Indeed, if emerging digital technologies are properly employed and barriers to their adoption are reduced, they could play a major role in tackling environmental challenges (Intergovernmental Panel on Climate Change (IPCC), 2022).

Figure 11-20 Obstacles to investment and investment in new green technologies (% of firms)



Science, research and innovation performance of the EU 2024

Source: EIBIS 2023.

Note: Firms are weighted by value added.

6. Conclusion

The EU policy agenda is increasingly emphasising the need to enhance and preserve the global competitiveness of European firms; for this, investing in innovation and addressing the challenges of climate change are crucial. As such, the agenda aims to foster a more competitive and smarter Europe by creating an inclusive environment that incentivises firms across the EU to accelerate the twin green and digital transition.

Europe is challenged in the global innovation landscape, and a successful twin transition of the EU economy will require a widespread uptake of new green and digital technologies, as they are key drivers of competitiveness and 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 AI, which is positively associated with firm performance and job creation and can be a catalyser for green innovation and transformation. Policy support for the adoption and diffusion of technologies is important for the innovation landscape to flourish and is complimentary to EU investment in frontier innovation and the global innovation leadership race.

The structural transformation of the EU seems to be mainly driven by companies in its more developed regions. Nevertheless, poorer regions do show signs of catching up in certain innovation areas, such as in the adoption of AI. Investment in key digital and green areas prove to be crucial for firm performance across all EU regions. Additionally, in the age of the twin green and digital transition, the flexibility of Europe's economy to adjust and transform will not only rely on the intensity of investments in these areas, but also on the efficiency of the operating environment.

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