INVESTMENT REPORT
2022/2023

Resilience and renewal in Europe

European Investment Bank

Chapter 2
Investment in Europe

EUROPEAN INVESTMENT BANK INVESTMENT REPORT
2022/2023

Resilience and renewal in Europe

Part I Investment environment in a time of crises

Chapter 2
Investment in Europe

European Investment Bank

Investment Report 2022/2023: Resilience and renewal in Europe.

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 how Europe is progressing towards a digital and green future amid an energy crisis. 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 the Economics Department, Debora Revoltella, heads a team of 40 economists.

Main contributors to this year's report
Report director: Debora Revoltella
Report coordinators and reviewers: Laurent Maurin and Atanas Kolev

Introduction: Atanas Kolev.
Chapter 1: Andrea Brasili, Jochen Schanz (lead authors), Alfredo Baldini, Peter Harasztosi and Bertrand Magné.
Chapter 2: Atanas Kolev (lead author), Koray Alper, Peter Bauer (European Commission, Box F), Andrea Brasili, Julie Delanote, Peter Harasztosi, Fotios Kalantzis, Bertrand Magné, Wouter Torfs (European Investment Fund), Annamaria Tueske, Wouter van der Wielen, Christoph Weiss, Marcin Wolski and Sabina Zajc.
Chapter 3: Laurent Maurin (lead author), Antonia Botsari, Helmut Krämer-Eis, Frank Lang, Rozalia Pal, Ricardo Santo, Wouter Torfs, Alex Coad, Peter Bauer, Clemens Domnick and Peter Harasztosi (Box A), Frank Betz and Luca Gattini (Box B) and Wouter van der Wielen (Box C).
Chapter 4: Désirée Rückert, Jochen Schanz, Patricia Wruuck (lead authors), Andrea Brasili (Box B), Matteo Gatti (Box C), Annamaria Tueske (Box B) and Wouter van der Wielen (Box C).
Chapter 5: Peter Harasztosi, Désirée Rückert, Christoph Weiss (lead authors), Nihan Akhan, Bianca Brunori, Julie Delanote, Clémence Faivre, Valentina Di Girolamo (European Commission, Box A), Alessio Mitra (European Commission, Box A), Giacomo Casali (Box C) and Andrea Coali (Bocconi University, Box C).
Chapter 6: Fotios Kalantzis (lead author), Frank Betz, Francesco Cimini, Emmanouil Davradakis, Bertrand Magné, Giorgio Musto, Désirée Rückert and Christoph Weiss.

Scientific advisory committee: Jos Delbeke (European University Institute), Robert Koopman (American University), Catherine L Mann (Bank of England), Steven Ongena (University of Zurich), Evi Pappa (Universidad Carlos III de Madrid), Dirk Pilat (The Productivity Institute and Valencia Institute of Economic Research), Peter Praet (Université Libre de Bruxelles), Istvan Szekely (European Commission), Jan Svejnar (Columbia University) and Reinhilde Veugelers (KU Leuven).

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Chapter 2

Investment in Europe

Since 2020, Europe has seen its economy's capacity to invest, transform and adapt hampered by a string of negative developments. Trends like digitalisation, the green transition, ageing and growing inequality constitute major challenges for the European economy. To address them, Europe will have to become more innovative, flexible and resilient — a feat that will require continuous effort. Furthermore, for the past ten years, Europe's national economies have shown a gap in productive investment of 1.5 to 2 percentage points of gross domestic product (GDP) relative to the United States. The pandemic, the energy crisis and now the deteriorating outlook have endangered Europe's ability to address investment needs in the public and private sectors. Focusing on policies that encourage productive investment is therefore crucial.

In many countries, the Recovery and Resilience Facility (RRF), Europe's EUR 723.8 billion investment plan, will play a key in role in sustaining transformative public investment even as concerns about fiscal health mount. Government investment is usually the first victim of budget cuts when countries face concerns about the sustainability of their debt. During the pandemic, however, Europe's decision to suspend fiscal rules and put in place the Recovery and Resilience Facility gave a major boost to government investment. Substantial funds remain available — some 1% of EU GDP per year until 2026. To benefit, governments will have to accelerate promised reforms, remove barriers to investment and move forward on planned projects.

Private investment is faced with high levels of uncertainty, tightening financial conditions and decelerating economic growth. The pandemic spurred corporate investment in digitalisation. The energy shock, in turn, might provide incentives for firms to invest in energy efficiency and renewable energy sources, giving impetus to the green transition. In the first half of 2022 aggregate investment held up well, underpinned by robust investment in buildings and structures. However, high uncertainty and a deteriorating economic outlook could depress investment. Against this backdrop, policy measures to incentivise investment are important, including measures to reduce barriers and financial instruments that help share risks.

Introduction

Fifteen years after the global financial crisis, European investment is again being battered by a series of major adverse developments. Coming hot on the heels of the pandemic, the energy crisis signals an important structural shift for the European economy. Given its intensity, the energy crisis has the potential to weaken investment substantially, just as the global financial crisis did. But crises often bring opportunities, and the current challenge could incentivise major changes and breakthrough investments.

Good policy has a role to play in encouraging investment. The right policies will not only prevent an investment downturn, they could actually turn this crisis into an opportunity, speeding up the green and digital transition.

To achieve the transition, major investment is required to enhance resilience, reduce fossil fuel dependence and accelerate digitalisation. But Europe needs more than investment in tangible fixed assets. It also needs innovation and new skills. However, elevated uncertainty and slowing economies put this investment in peril.

This chapter outlines recent investment developments and examines what is needed to transform the EU economy. The first section gives an overview of investment dynamics and investment in different asset types. It shows that high levels of uncertainty are dragging down investment. The section contains a box on the gap in productive investment between the European Union and the United States and another on how funds from the Recovery and Resilience Facility are being deployed. Section two outlines recent trends in government investment. It contains two boxes discussing the importance of government investment in times of crisis. The third section looks at corporate investment through the lens of the EIB Investment Survey (EIBIS). It discusses the investment outlook, along with the short- and longer-term effects of the COVID-19 crisis on corporate investment. Section four focuses on recent trends in investment in intangible assets and innovation, and it contains a box on the effects of the pandemic on investment in intangible capital. The fifth section outlines recent developments in investment in climate change mitigation and adaptation. It includes a box on barriers to climate-action investment.

Following a strong rebound from the pandemic, investment still faces challenges

Investment in buildings and structures underpinned overall EU investment

Investment recovered relatively quickly from the pandemic shock. Real gross fixed capital formation (GFCF) in the European Union exceeded pre-pandemic levels at the end of 2021 and kept increasing in the first half of 2022.[1] By the end of the third quarter of 2022, the aggregate investment rate, defined as the ratio of investment to GDP, was about a percentage point above its historical average and slightly exceeded its pre-pandemic level. In the third quarter, the investment rate in the European Union was actually slightly above that in the United States, a situation that had not been seen since 2013 (Figure 1a). Investment rates among countries are also converging within the European Union. Very high investment in Southern Europe since early 2021 has pushed the investment rate back up to its long-term average, and the region is rapidly closing the gap with the rest of the European Union (Figure 1b).

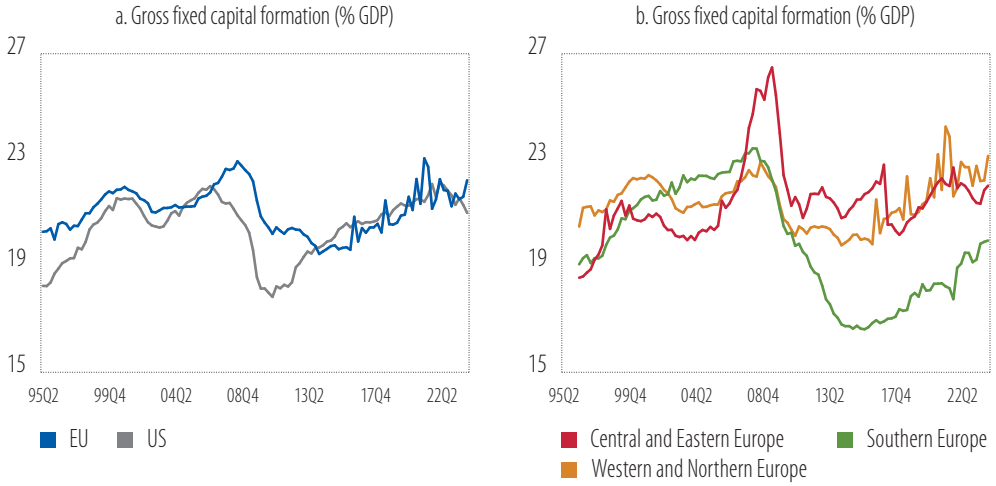
While Europe has kept up with the United States in the rate of investment, a closer look reveals big differences in productive investment across the Atlantic. Total investment in an economy consists of spending on assets that are not engaged in the production of economic output, like residential buildings,

1 Gross fixed capital formation and investment are used interchangeably in this chapter.

and those directly used for production, like equipment, intangible business capital, infrastructure or commercial real estate. While residential buildings are indispensable, it is investment in productive assets that enhances an economy's potential for medium- and long-term growth. Removing investment in residential buildings from the aggregate investment rate reveals a gap of two percentage points of GDP between the United States and the European Union (Figure 2a). This gap appeared after the end of the global financial crisis and has persisted since then. After removing other buildings and structures used in production, what remains are essentially machinery, equipment and intellectual property products. Looking at these kinds of investments, the gap widens to a staggering 3.8 percentage points of GDP (Figure 2b). This gap threatens to weigh on Europe's productivity and further increase the distance with the United States.[2]

Figure 1

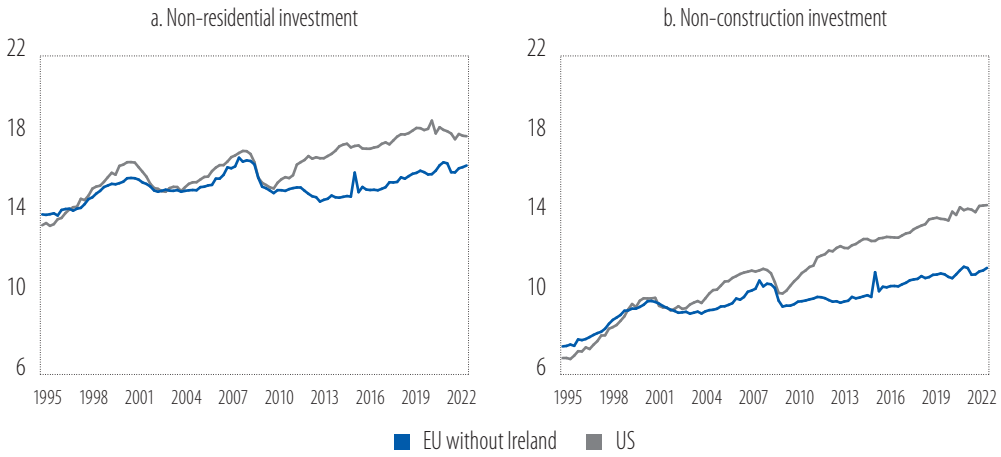
Investment rates are near a 27-year high in the European Union and the United States



Source: *Eurostat and Organisation for Economic Co-operation and Development (OECD) national accounts statistics.*

Figure 2

Rates of productive investment in the European Union have diverged from those in the United States since the global financial crisis



Source: *Eurostat and OECD national accounts statistics.*
Note: *Non-construction investment includes investment in machinery, equipment and weapon systems, intellectual property products and cultivated biological assets.*

2 The ways productivity growth benefits from investment in equipment and intangible capital, which is embodied in many intellectual property products, have been widely documented in academic literature (Brynjolfsson et al., 2002, Corrado et al. 2009, Corrado et al., 2016, Gordon and Sayed, 2020, van Ark et al., 2009).

Box A

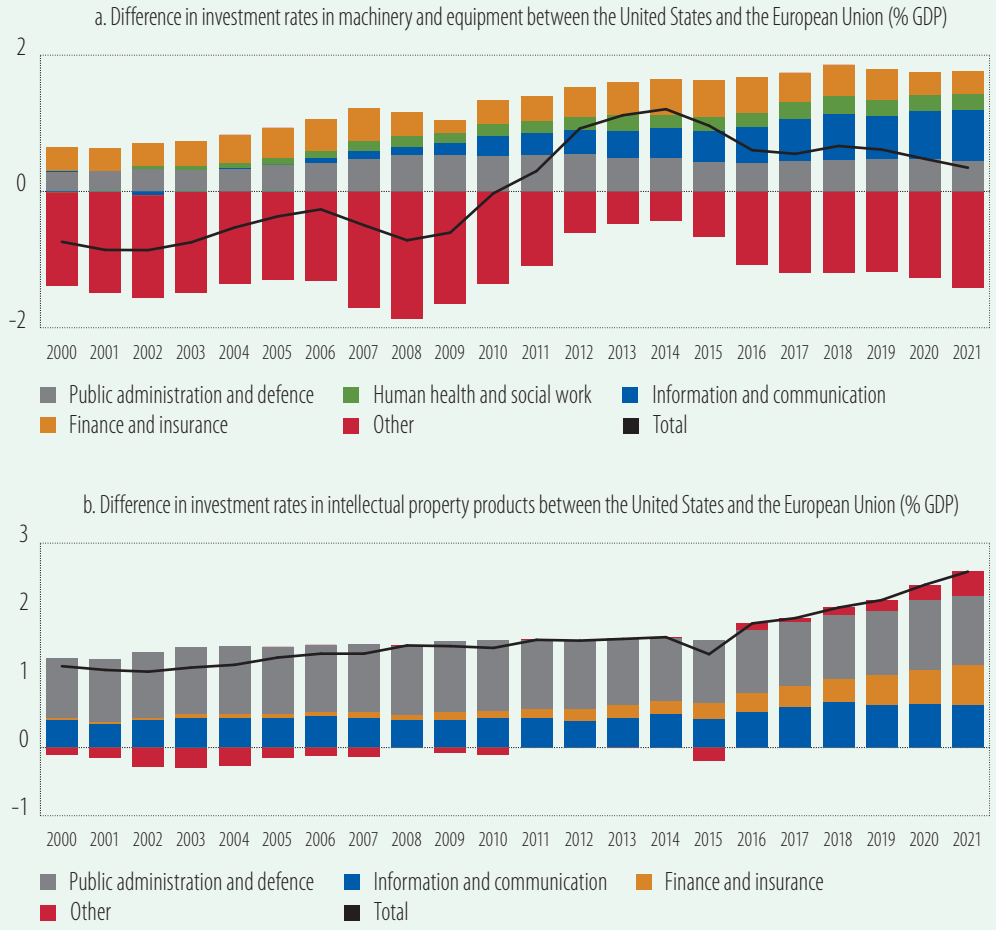
The EU-US gap in productive investment

The gap in productive, or non-residential, investment rates between the European Union and the United States widened at the end of the recession following the global financial crisis. It has gradually increased and has remained above 1.5 percentage points of GDP, underpinned by higher investment in equipment and in intellectual property products in the United States than in the European Union.

The higher investment in machinery and equipment in the United States is accounted for by rising investment in the information and communication sector and the health and social work sector. As discussed in EIB (2020), the investment surge in these sectors is due to higher investment in information and communication technology equipment. The relative increase of this investment in the United States has been very persistent, and had a cyclical component, as EU firms' investment stalled in the aftermath of the global financial crisis and the subsequent sovereign debt crisis (Figure A.1a).

Figure A.1

A sectoral breakdown of the gap in productive investment between the United States and the European Union

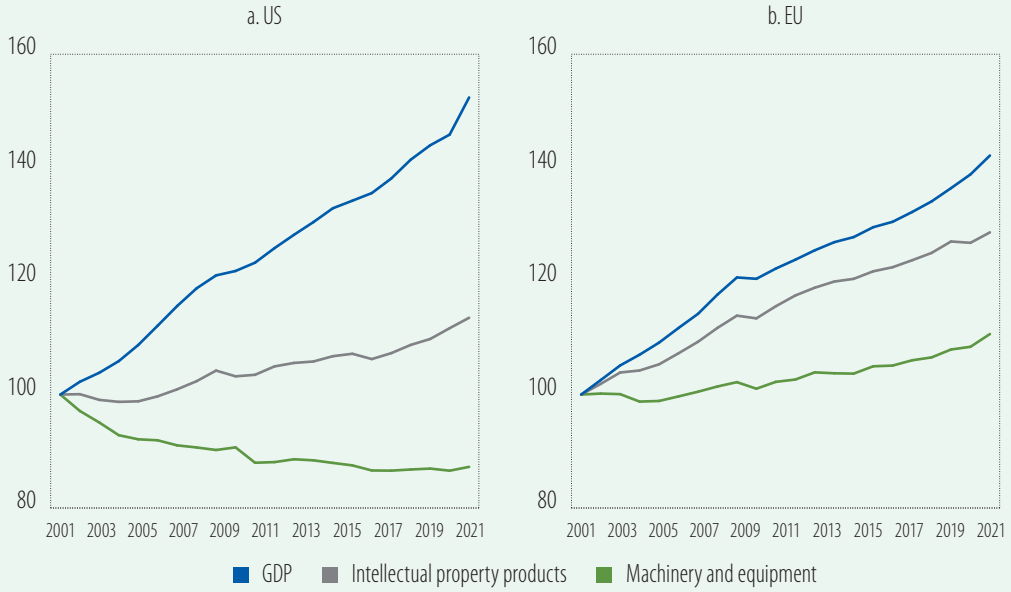


Source: *OECD national accounts.*
Notes: *US GDP and GFCF are measured in US dollars in 2015 chain-linked volumes. EU GDP and GFCF are measured in euros in 2015 chain-linked volumes. The EU aggregate does not include Ireland.*

The gap in investment in intellectual property products has existed at least since 2000. It is sizable and is mainly due to higher investment in public administration and defence and in information and communication. Since the early 2000s, it has gradually widened due to higher investment in the United States in finance and insurance, and in other sectors (Figure A.1b).

In calculating the investment gap, it is important to take the ratio of real gross fixed capital formation and real GDP. While taking the ratio of the nominal variables is temptingly simple, the result would not be informative because the prices of goods normally purchased for investment have evolved very differently from overall prices, making an intertemporal comparison impossible. A country comparison of nominal ratios would be of no great use either, as investment and overall prices evolve differently across countries (Figure A.2).

Figure A.2
Price deflators for GDP, machinery and equipment and intellectual property products (an index, 2000=100)



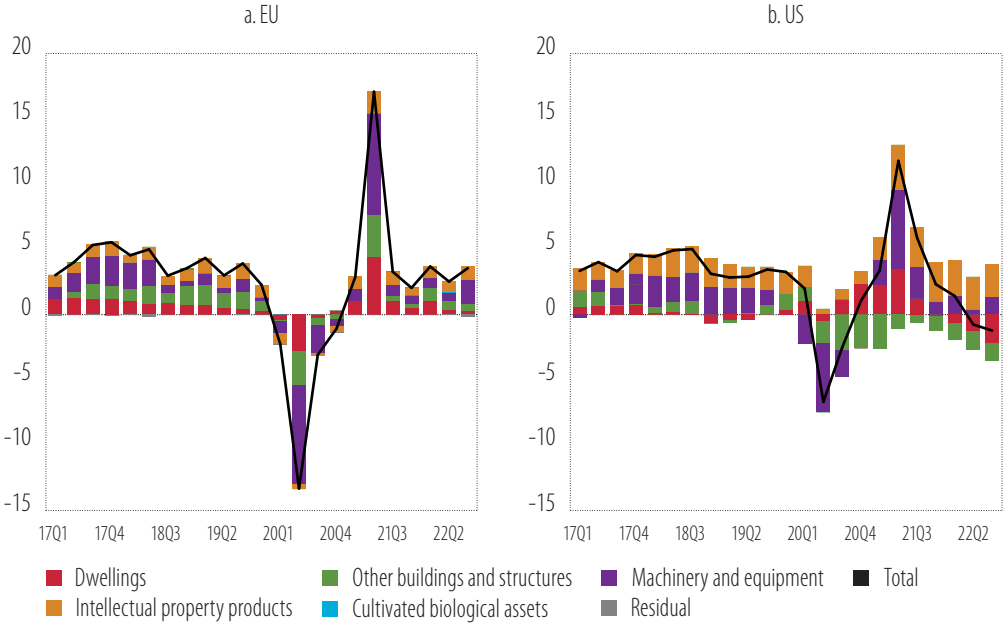
Source: *OECD national accounts.*

Using real quantities is crucial, but it is also important to bear in mind that price deflators, which take into account inflation, are imperfect. The further away an observation is from the base year, the less precise the estimate of the gap will be. For this reason, the value of the gap in any given year is only indicative, and it should not be viewed as an exact estimate. That said, the errors are small. Also, the gap has been cumulating over a long period of time, 12 years, and has turned into a serious challenge for Europe, which needs to tackle underlying impediments to investment.

Investment in machinery and equipment in the European Union exceeded its pre-pandemic level in the third quarter of 2022 (Figure 3). The rise helped total aggregate investment bounce back to its pre-pandemic level, accounting for just over a quarter of the increase. For its part, investment in dwellings and other buildings and structures contributed some 35% to the overall recovery in investment. Spending on intellectual property added 42% to the overall increase in investment from the fourth quarter of 2019 to the third quarter of 2022.

In the United States, the composition of the investment rebound was very different. Spending on intellectual property accounted for 100% of the investment recovery from the fourth quarter of 2019 to the third quarter of 2022, while investment in machinery and equipment made up about three-quarters of the total investment recovery. However, investment in other buildings and structures, which has been declining since early 2020, declined sharply and wiped out about half of the positive contributions made by the other two asset classes. Investment in buildings and structures has dropped to the level in 1994.

Figure 3
Gross fixed capital formation in the United States and the European Union (% change from the previous year)**, by asset type**



Source: Eurostat and OECD national accounts statistics.

The recovery in the European Union was driven by strong investment in Southern Europe (Figure 4). In the European Union, real investment in the third quarter of 2022 was nearly 4% higher than in the fourth quarter of 2019. Countries in Southern Europe contributed the most to this increase (2.2 percentage points, or 55%). Countries in Western and Northern Europe contributed another 1.3 percentage points, while countries in Central and Eastern Europe added only 0.5 percentage points. Southern Europe's growth spurt of 9.9% from the fourth quarter of 2019 to the third quarter of 2022 came mostly from Italy and Spain, and, to a lesser extent, from Greece.[3] Investment in machinery and equipment accounted for much of this growth (4.3 percentage points, or 43%). Investment in other buildings and structures added 2.5 percentage points, and dwellings an additional 2 percentage points. Investment in intellectual property products, most of which originated in Spain, contributed 1.1 percentage points.

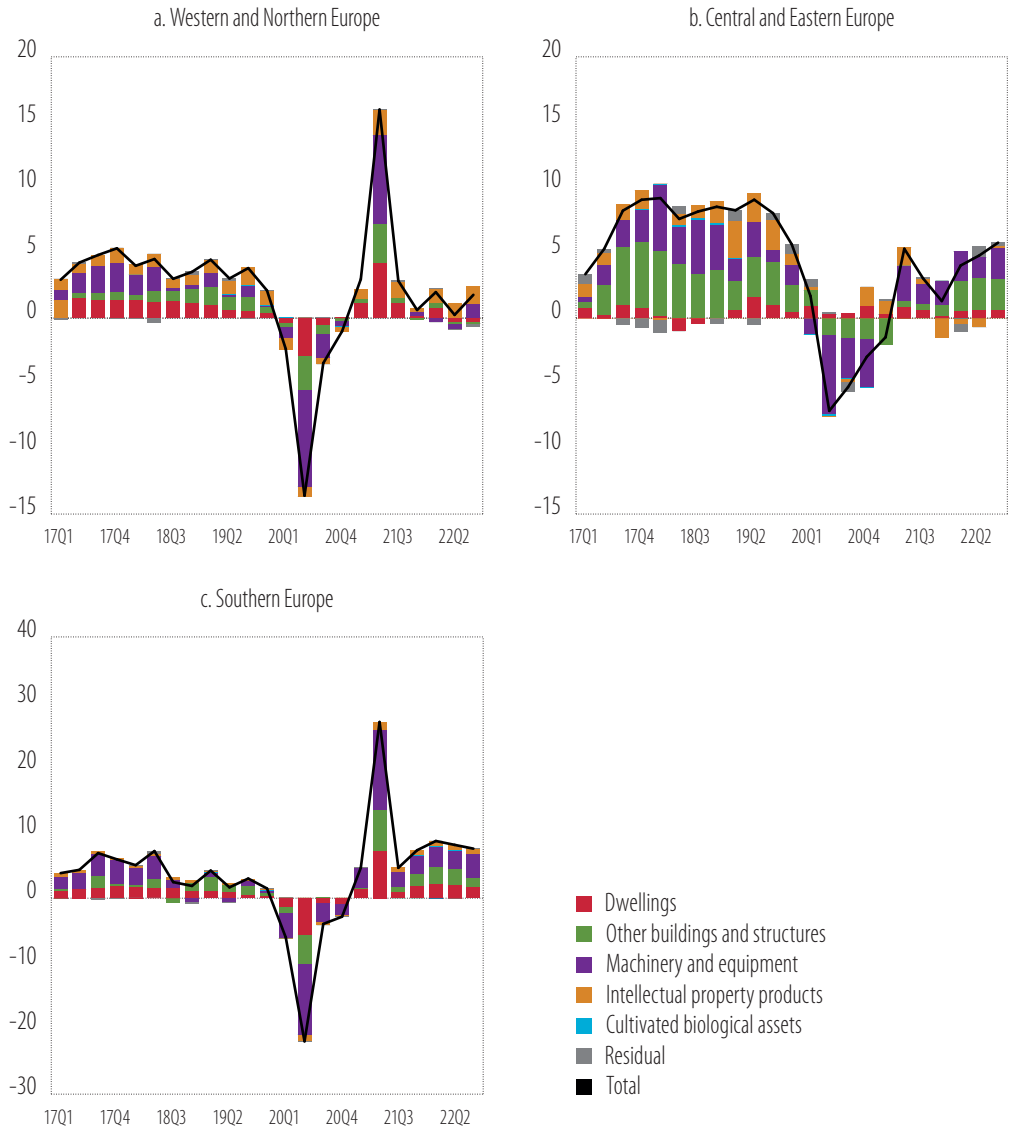
High energy prices have increased input costs — substantially so in some countries and industries — causing the investment outlook to deteriorate.[4] Large shocks to input costs (such as the ongoing rise in energy prices) put considerable pressure on companies' profit margins. Firms that cannot pass a significant part of the increase on to their customers are seeing their cash flows reduced, in some cases substantially, which affects their ability to service debt, finance investment and retain net worth. Companies

3 Incentives to invest in energy efficiency in Italy substantially boosted investment in buildings and structures, and in equipment. In Spain, the rise came from equipment investment from the private and the public sectors. The private sector faced relatively favourable financing conditions, while the government increased spending on digitalisation investment to cope with the challenges posed by reduced mobility and limits on personal contact during the pandemic.

4 See Chapter 6 of the Investment Report for more details on price increases across countries and industries, and the repercussions of those higher energy prices for European economies.

that so far have been able to increase prices may still be affected in the near future if the economy slows down, as recent forecasts suggest. Chapters 3 and 6 of this report provide further detail on the effects of these price increases on firms' balance sheets and the likely consequences for their investment decisions.

Figure 4
Contribution to total investment (% change from the previous year)**, by asset type**



Source: *Eurostat national accounts statistics.*

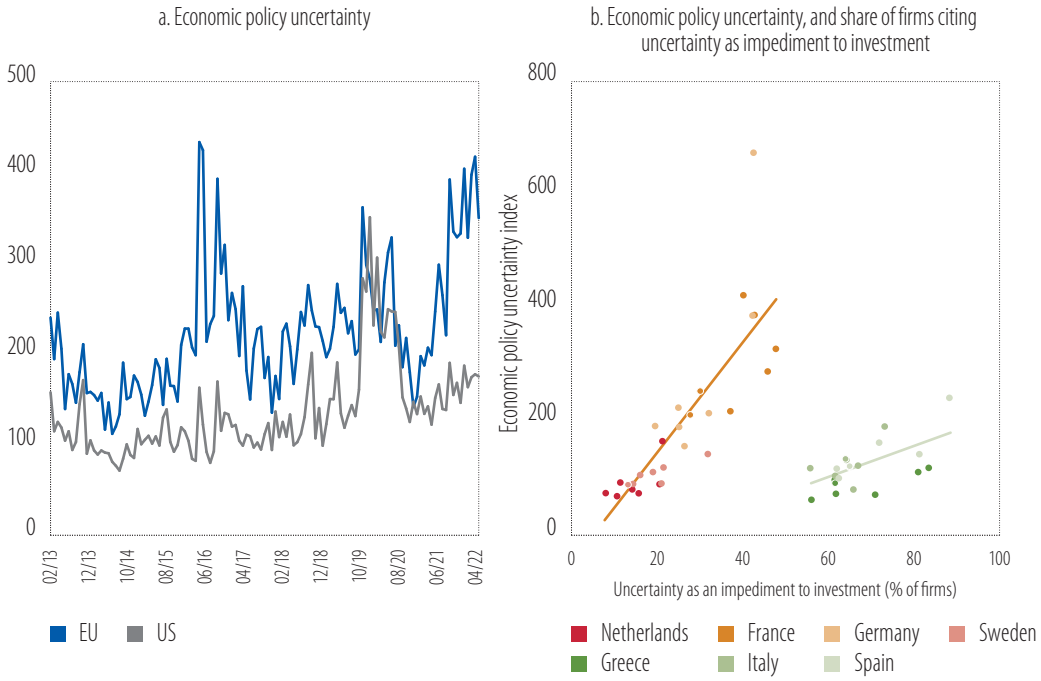
High energy prices, deteriorating economic prospects and elevated uncertainty are testing investment's resilience

High inflation is eroding real incomes, which in turn is putting pressure on aggregate demand. Increasing energy prices fed directly into higher inflation in the second half of 2021. Second-round effects pushed inflation even higher. More than a year of accelerating inflation has started to affect real incomes (see Chapter 1). As household savings are depleted and their real value reduced by inflation, demand will falter.

These pressures, combined with expectations of a worsening economy, will likely prompt firms to revise investment plans downwards.

Uncertainty increased substantially in 2022 (Figure 5). The persistence of the energy price shock, the threat of energy rationing and a likely economic slowdown all aggravated uncertainty. The EIBIS also shows a major increase in firms' uncertainty, following a decline in 2021. These fears are closely linked to energy costs, with firms in more energy-intensive industries likelier to cite uncertainty as an obstacle to investment.

Figure 5
Uncertainty among businesses and consumers is on the rise



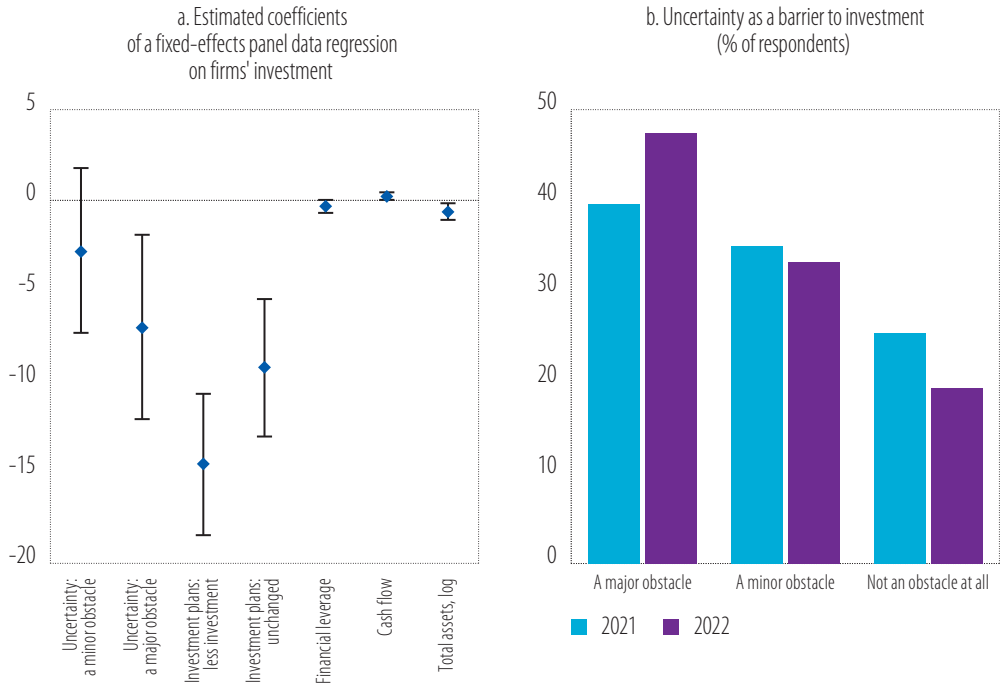
Source: EIBIS 2016-2022, the Economic Policy Uncertainty Index and EIB staff estimates.

The irreversible nature of investments means that uncertainty can weigh heavily on companies' plans. As uncertainty about the future grows, companies look for higher expected returns on investments to compensate for increasing risks. Thus, rising uncertainty could render a project undesirable even if its expected return remains the same. The effect of uncertainty on investments can be substantial, particularly in the short run, if a project is not now-or-never (that is, if firms are able to delay it). By postponing an investment with an uncertain outcome, firms can avoid the risk of making costly mistakes, and instead delay the investment until the economic environment stabilises.

Elevated uncertainty will have a negative effect on investment. Numerous academic studies find that uncertainty substantially affects aggregate investment (Baker, Bloom and Davis, 2016; Bloom, 2014; Bunn et al, 2021). Research by the EIB's Kolev and Randall (2023) uses a merged EIBIS-Orbis dataset, which adds firms' financial information from Bureau van Dijk's Orbis database to firms' answers in EIBIS, to gauge uncertainty's effect on corporate investment in 2022. The authors estimate standard investment models with financial factors (see for example Kalemli-Ozcan, Laeven and Moreno, 2022), adding a variable from the EIBIS to measure uncertainty.

In addition to perceptions of uncertainty, the investment rate — the ratio of net investment to fixed assets in the previous year — is a function of a firm's stated financial plans at the beginning of the year in which the investment is made, the firm's expectations about demand, business prospects in its sector and its size.[5] The ratios of financial debt and cash flow to total assets are also included in the set of explanatory variables. As investment plans and demand are stated in the beginning of the year, we saturate our model with country-sector and country-year dummies to account for developments later in the year.

Figure 6
The negative effects of elevated uncertainty on investment are likely to be substantial



Source: *Kolev and Randall (2023).*
Notes: *Panel-data regression using the EIBIS-Orbis dataset of net investment rate (fixed assets) on uncertainty perceptions (see question below Figure 6b), stated investment plans (more investment relative to previous year, keep about the same or less investment), firm-level controls, country-sector and country-year fixed effects. The figure above plots coefficient estimates and 95% confidence intervals based on standard errors, clustered at the firm level.*

Source: *EIBIS 2021-2022.*
Notes: *Firms are weighted by value added.*
Question: *Thinking about your investment activities, to what extent is uncertainty an obstacle? Is it a major obstacle, a minor obstacle or not an obstacle at all?*

Uncertainty has a significant negative effect on investment (Figure 6a). Holding other factors constant, a firm that perceives uncertainty as a major obstacle to investment will have an investment rate 7.5 percentage points lower than a firm that does not. Using the estimated equation, we calculate the difference between the predicted investment rate for 2022 and a counterfactual prediction, where uncertainty perceptions of each firm are held at their 2021 levels (Figure 6b). We find that, other factors held constant, higher uncertainty in 2022 may have reduced the investment rate by about 1.2 percentage points of GDP, or half of the gap in productive investment between the European Union and the United States (Figure 2a).

5 Our sample is an unbalanced panel dataset covering 2016 to 2022.

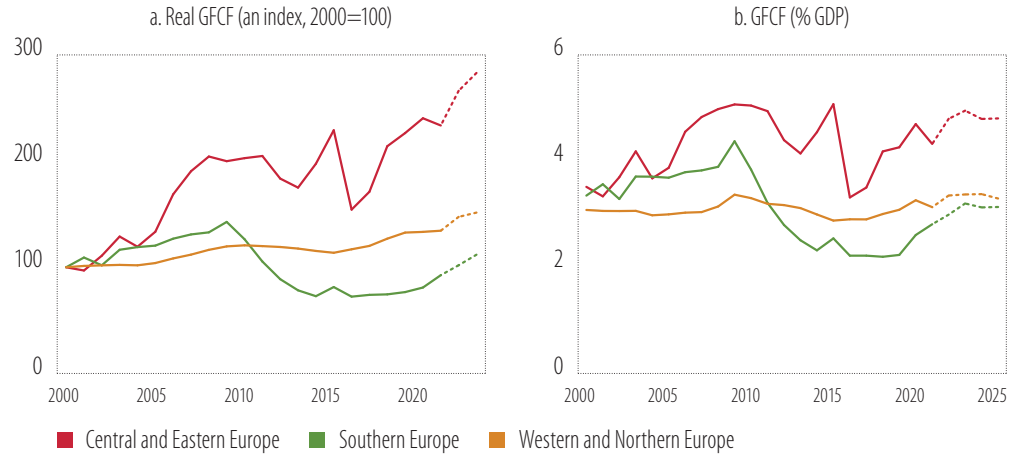
The pandemic response boosted government investment

Growth was robust throughout the COVID-19 crisis

Real government investment increased in the European Union in 2021. In the first half of 2022, government investment continued to grow in nominal terms, but it stagnated in real terms because of high inflation. Compared to 2020 levels, real government investment rose about 3% in the European Union in 2021. The overall increase was largely driven by a strong, 14% increase in investment in Southern Europe (Figure 7a). In Central and Eastern Europe, however, real government investment declined by about 3% during 2021, a drop that was widespread across the region, except for Estonia and Slovenia.[6] Sustained growth in government investment in the European Union bolstered the economy in the short term, and this impact is likely to last in the medium and long term, as discussed in Box D.

Government investment rates — the ratio of government investment to GDP — stabilised across the European Union in 2021 (Figure 7b). As economies were recovering from a decline in output during the pandemic, the increases in real investment were not proportionate to increases in GDP. Investment growth in Southern Europe outpaced GDP growth, allowing the investment rate there to continue the upward trajectory that began after the pandemic. In Central and Eastern Europe and Western and Northern Europe, however, investment rates dropped sharply from their 2020 levels.

Figure 7
General government gross fixed capital formation



Source: *Eurostat national accounts, national stability programmes, EIB staff estimates.*
Notes: *Values for 2022 onwards, indicated by dashed lines, are based on countries' stability and convergence plans.*

In the medium term, growth in general government investment will continue, with a strong boost from the Recovery and Resilience Facility (Box B). Accounting for the investments outlined in national stability and convergence plans, real government investment in the European Union is expected to increase by almost 20% by 2023 compared to 2020. These strong predictions belie past experiences of public belt tightening, when governments found it more politically feasible to prioritise current spending and transfers at the expense of investment. This time around, however, ample resources available from the Recovery and Resilience Facility provide an opportunity to sustain planned investment.[7] Countries must, however, prove that they can implement their national investment plans while meeting the facility's conditions.

6 This decline cannot be considered a setback for the region, as it follows an enormous increase in 2020 that raised overall investment. Compared to 2019, before the pandemic, real government investment in Central and Eastern Europe had risen 9% by 2021. Furthermore, the investment rate as a share of GDP remains above the historical 20-year average.

7 Available funds from the Recovery and Resilience Facility are equal to about 1% of EU GDP per year until 2026, which represents one-third of average annual government investment in the European Union.

Box B

The Recovery and Resilience Facility continues to stabilise and protect public investment

The Recovery and Resilience Facility's resources are being disbursed to Member States until 2026 to support investment and structural reforms. One-fifth (EUR 136.6 billion) of the total envelope (EUR 724 billion) has already been disbursed (Table B.1) to nine different countries.

About one-third of the total package consists of pre-financing made available to Member States upon approval of their investment plans. The remainder is conditional on countries hitting reform targets (such as streamlined administrative approval processes) and on investment milestones (such as having started the procurement processes for a project). Over the next four years, EUR 590 billion (amounting to around 4% of EU GDP in 2021) will be disbursed at an average rate of around 1% of GDP per year across all countries (but substantially more for some). In other words, with public investment accounting for 3.2% of GDP, the facility will provide resources for one-third of total public investment. Not all facility expenditures will go to investment, but the comparison illustrates the impact. So far, so good, but going forward governments' ability to execute their investment programmes and disburse the resources available will be tested.

Table B.1

Recovery and Resilience Facility disbursements as of October 2022

				% GDP (in 2021)	
	Grants	Loans	Total	Grants	Total
Recovery and Resilience Facility total (EUR billion)	338	385.8	723.8	2.3	5.0
Disbursed (EUR billion)	91.39	45.16	136.55	0.6%	0.9%
(as a share of total)	27%	12%	19%		
Pre-financing (EUR billion)	36.6	19.9	56.5		
Disbursement (EUR billion) (after assessments)	54.7	25.4	80.1		

Source: EIB staff estimates using the European Commission's scoreboard data for the Recovery and Resilience Facility.

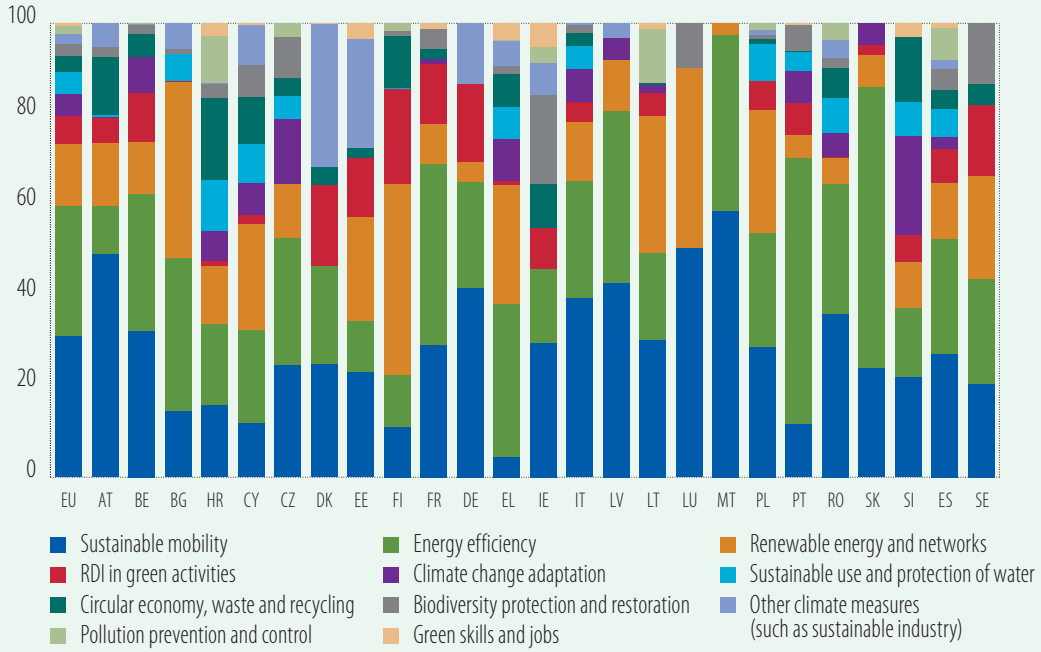
The ongoing implementation of the facility shows that the European Union is committed to preserving public investment in key areas, even in times of challenging fiscal developments. The facility provides important support for the recovery by mitigating the economic and social impact of the pandemic. It also makes societies more sustainable and resilient by pursuing long-term policy objectives like the green and digital transition. Member States have EUR 338 billion in grants and EUR 386 billion in loans at their disposal to help implement ambitious reforms and investments. The aim is to spend at least 37% of the funds on the green transition, 20% on digital transformation and the rest on the other four pillars[8] by 2026, at which point the European Commission will assess the progress made towards milestones and targets.

When looking at the sub-components of the green transition, the largest investments are for renewable energy, energy efficiency and sustainable mobility (Figure B.1). Since measures in these categories are crucial to meeting the European Union's target to reduce carbon emissions 55% by 2030, compared to 1990 levels, it is very important to keep investments rolling. The significant energy investment planned should help bring in the private sector. A wide swathe of investments are planned in energy networks and infrastructure, such as energy storage, district heating networks, electricity interconnectors and smart grids. Investments are also planned across the hydrogen value chain, from production to transport, storage and end-use in hard-to-electrify industrial sectors and transport modes.

8 The other four pillars are smart, sustainable and inclusive growth; social and territorial cohesion; health and economic, social and institutional resilience; policies for the next generation.

Figure B.1

Recovery and Resilience Facility expenditure supporting the green transition (% of total)**, by policy area**



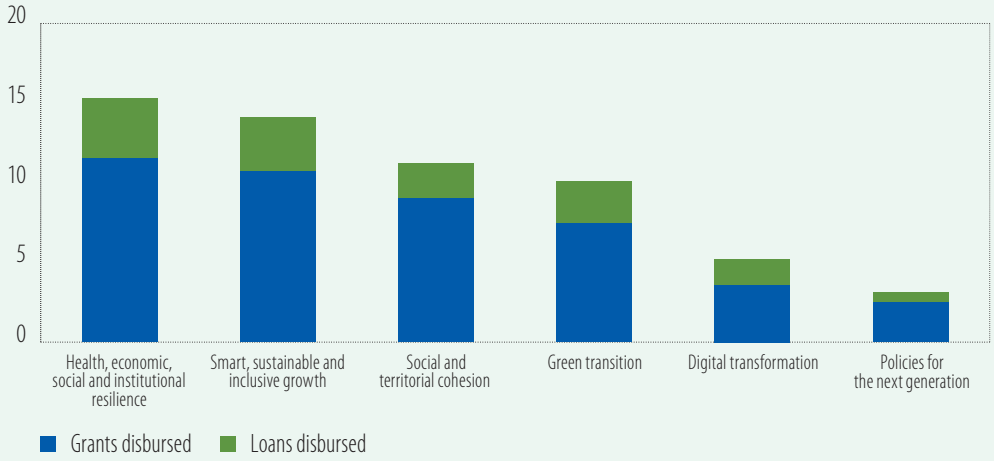
Source: European Commission and EIB staff estimates.

Countries in Western and Northern Europe and Southern Europe will benefit from a higher share of Recovery and Resilience Facility allocations relative to funding they already receive under the European Union's cohesion policies, while the opposite is true for Central and Eastern Europe.[9] Since the facility's overall objective is to improve "the resilience, crisis preparedness, adjustment capacity and growth potential of the Member States," funding approvals take into account the economic fallout of the pandemic, pre-crisis unemployment levels and GDP per capita.

Begun in 2021, the facility has been implemented at different speeds in different countries. By October 2022, nine countries had received disbursements linked to the achievement of milestones and targets. Overall, 26% of the facility's grants and 22% of its loans allocated have been disbursed. Spain is the first country to have received a second payment. However, 14% of the facility's grants and 60% of loans have not yet been allocated to Member States.[10] Although the estimated share of the facility spent on climate is around 40% and digital expenditure is around 26%, climate only accounts for 17% of disbursements and digital around 9% so far. The green transition and digital transformation are only the fourth- and fifth-largest categories of expenditure (Figure B.2). Reasons for the relative lag in these investments might be spiralling costs, a shortage of skilled staff and supply chain constraints. Implementation risks are also growing as fiscal budgets become strained by the economic downturn and the need to fund transfers aimed at dampening the impact of high energy prices on households and firms.

9 See CEPS RRF Monitor: RRF Figures (rrfmonitor-ceps.eu).
10 See Recovery and Resilience Scoreboard (europa.eu).

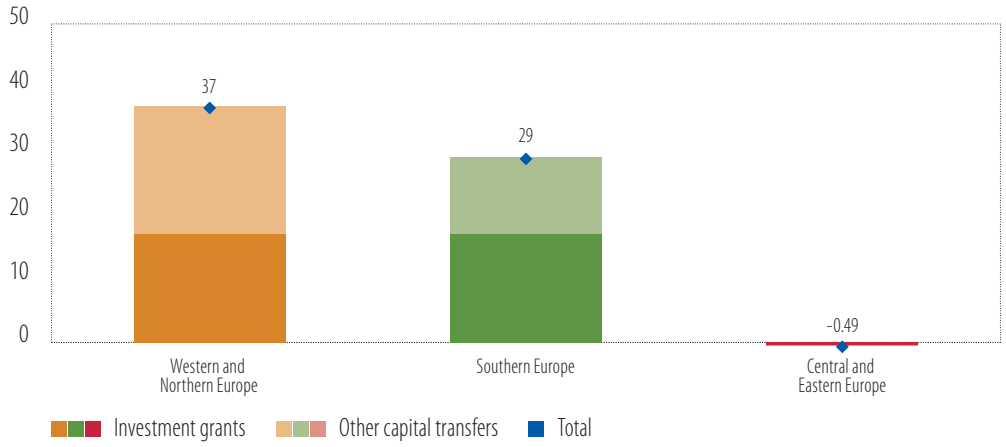
Figure B.2
Disbursed grants and loans funded by the Recovery and Resilience Facility (EUR billion)**, by EU policy objective**



Source: *European Commission.*

Capital transfers by general governments in the European Union increased further in 2021 (Figure 8). Expenditures on capital transfers in 2021 increased less than in 2020, and they did not change in Central and Eastern Europe. The composition of the change from 2020 to 2021 proved to be relatively balanced between investment grants and other capital transfers (Figure 8). For Central and Eastern Europe, there was little to no change in levels relative to 2020, suggesting that the observable drop in capital transfers relative to GDP was primarily driven by the increase in GDP. Capital transfers in the European Union decreased slightly in the first half of 2022 compared with the first half of 2021. That drop was entirely driven by a decline in Southern Europe, and it is attributable to the high base established in 2021. The high level was created by pandemic-related fiscal stimulus that relied substantially on government capital transfers.

Figure 8
General government capital transfers (% change from 2020)



Source: *Eurostat national accounts, national stability and convergence plans, EIB staff estimates.*

Box C

Investment in times of crisis

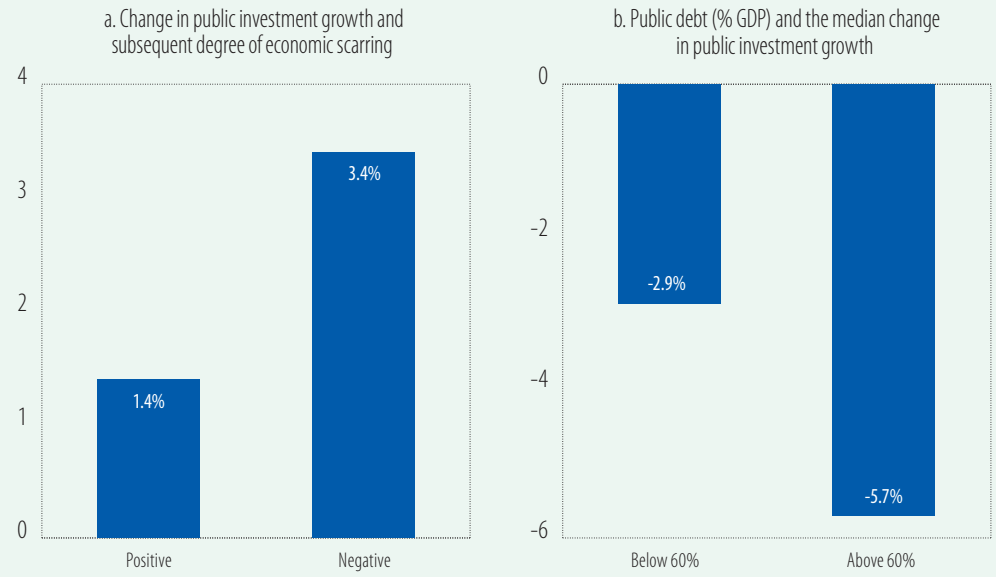
This box shows evidence that investment, particularly by governments, helps moderate the scarring effects of economic crises. There is a broad consensus that fiscal policy multipliers are positive in the short term, and that the size of the multiplier depends on a country's position in the economic cycle and the monetary policy stance. However, the positive effect on output is not particularly persistent, and even turns negative in the medium term. The notable exception are multipliers of government investment, which explains the focus on investment's role in limiting economic scarring during major downturns.

Looking at the anatomy of major economic downturns, economies contract during downturns and rebound in the years that follow. However, the average rebound does not overshoot the economic growth rates recorded prior to the downturn. The result is a downward shift in the level of economic activity. On average, real GDP resumes an upward trend, but that trend remains below the pre-recession level.

Scarring effects are a recurring feature of major economic downturns. Recent analysis using panel data on such downturns in advanced economies over the past five decades confirms the tendency for sizeable and significant scarring (Larch et al., 2022). The average annual shortfall of real GDP three to seven years after a major economic downturn is around 2% less than the level it would have been if the economic shock had not occurred.

Figure C.1

The growth of public investment fluctuates in times of crisis



Source: *Larch et al. (2022).*
Note: *The relationships presented also hold up in regression analysis controlling for automatic stabilisers, systemic banking crises, the presence of subsequent crises, monetary policy and fixed effects, as well as across multiple definitions of the degree of economic scarring represents public investment growth in a given year vs. the average public investment growth in the three preceding years.*

Governments react, on average, quite forcefully to downturns, recording budget deficits of around 3% of GDP. However, most of the discretionary spending is centred on current expenditure, while public investment remains broadly flat or even declines. The lower investment is noteworthy, as the analysis also finds evidence that an actual acceleration of public investment in times of crisis is

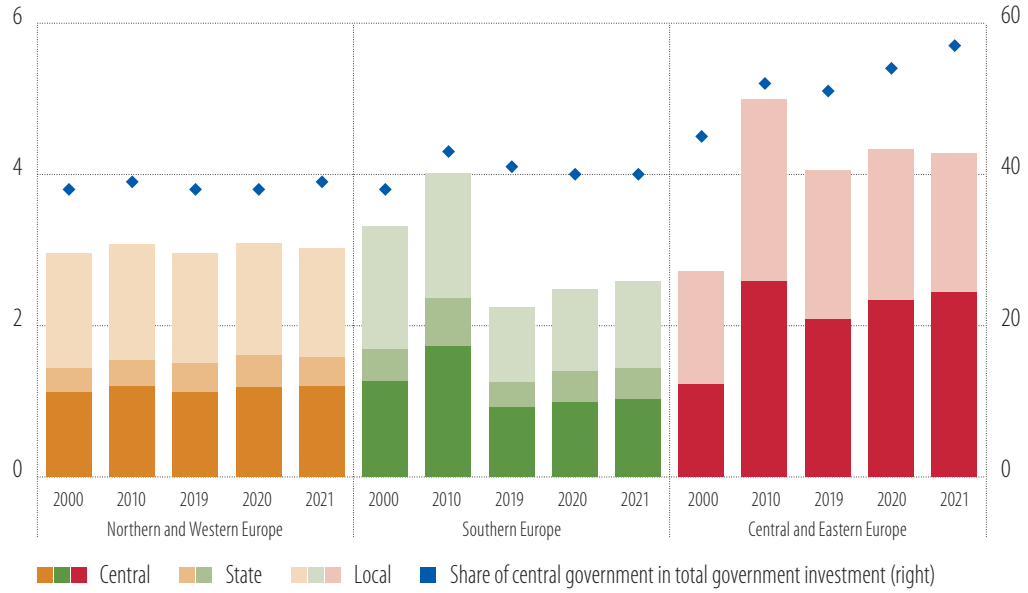
associated with a statistically significant moderating effect on the degree of economic scarring in the subsequent three to seven years (Figure C.1, panel a).

In this context, the Resilience and Recovery Facility takes on particular importance as an instrument to help Member States address medium-term challenges by supporting structural reforms and government investment projects. If implemented effectively with a focus on additional and productive investment, the facility certainly has the potential to limit the heightened risk of scarring after two major economic shocks — the pandemic and the energy crisis — in rapid succession.

In the medium to long term, the succession of economic scarring and higher deficits leads to higher government debt, which in turn tends to limit governments' fiscal wherewithal to react to future recessions. The results of the analysis also show that during a major economic downturn, higher government debt tends to come with lower growth in government expenditure — current spending and investment (Figure C.1, panel b) — and/or lower government deficits. This finding very much confirms the more general consensus in the literature that high government debt limits countries' ability to address crises.

The relative importance of the central, state and local governments in overall public investment has remained relatively stable over the past year. Central governments' share of public investments hovers around 40% for Western and Northern Europe and Southern Europe (Figure 9). In Central and Eastern Europe, the share has been above 50% since the early 2000s and is growing. Nevertheless, gross fixed capital formation of local governments in Central and Eastern Europe, as a share of GDP, has consistently been higher than that of local governments in Western and Northern Europe or in Southern Europe.

Figure 9
Local and state government investment (left axis, % GDP)**, central government investment** (right axis, % share)



Source: Eurostat national accounts, EIB staff estimates. Share of central government refers to the percentage central government investment accounts for in total investment.

Local government investment may have a strong and persistent effect on growth. Government investment, such as building and maintaining adequate infrastructure, is key to creating the conditions private enterprises need to thrive. Local governments are particularly well positioned to serve this role. According to Brueckner,

Pappa and Valentinyi (2022), more decentralised governments are able to deliver more productive public goods, implying a higher fiscal multiplier and a larger crowding-in of private investment. This can be linked to the efficient coordination of different levels of government, but the issue deserves more analysis (Organisation for Economic Co-operation and Development (OECD), 2014). In Box D we argue that local government investment has a more persistent impact on growth than central government investment.

Box D

The effect of local government investment on private investment and growth

Public capital provides key services the private sector needs to prosper. Analyses focusing on the impact of public capital on GDP (such as Bom and Ligthart, 2014) point out that public capital provided by local governments, as opposed to central governments, is more productive. This may reflect local governments' better understanding of local needs. Studies controlling for the business cycle find public capital is more effective in supporting growth.

With a forthcoming working paper, Brasili et al. (2023), the EIB contributes to this literature by taking a slightly different approach. It uses regional data and focuses on the impact of local government investment — a flow instead of a stock variable — on GDP and private investment, compiling an unbalanced panel dataset for 98 NUTS 2 European regions[11] in 13 Member States running from 2000 to 2019. Based on local projection methods, the estimates show evidence of a positive and significant association between investment by local governments and GDP on one hand, and private investment on the other. The multiplier for private investment is clearly positive and significant for the first two years after the shock. The same holds true for the GDP multiplier for the first three years after the shock.

The analysis turns to specific areas of investment to better understand where local public investment can make the greatest difference. Table D.1 shows that, among the categories for which comparable data for 50 regions are available, GDP growth is more sensitive to public investment in education, training and research and development (R&D), and in public administration operations and territorial infrastructure.

Table D.1

Public investment's effect on GDP, by category

	Periods ahead				
Response of GDP to:	1	2	3	4	5
Public investment in general	0.0159***	0.0172**	0.0128	0.0124	0.0052
	(0.00469)	(0.00583)	(0.00721)	(0.00943)	-0.0116
Public investment in:					
Education, training and R&D	0.0064*	0.0013	0.0020	0.0009	-0.0012
	(0.0031)	(0.00391)	(0.00474)	(0.00631)	(0.00796)
Territorial infrastructure	0.0064*	0.0013	0.0020	0.0009	-0.0012
(water, waste treatment)	(0.00192)	(0.00245)	(0.00304)	(0.00393)	(0.00535)
Environmental protection	0.0040	0.0028	0.0020	0.0036	-0.0026
	(0.0021)	(0.00258)	(0.0032)	(0.00381)	(0.00472)
Public administration operations	0.00360*	0.0023	0.0040	0.0030	0.0048
(such as justice, general services)	(0.00167)	(0.00219)	(0.00284)	(0.00338)	(0.00394)
Transport infrastructure	0.0035	0.0006	0.0045	0.0007	0.0006
	(0.00379)	(0.00493)	(0.00646)	(0.00785)	(0.00899)

Source: *EIB staff estimates.*

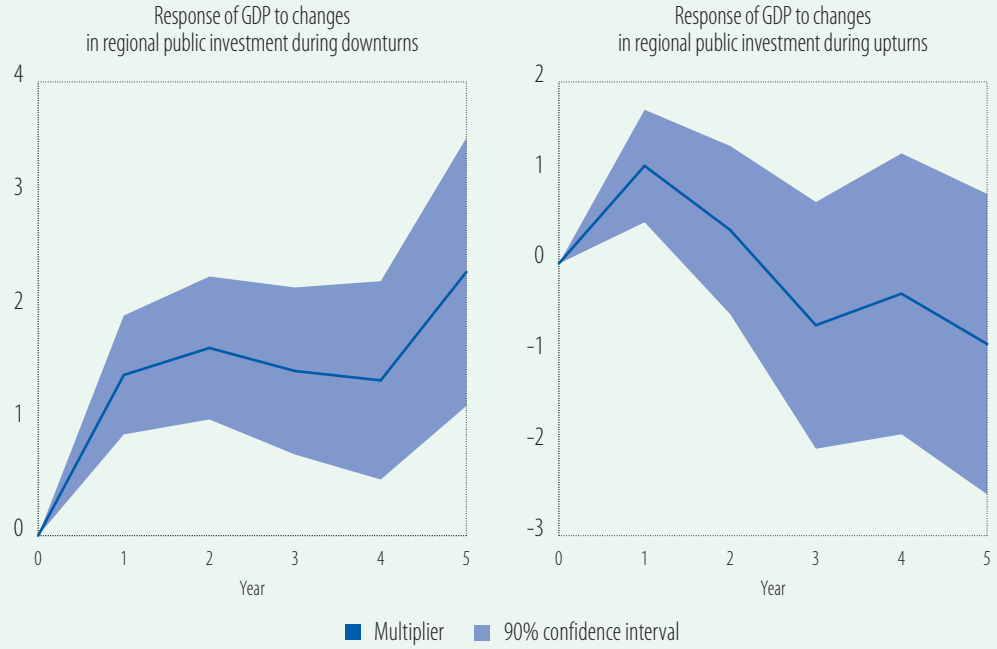
Note: *Response of GDP growth n (1,…,5) periods after one standard-deviation shock to growth, separated by category of local public investment. Standard errors are in parentheses. Statistical significance: *p-value p<0.05, ** p-value<0.01.*

11 Nomenclature des unités territoriales statistiques, or NUTS, is referencing standard for the administrative divisions of countries for statistical purposes. The current NUTS 2021 classification is valid from 1 January 2021 and lists 92 regions at NUTS 1 242 regions at NUTS 2 and 1 166 regions at NUTS 3 level.

Looking at the potential cyclicality of the impact, the results confirm that the response to local public investment is stronger in downturns than in upturns. Regarding the impact of local public investment on GDP, Figure D.1 shows that in downturns, the response is significant in all periods projected and the impact is larger in downturns than in upturns.

Figure D.1

Local public investment's impact on GDP during economic downturns and upturns, measured by multiplier effects



Source: EIB staff estimates.

It is possible that causality goes in the opposite direction — that is, from GDP to public investment. In a context of expanding economic activity, more resources from tax revenues allow for higher spending, including investment. However, one way to check for the absence of reverse causality is to apply an instrumental variable regression to control for the impact of GDP growth on public investment.[12] The instrumented GDP growth is not found to alter public investment. At the same time, the instrument is relevant in explaining GDP.

Overall, evidence exists of a positive correlation between local public investment and private investment, with causality running from public to private investment. Indeed, the multiplier for private investment is clearly positive and significant for the first two years after the shock. The impact of local public investment on GDP seems to be stronger in downturns. The results show that investments in education, training and R&D, public administration and territorial infrastructures are among the most effective at promoting economic growth. These results illustrate how important local governments are in crowding-in private investment for multiple reasons. They are more attentive and sensitive to the needs of the private sector for skills and labour, and they have the knowledge and capacity to adapt to specific local features and to create the right infrastructure and environment for the private sector.

12 Mimicking the approach suggested by Jaimovich and Panizza (2007) and Saccone et al. (2022), we use an instrument, built using world trade growth multiplied by the regional manufacturing share in regional value added, to highlight the regional exposure to external shocks. The "shock" variable should be significantly associated with the regional GDP growth, but uncorrelated with public investment.

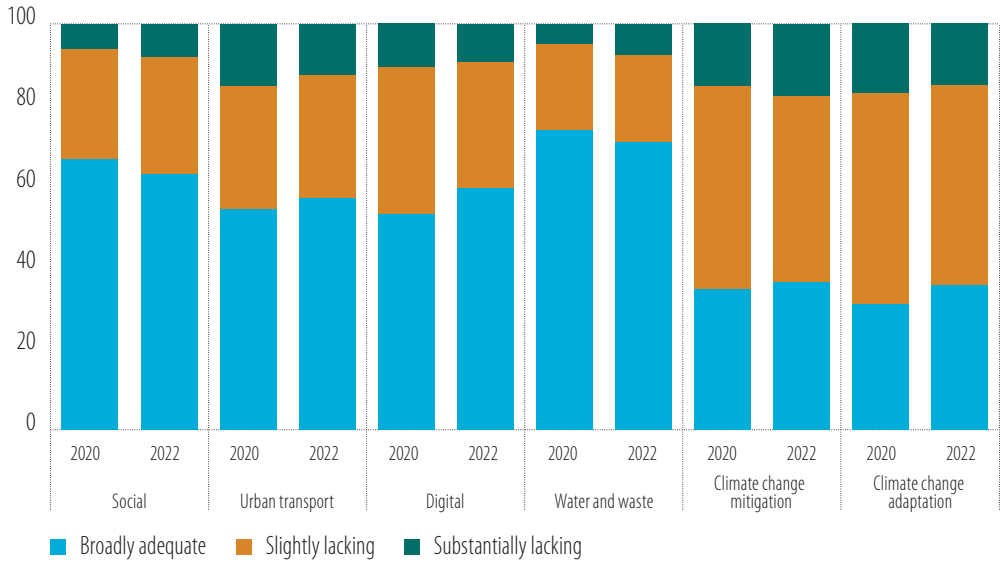
Local governments plan to increase infrastructure investment, but financing remains a constraint

Local governments play a key role in total government investment (Figure 9), including infrastructure. Infrastructure accounts for a significant share of government investment — about one-third in the European Union on average (Wagenvoort, De Nicola and Kappeler, 2010). Amid a dearth of official information regarding infrastructure investment, some light is shed by the recent EIB Municipality Survey conducted from May to July 2022. The survey encompasses 744 municipalities across all Member States.

Across the European Union, the biggest and the most persistent infrastructure deficiencies are observed in the areas of climate change, digital infrastructure and urban transport. Municipalities were asked about the adequacy of their recent investment in each of the following areas: social infrastructure, urban transport, water and waste utilities, climate change mitigation and climate change adaptation. On balance, only 35% of respondents report satisfaction with their investments in climate change mitigation and adaptation (Figure 10). This is followed by urban transport and digital infrastructure, with nearly 60% of respondents saying investments are adequate in each of these categories. Urban transport seems to be mostly lacking among the municipalities in Southern Europe, with less than half of those respondents saying they are satisfied with current infrastructure investments. Digital infrastructure investments are predominantly lacking among countries in Central and Eastern Europe, with about half of respondents reporting insufficient digitalisation.

Figure 10

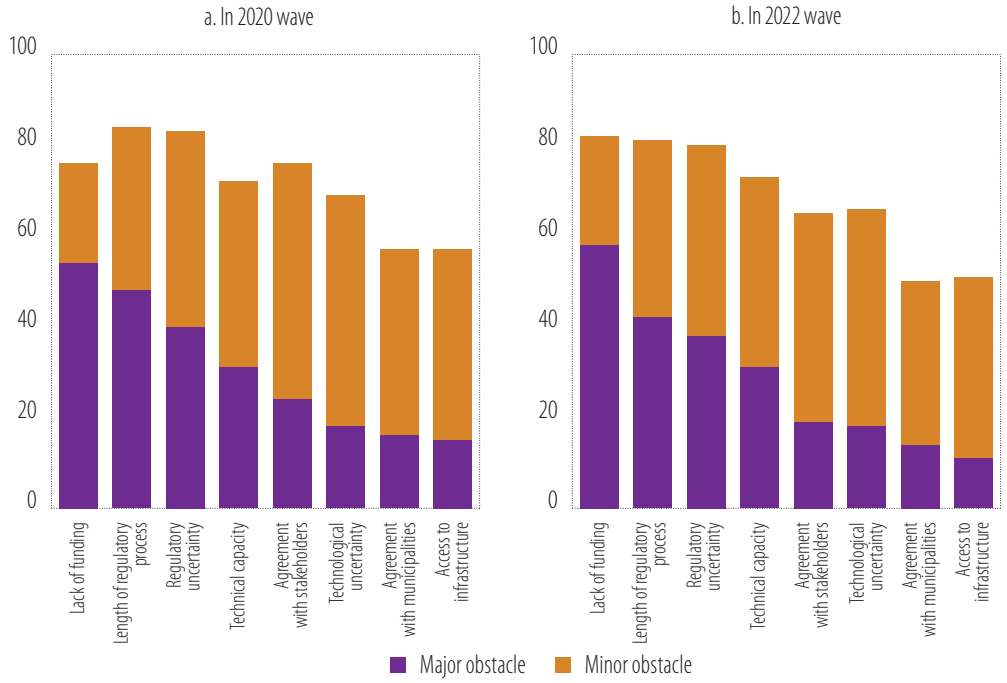
Adequacy of infrastructure investment over the past three years (% of respondents)**, by asset class and survey wave**



Source: *EIB Municipality Survey 2020 and 2022, and EIB staff estimates.*
Base: *All municipalities excluding don't know/refused responses.*
Question: *In the last three years, would you say that within your municipality or city the level of investment in infrastructure projects was broadly adequate, slightly lacking or substantially lacking in each of the following areas?*

Lack of funding, the length of regulatory processes and regulatory uncertainty seem to be the biggest drags on municipal investments. As in 2020, nearly 80% of municipalities continue to claim that their efforts are impeded by lengthy and uncertain investment approval processes. Compared to 2020, however, access to finance has grown as a factor hampering investment. In 2022, lack of funds or financing discouraged investment plans for more than 80% of municipalities — nearly 6 percentage points higher than in 2020. Moreover, lack of funding is the most common major investment barrier, cited by nearly 60% of municipalities (Figure 11b).

Figure 11
Municipal barriers to investment (% of respondents)



Source: *EIB Municipality Survey 2020 and EIB staff estimates.*
Base: *All municipalities excluding don't know/refused responses.*
Question: *To what extent is each of the following an obstacle to the implementation of your infrastructure investment activities? Is it a major obstacle, a minor obstacle or not an obstacle at all?*

Source: *EIB Municipality Survey 2022 and EIB staff estimates.*
Base: *All municipalities excluding don't know/refused responses.*
Question: *To what extent is each of the following an obstacle to the implementation of your infrastructure investment activities? Is it a major obstacle, a minor obstacle or not an obstacle at all?*

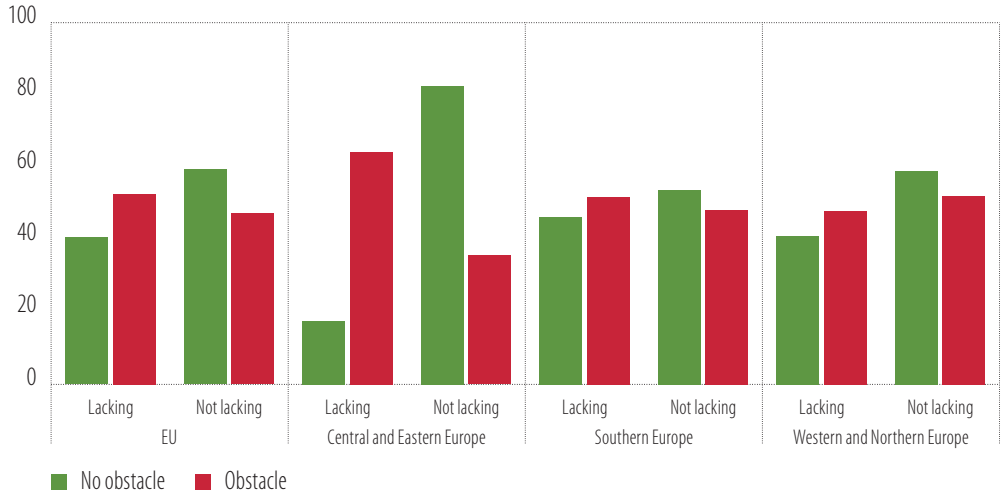
Lack of funding can have a persistent negative effect on investment and on the rollout of municipality investment plans. There is a negative relationship between the reported shortage of finance and the adequacy of investments (Figure 12). Of the municipalities that reported dissatisfaction with recent investment levels in at least three asset categories, more than half report a lack of funding as an investment barrier. This pattern is particularly strong in Central and Eastern Europe, where more than 60% are concerned about funding. Furthermore, for each asset type, municipalities with funding obstacles declare less ambitious investment plans (Figure 13). For social infrastructure, the effects are particularly strong and statistically significant.

In addition to funding, municipalities struggle to find the expertise needed to develop and implement infrastructure projects. The problem is especially pertinent to the twin transition to a green and digital future. Nearly seven in ten municipalities report problems with access to environmental and climate assessment skills, while about six in ten report a lack of engineering or digital skills to deliver their investment programme (Figure 14). Financial skills seem to be the least frequently reported impediment to investment (43% in the European Union), yet more than half of municipalities in Southern Europe struggle to access financial knowledge and skills, with more than one-quarter reporting it as a major problem.

On average, 40% of municipal investments were funded from current income or own resources, 42% by capital transfers and 18% through external financing (Figure 15). Overall, the use of own funds has decreased slightly compared to the 2020 survey. In Central and Eastern Europe, it seems to have been substituted by a broader use of capital transfers. In the 2020 survey, around 44% of municipal investment finance came from capital transfers. In 2022, it was more than 50%. In Southern Europe, own resources were more frequently replaced by capital transfers and external sources of finance. In particular, the share of external finance in this region grew from 9% in 2020 to 12% in 2022. The proportions in Western and Northern Europe appear to be evenly distributed across the three sources of financing and are stable over time.

Figure 12

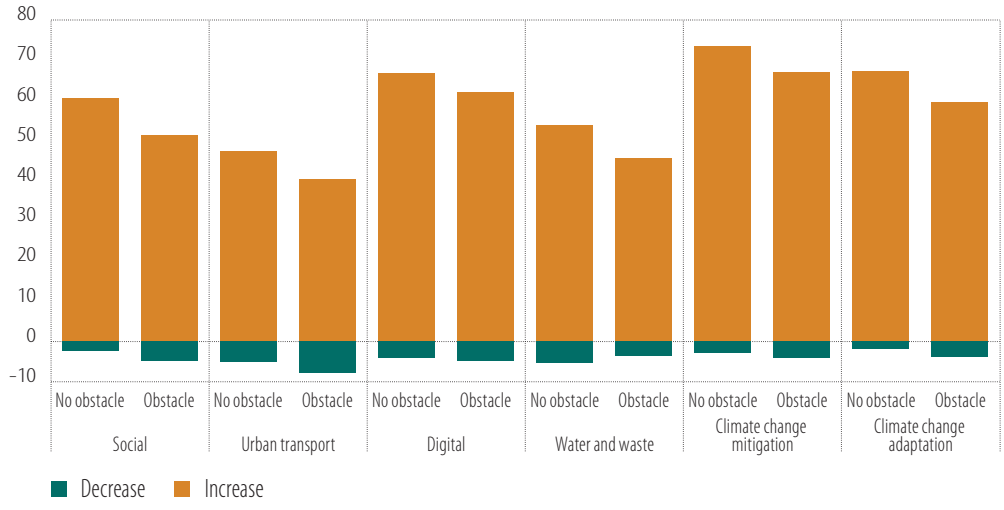
Municipal infrastructure funding obstacles (% of respondents)**, by investment adequacy in the last three years**



Source: *EIB Municipality Survey 2022 and EIB staff estimates.*
Base: *All municipalities excluding don't know/refused responses.*
Notes: *Lacking investments consists of municipalities that declare slightly or substantially lacking investment in at least three out of six asset categories (see Figure 10 for reference).*
Question: *To what extent is each of the following an obstacle to the implementation of your infrastructure investment activities? Is it a major obstacle, a minor obstacle or not an obstacle at all?*

Figure 13

Municipal infrastructure investment plans (% of respondents)**, by lack of funding obstacle and asset class**



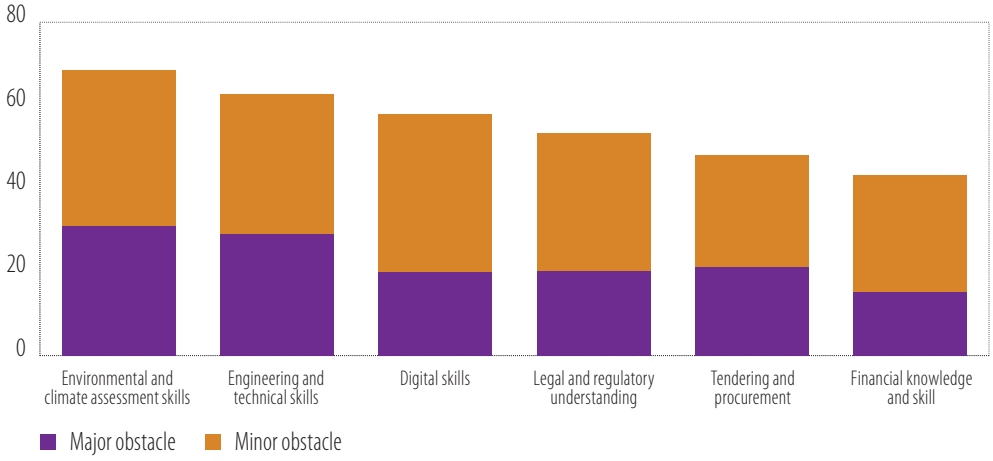
Source: *EIB Municipality Survey 2022 and EIB staff estimates.*
Base: *All municipalities excluding don't know/refused responses.*
Question: *For each of the following areas, if you compare the average annual infrastructure investment you are planning for the next five years vs. the average annual infrastructure investment recorded in in the last three years, does your municipality or city expect to increase, decrease or have around the same level of spending on infrastructure investment?*

Policymakers should address the identified structural impediments to local governments' infrastructure financing. Investments from local governments, especially in infrastructure, are a significant part of public investment, quantitatively (Figure 9) and qualitatively (Box D). Removing impediments to local

government investment should therefore be a priority for national governments and EU policymakers. Financing, administrative capability, implementation skills and the apparent need for improved procedures in allocating the available funds to different projects are among the most pressing constraints for local authorities. National policymakers should take note, involve local governments more in the selection of local projects eligible for financing and make bolstering administrative capacity a policy priority. This will allow for a better and fuller utilisation of the large volume of funds available through the Recovery and Resilience Facility and European structural and investment funds.

Figure 14

Availability of expert skills is an obstacle to implementing investment programmes (% of respondents)



Source: *EIB Municipality Survey 2022 and EIB staff estimates.*
Base: *All municipalities excluding don't know/refused responses.*
Question: *For each of the following areas, to what extent is access to experts a problem to the delivery of your investment programme?*

Figure 15

Composition of municipal financing (% of respondents)**, by region**

Source: *EIB Municipality Survey 2022 and EIB staff estimates.*
Base: *All municipalities excluding don't know/refused responses.*
Question: *Can you tell me approximately what proportion of your infrastructure investment activities over the last three years was financed by each of the following?*

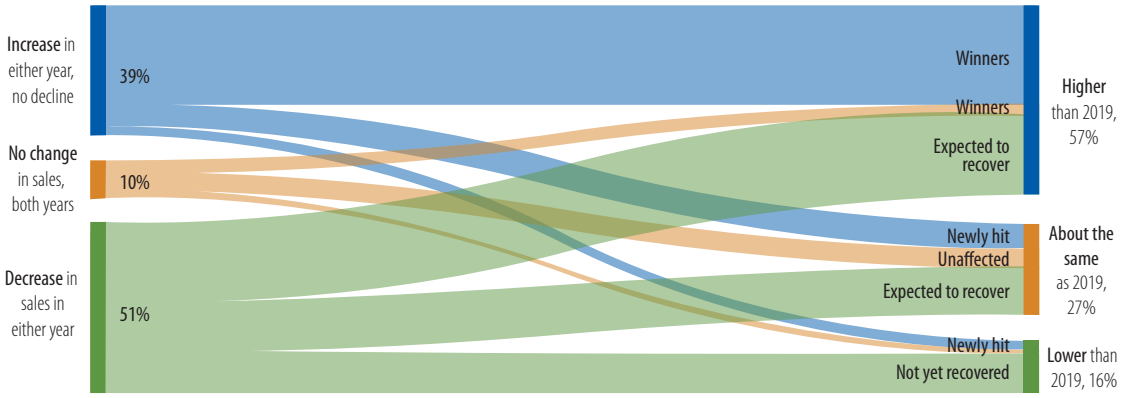
Corporate investment as seen through the EIB Investment Survey

A swift recovery from the pandemic

The recent economic turbulence hit businesses in the European Union, but firms have been relatively quick to recover (Figure 16). EIBIS 2022 provides information about the effect of the COVID-19 crisis on company sales. Firms reported the change in sales for 2020 and 2021 as well as the expected change in 2022. Figure 16 maps the sales dynamics of EU firms since the pandemic. Nearly 33% of firms ("winners") have experienced no decline in sales since 2019, and they do not expect a decline in 2022. About 38% of firms say sales dropped from 2020 to 2021, but expect their sales in 2022 to reach at least 2019 levels ("expected to recover"). Some 6% of firms had stable sales throughout the period ("not affected"), while nearly 13% of firms have not recovered and do not expect to recover in 2022 ("not yet recovered"). About 11% of firms expect their sales in 2022 to match or undershoot those of 2019, despite having beat them in 2021 ("newly hit"). Overall, 16% of firms expect lower sales in 2022 than pre-pandemic levels. The effect of the pandemic on firm finances was much less damaging than originally forecasted.

Figure 16
Effect of COVID-19 on EU firms' sales

Changes in sales in 2020, 2021 and expected change in sales by the end of 2022, compared with 2019 sales (% of firms)



Source: *EIBIS 2022.*
Note: *Firms are weighted by value added.*
Question: *Compared to 2019, before the pandemic started, did your company's sales and turnover in 2020 decline, increase or stay the same? Compared to 2020, did your company's sales and turnover in 2021 decline, increase or stay the same? Compared to 2019, do you expect your sales or turnover in 2022 to be higher, lower or about the same?*

The uneven effect of the pandemic lingers two years on. The pandemic hit economic sectors asymmetrically, with those most reliant on social interaction suffering the most (Figure 17). That said, some firm-level characteristics made an impact. Larger firms and firms with higher labour productivity were more likely to fall in the winners' group, while smaller firms were more likely to be among those not yet recovered.[13]

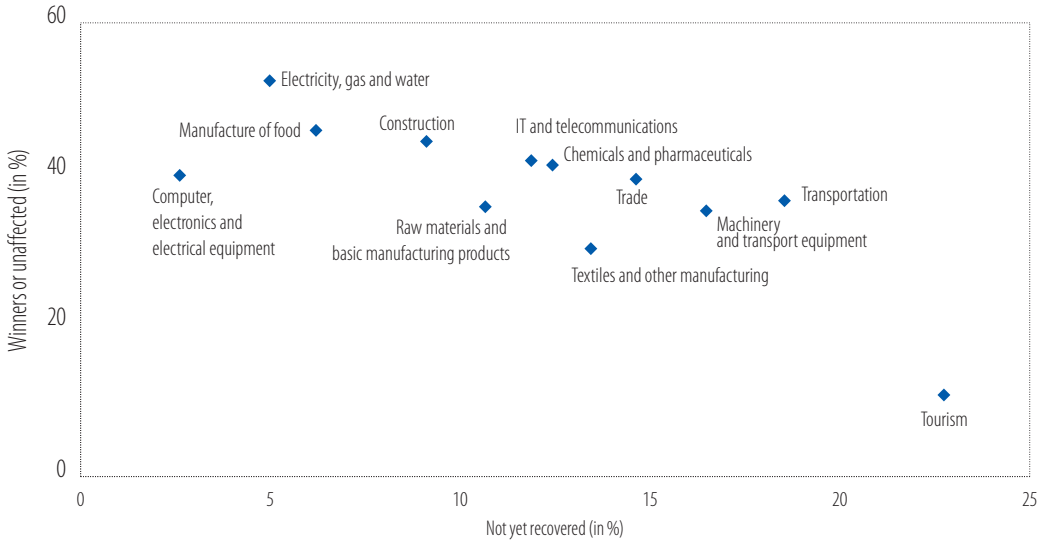
The pandemic shock continued to negatively affect firm investment in 2021. Unsurprisingly, firms from the winners' group were the most likely to have increased investment in 2021. Firms whose sales have recovered and those whose sales were only affected in 2022 were least likely to have reduced investment in 2021 and most likely to have increased it. A higher share of firms whose sales have not yet recovered

13 Size and labour productivity are measured in 2019. Size and productivity effects are statistically and economically significant, controlling for sector and country of origin.

from the pandemic have reduced investment in 2021 (Figure 18a). According to investment plans for 2022, most of the firms that have not yet recovered intend to catch up. This group is the most likely to increase investment in 2022 (Figure 18b). Recent economic turbulence has already upset investment plans, as the newly hit group has the second-lowest share of firms planning to increase investment and the highest share planning to reduce it in 2022.

Figure 17

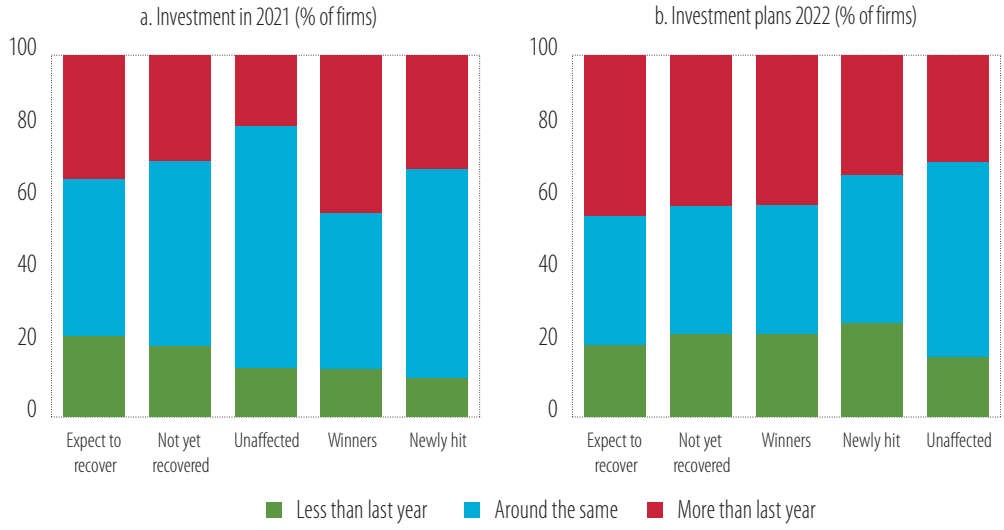
Share of firms that are winners or unaffected, and share of firms not yet recovered



Source: *EIBIS 2022.*
Note: *Firms are weighted by value added.*
Question: *Compared to 2019, before the pandemic started, did your company's sales and turnover in 2020 decline, increase or stay the same? Compared to 2020, did your company's sales and turnover in 2021 decline, increase or stay the same? Compared to 2019, do you expect your sales or turnover in 2022 to be higher, lower or about the same?*

Figure 18

Investment plans, by COVID-19 impact on sales

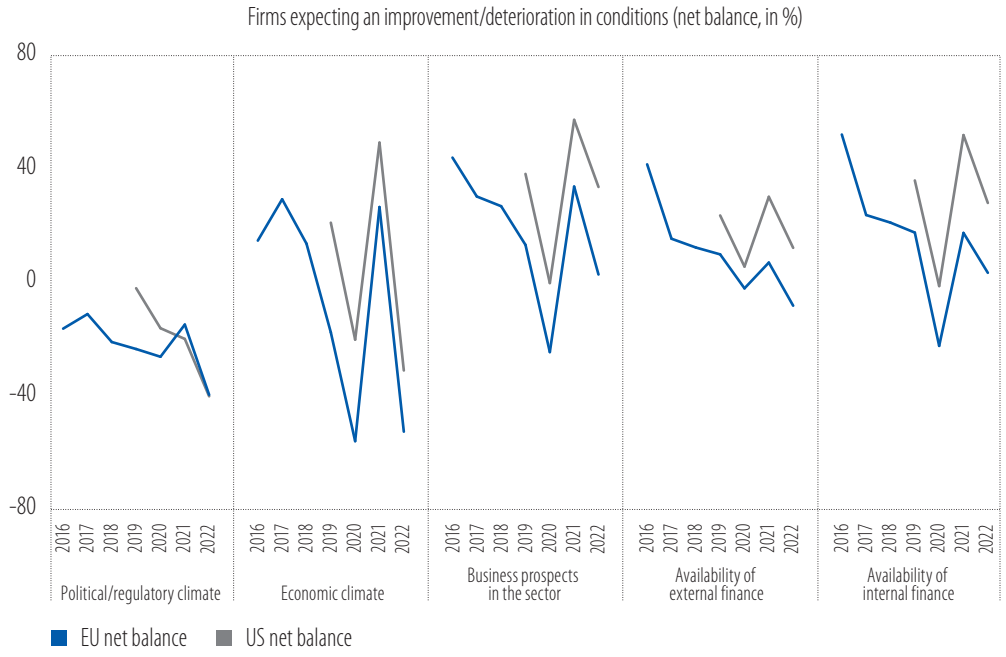


Source: *EIBIS 2022.*
Note: *Firms are weighted by value added.*
Question: *Overall, was your investment in 2021 more, less or about the same amount of investment as in the previous year? For the current financial year, do you expect your total investment spend to be more, less or about the same amount of investment as last year?*

European firms' investment outlook deteriorated substantially in 2022

The short-term outlook deteriorated in the first half of 2022 (Figure 19). EIBIS was in the field between April and June 2022. At that time, firms predicted a major deterioration of the economic climate over the next 12 months, commensurate with that in 2020. Business prospects have also deteriorated, albeit by less. More firms expected the availability of external finance to deteriorate, following tightening monetary policy in Central and Eastern Europe and signals that the European Central Bank would continue to tighten it in the second half of 2022. Firms in the United States expected a similar deterioration in the economic climate but were more optimistic about business prospects and the availability of finance than their EU peers.

Figure 19
Business sentiment in the European Union and the United States

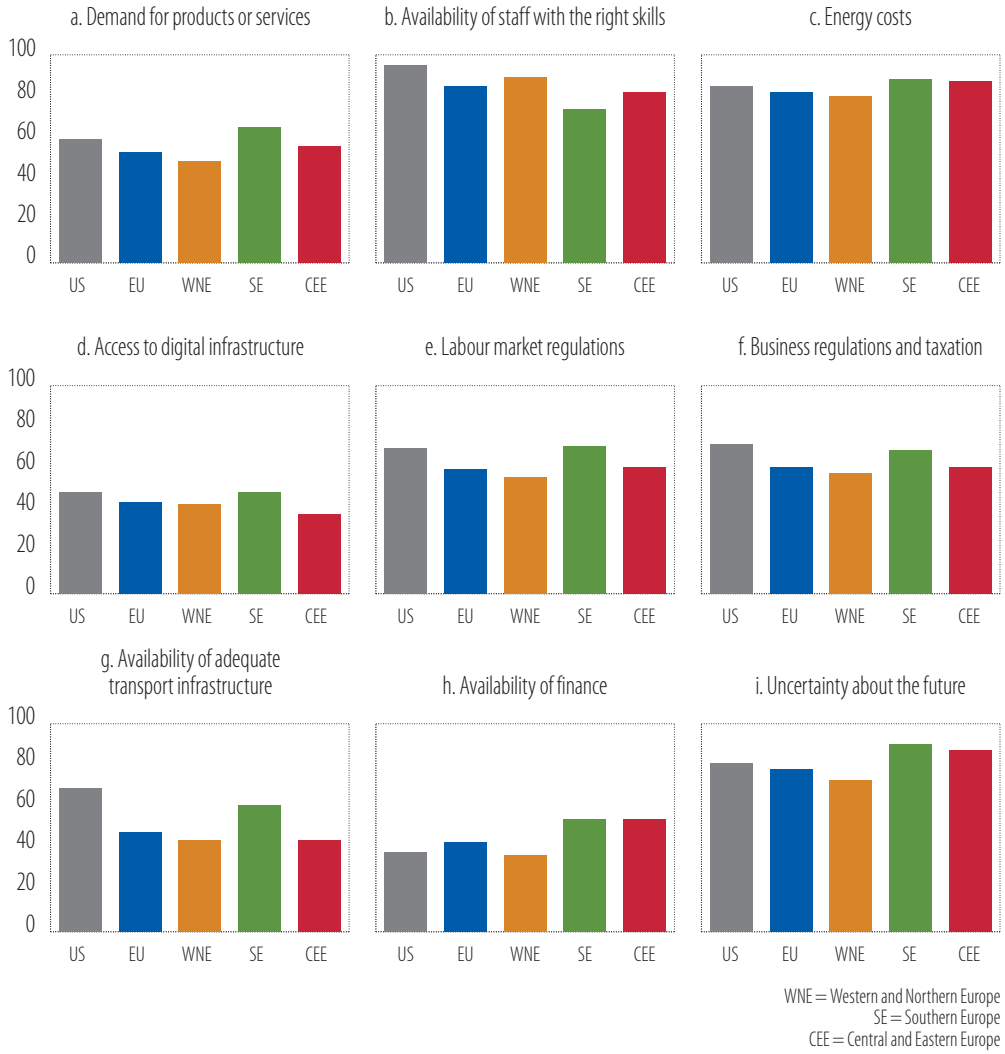


Source: *EIBIS 2016-2022.*
Base: *All firms (excluding don't know/refusals to respond).*
Question: *Do you think that each of the following will improve, stay the same, or get worse over the next 12 months?*

Concerns about the effects of high energy costs on investment increased significantly in 2022 (Figure 20). Energy costs have become the second-most cited impediment to investment (82% of EU firms), after the availability of staff with the right skills (85%) and just ahead of uncertainty about the future (78%). In 2021, 64% of firms in the European Union were concerned about high energy prices. There is a broad variation across countries, as well, from 96% in Greece to 63% in Finland.

Perceptions about high energy costs are rather evenly spread across size classes. Larger firms are more concerned about the availability of staff with the right skills than smaller firms, while smaller firms are more concerned about uncertainty than larger ones. Concerns about the effects on investment of the availability of staff with the right skills and uncertainty about the future have also increased relative to 2021. Perceptions about other barriers to investment remain broadly stable.

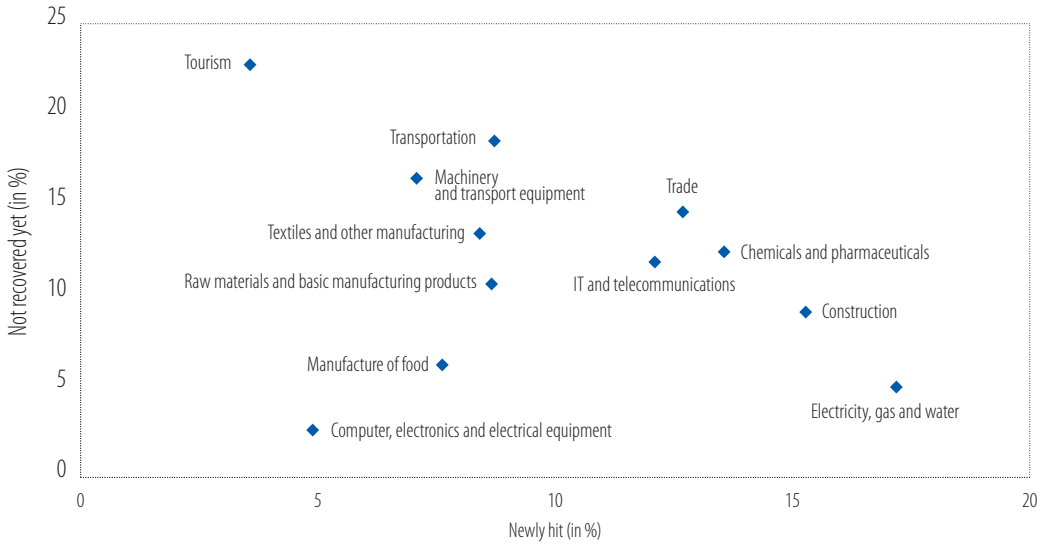
Figure 20
Barriers to investment (% of firms)



Source: *EIBIS 2022.*
Base: *All firms (excluding don't know/refusals to respond).*
Note: *Firms are weighted by value added.*
Question: *Thinking about your investment activities, to what extent is each of the following an obstacle? Is it a major obstacle, a minor obstacle or not an obstacle at all?*

The energy crisis is having a bigger effect on industries that were less affected by the pandemic (Figure 21). The ongoing economic turbulence creates substantial policy challenges, though the impact has been worse for the sectors that were less affected by the pandemic shock. Firms that are still recovering from the pandemic are therefore enjoying some respite, while more affected sectors should be in a relatively good position to navigate the adverse economic environment. That said, the uncertainty brought about by this new environment has significantly affected both the group of newly hit firms and those whose sales were most affected by the pandemic. This will weigh on investment.

Figure 21
Share of firms that are not yet recovered, and share of firms newly hit



Source: *EIBIS 2022*
Note: *Firms are weighted by value added.*
Question: *Compared to 2019, before the pandemic started, did your company's sales and turnover in 2020 decline, increase or stay the same? Compared to 2020, did your company's sales and turnover in 2021 decline, increase or stay the same? Compared to 2019, do you expect your sales or turnover in 2022 to be higher, lower or about the same?*

High energy prices provide an opportunity and an incentive for firms to increase their investment in energy efficiency, balancing out the decline in other investment. New economic turbulence adds pressure to firms already under strain from the pandemic. At the same time, businesses would benefit from embracing a quicker energy transformation. Investment in energy-saving technologies reduces operating costs and exposure to volatile prices for fossil fuels. The current high levels and their expected persistence should push firms to invest in energy-saving equipment and production technologies. Firms with very high energy intensity have the biggest incentives. However, other considerations — such as deteriorating financing conditions, falling demand and uncertainty (see Chapter 6) — could put a brake on firms' investment.

Europe continues to trail peers in intangible investment

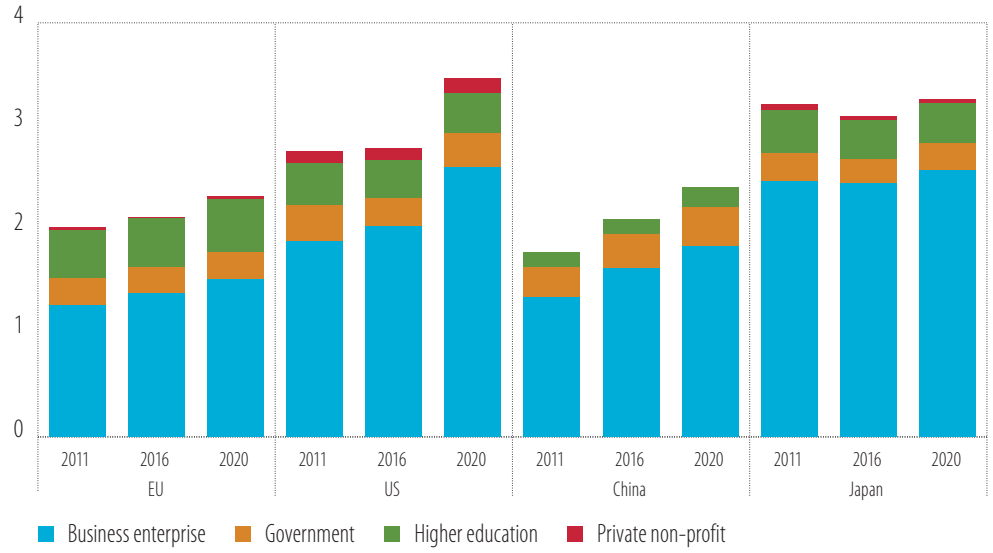
Innovation and investment in intangible capital are key to sustaining high productivity growth and increasing wealth. However, they are difficult to quantify and measure. Official statistics cover only part of intangible capital, and there is no official direct measure of innovation. To complement official data on intangible capital, this section provides information on innovation activity and investment in intangible capital based on aggregate statistics on expenditures for R&D, patents and information gathered for the EIBIS.

Aggregate R&D and patenting activities

Europe remains far from its goal of dedicating 3% of GDP to gross domestic expenditure on research and development (GERD), with current levels standing at 2.3% of GDP. Expenditure on R&D is a key indicator of innovation activity. One of the main EU policy goals is to invest 3% of GDP on GERD, with 2% coming from business enterprise expenditure on R&D (BERD). While Japan and the United States have already exceeded this goal, the European Union (Figure 22) is lagging, with R&D expenditure remaining

below 2.5% of GDP. Businesses are the main contributor to R&D expenditure in the European Union, contributing slightly more than 1.5% of GDP in 2020 (below the 2% target).

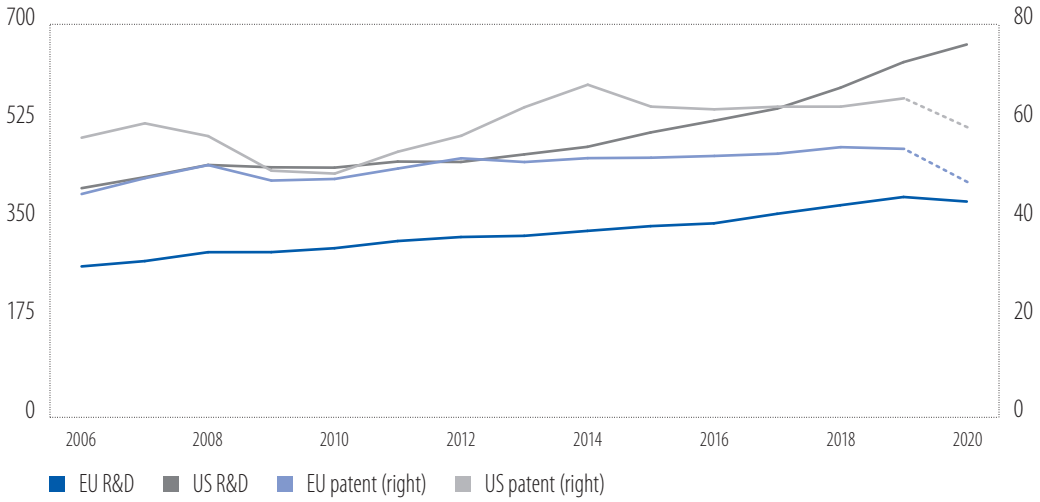
Figure 22
Gross domestic expenditures on R&D (% GDP)



Source: *Eurostat.*
Note: *GERD as a share of GDP.*

In Europe, R&D expenditure and patent applications have stagnated, falling further behind the United States (Figure 23). R&D expenditure in the United States rose strongly, compensating for a stagnation in patenting. Given that R&D expenditure is often considered an input in the innovation process and in patenting, Europe's lower spending and patent performance could be a harbinger for less EU innovation in the years to come.

Figure 23
Evolution of R&D expenditures and patents over time (left axis: USD billion, constant prices; right axis: patent count)



Source: *OECD and Patent Cooperation Treaty (PCT) patent count (Patstat).*
Note: *R&D expenditures are measured in USD constant prices using 2015 as a base year and purchasing power parities. Patent counts for 2020 are not complete.*

While Europe is trailing the United States in digital innovation (Chapter 5), Europe's position in green innovation appears more promising (Box E). In absolute patent counts and relative focus, Europe continues to lag behind the United States in patents related to digitalisation, with no clear sign of catching up. Its performance in green innovation is better but is increasingly contested. Despite Europe's lead in patenting activities for green innovation, not all investment measures are as positive — for example R&D. In addition, the US Inflation Reduction Act, which is expected to provide almost $369 billion for energy and climate change projects, could give an enormous boost to US activities in green innovation.[14]

Box E

Innovations generating environmental benefits

The development and diffusion of technologies that generate environmental benefits are crucial for green growth. By now it is clear that the challenge of climate change cannot be tackled without technological advances (Aghion et al., 2019). Technical progress must be made in a variety of sectors, and green innovations covering a wide array of fields are key.

Investing in environmentally friendly technologies and supporting innovation in the private sector are clearly stated ambitions of the European Green Deal (European Commission, 2019). By lowering the cost of greenhouse gas abatement or pollution reduction, green innovation can ensure that the European Union reaches climate neutrality in a cost-efficient manner. For example, from 2010 to 2019, technological breakthroughs in green technologies have decreased the unit costs of solar energy (-85%), wind energy (-55%) and lithium-ion batteries (-85%), leading to a strong increase in adoption rates (Intergovernmental Panel on Climate Change (IPCC), 2021).

Europe's main strengths lay in the areas of electrification, energy efficiency and the transport and mobility sector. Not only does Europe hold most internationally oriented climate-related patents in these areas — more than China and the United States — but it also saw the highest increase in patenting in these domains compared to other regions over the past decade.

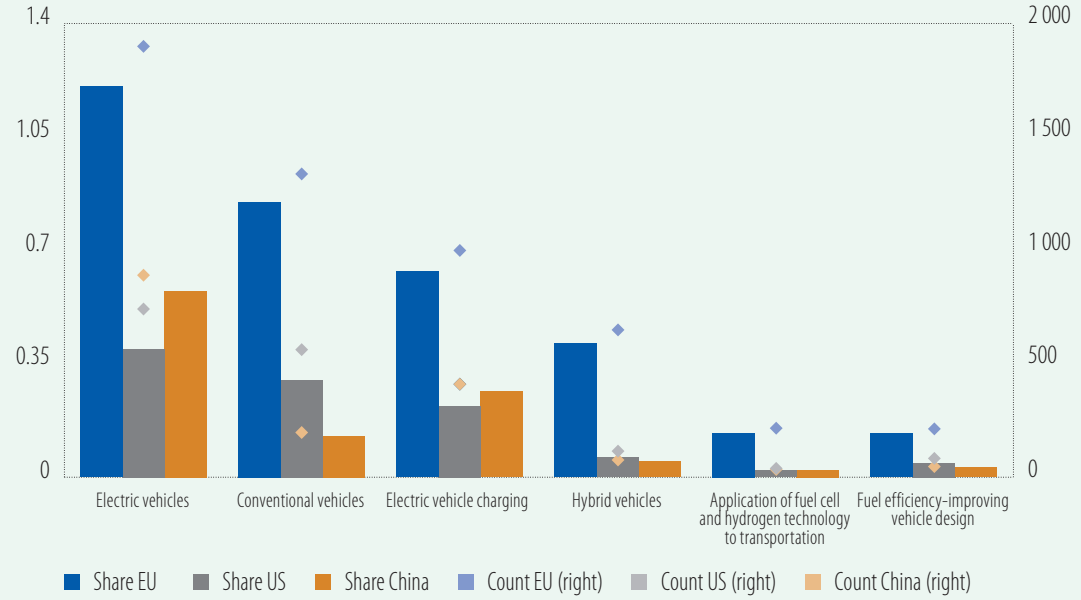
In the transport and mobility sector the focus is currently on electric vehicles, an evolution that goes hand in hand with current policy priorities. Still accounting for 24% of direct carbon emissions from fuel combustions, transport and mobility is one of the key sectors needing (and currently undergoing) a shift towards clean energy (International Energy Agency (IEA), 2020). Figure E.1 shows that Europe is prioritising development in this area.

Europe seems to have a competitive advantage in key and enabling technologies. It is a leading innovator in wind energy. Solar, on the other hand, is not a centre of EU expertise, and China is the driving force in that area (Figure E.2a). Smart grid and energy storage technologies are viewed as enabling the electrification transition (Figure E.2b). In both, Europe and China are ahead of the United States when it comes to the number of new innovations or the share of the global patent portfolio.

In addition, the focus worldwide remains on well-established technologies. Technologies like hydrogen have yet to be thoroughly developed (EIB, 2022a). Although progress in this area is highest in Europe and still increasing, it is still only in its initial stages (Figure E.3).

14 See Box D in Chapter 1 for more information about the US Inflation Reduction Act.

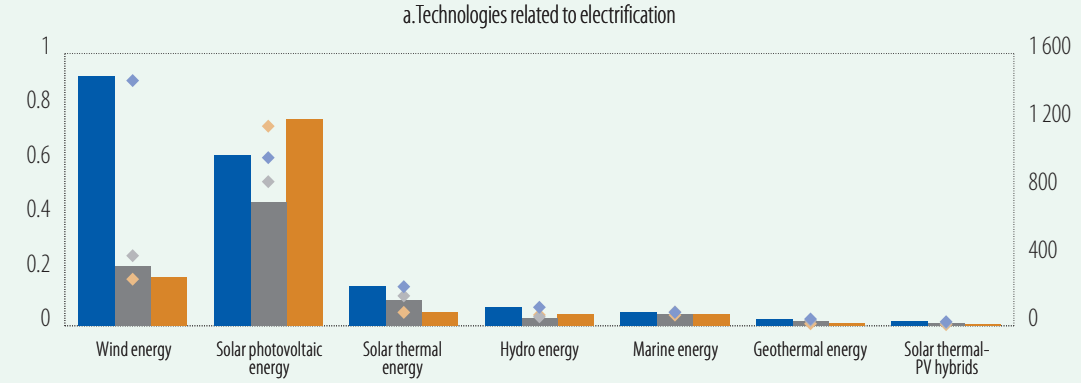
Figure E.1
Climate change mitigation technologies (left axis: % of total patents: right axis: patent count) **related to transport and mobility, 2018-2020**



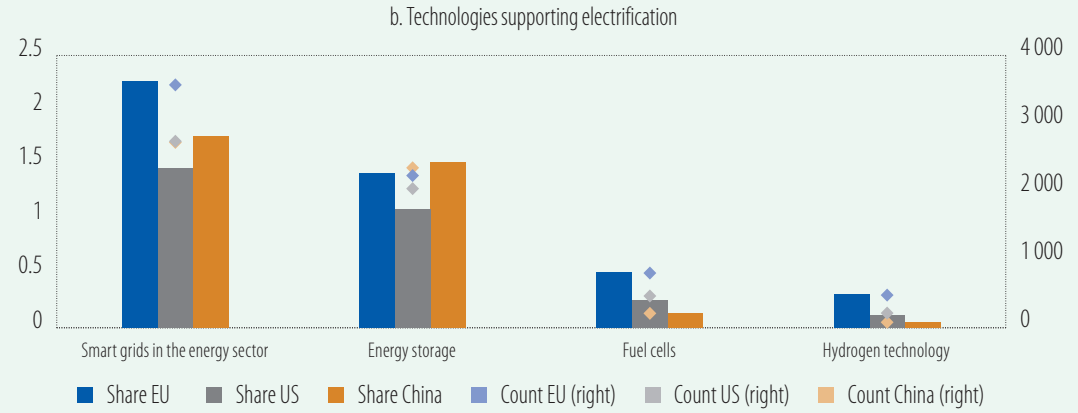
Source: *Authors' calculations based upon PATSTAT (PCT) data in collaboration with Expertise Centre for Research and Development Monitoring (ECOOM).*

Part of the technologies developed in transport and mobility are closely related to energy efficiency. When it comes to fuel efficiency, the motorisation of electric vehicles or the application of hydrogen technology, advancements are highly dependent on developments in the energy sector and the level of efficiency that can be attained. If coal or other polluting fuels are used to generate the electricity needed to charge electric cars, the progress in this area will not pay off.

Figure E.2
Climate change mitigation technologies in electrification (left axis: % of total patents; right axis: patent count)

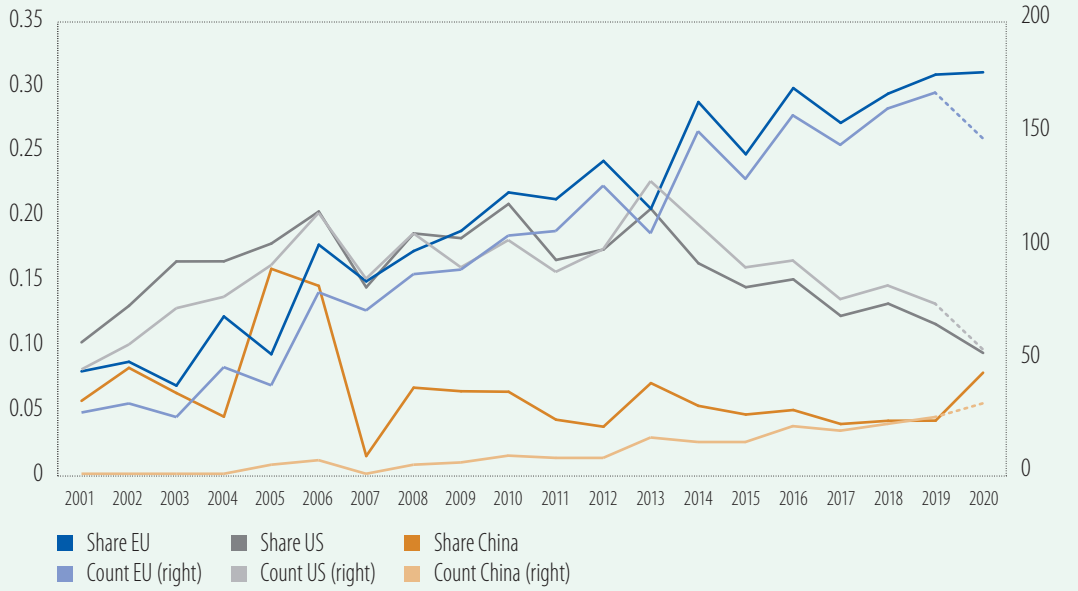


Source: *PATSTAT (PCT) data prepared in collaboration with ECOOM.*
Note: *The bars show the share of climate change mitigation technologies related to electrification in the total domestic patent portfolio (in %), the diamonds show the count of these patents in the respective region, during 2018-2020.*



Source: *Authors' calculations based upon PATSTAT (PCT) data in collaboration with ECOOM.*
Note: *The bars show the share of climate change mitigation technologies supporting electrification in the total domestic patent portfolio (in %), the diamonds show the count of these patents in the respective region, during 2018-2020.*

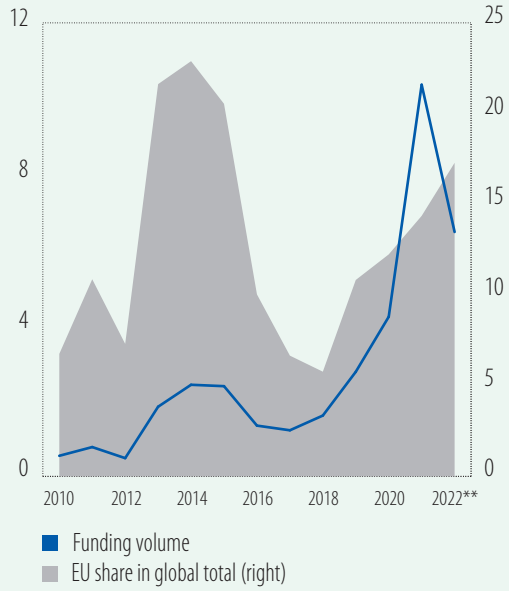
Figure E.3
Climate change mitigation technologies related to hydrogen
(left axis: % of total patents; right axis: patent count)**, 2001-2020**



Source: *Authors' calculations based upon PATSTAT (PCT) data in collaboration with ECOOM.*

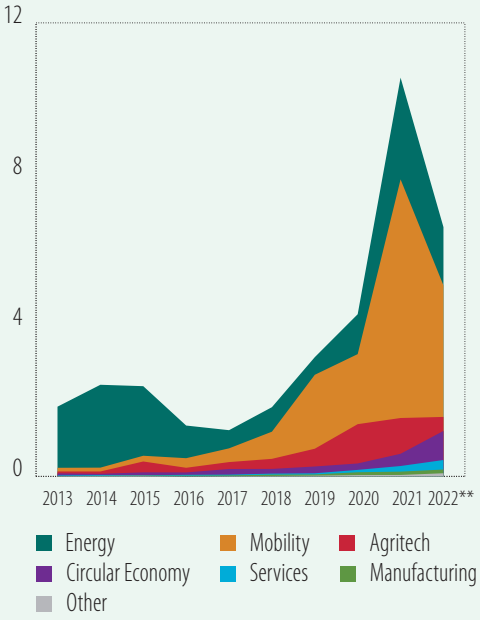
The development of green technologies is critically dependent on the availability of equity-based financing provided by outside sources. Venture capital and private equity growth funding volumes for EU green technology companies have risen strongly in recent years (Figure E.4). From 2018 onwards, the market experienced exponential growth, reflecting the growing societal concerns about the environment and sustainability and the increased focus of EU policymakers on private financing as a catalyst for the green revolution.

Figure E.4
EU greentech funding volume
(left axis: EUR billion; right axis: in %)



Source: *European Small Business Finance Outlook (ESBFO) (Kraemer-Eis, 2022).*
Note: ** Venture capital and private equity growth financing for greentech companies headquartered in the EU27*
*** Annual totals were incomplete when the data was gathered (11 August 2022).*

Figure E.5
Recent trends in some select environmental segments of EU greentech (EUR billion)



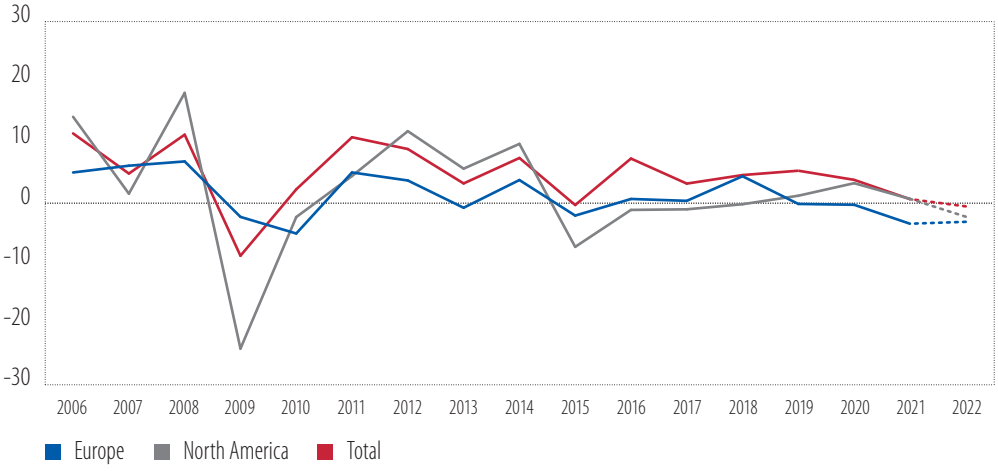
Source: *ESBFO (Kraemer-Eis, 2022)*
Note: *Venture capital and private equity growth deals in EU greentech companies. Data for the year was incomplete at the time of gathering (August 2022).*

Green technology companies are typically active across a variety of fields (Figure E.5). Emission abatement in the transport sector is widely recognised as one of the most challenging aspects in the European Union's net-zero carbon strategy. Unsurprisingly, the European green technology industry has grown increasingly focused on mobility solutions in recent years, and investments in mobility and transport were the driving force behind the recent growth in funding for green technologies, accounting for 60% of investments in 2021.

Clean energy investments, the second-largest funding category, cover renewable energy infrastructure as well as equipment development and production. These investments accounted for 26% of investment in green technologies in 2021. Given the Ukraine war and Europe's efforts to reduce its dependence on Russian fossil fuels, as outlined in the REPowerEU initiative, demand for clean energy innovation is likely to increase significantly in the years ahead. Agritech companies with business models focused on things like innovations in insect-based protein production, sustainable soy production or internet of things technology for vertical farming systems are essential players in making agriculture more sustainable. In 2021, they accounted for 9% of the green technology sector in the European Union. Although still relatively modest in size, circular economy companies have received a growing amount of green technology funding recently, attracting 3% of funding for green technologies in 2021, but preliminary data for 2022 shows a significant increase.

The recent economic turbulence could cause innovation activity to stagnate further. To get a better view of what to expect, we can look to the trends in Patent Cooperation Treaty (PCT) applications, by date of receipt at the International Bureau of the World Intellectual Property Organization (WIPO). These data show that innovation activities respond to the business cycle. Patent applications declined during the global financial crisis, especially in the United States. Growth accelerated again shortly thereafter. After growing stably in the subsequent years, patent applications again fell in 2020 and 2021, with a contraction expected in 2022.

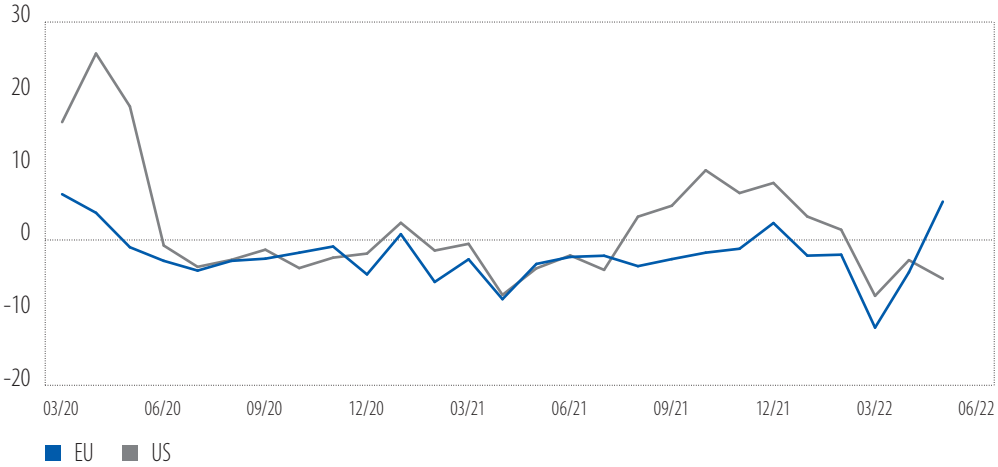
Figure 24
Annual growth rate of PCT applications (in %)**, by date of receipt**



Source: *WIPO statistics database. Last updated: September 2022.*
Note: *Data for 2022 are incomplete.*

Innovation activities were clearly hit during the coronavirus pandemic, with fewer patent applications in the European Union and the United States since the beginning of 2020. Zooming in on monthly changes in growth rates over the past years shows an overall steady decline in patent applications since the pandemic, albeit with more dynamism in the United States (Figure 25). With the COVID-19 crisis already pushing down growth rates in applications, the current situation could put further pressure on innovation activities.

Figure 25
Monthly three month moving average growth rates of PCT applications (in %)**, by date of receipt**



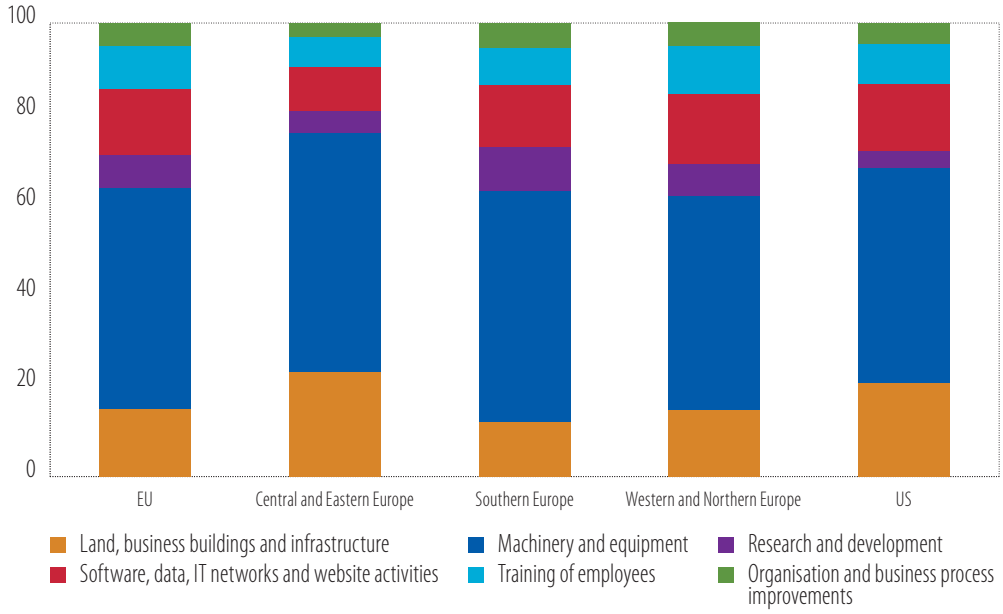
Source: *WIPO statistics database. Last updated: September 2022.*
Note: *Data for 2022 are incomplete.*

Given the crucial role of innovation in economic growth, policies to support it are urgently needed in Europe, specifically in a period of crisis. Falling further behind in innovation will have a detrimental effect for economic growth in the European Union and for its global economic leadership. Areas in which EU businesses and researchers excel are subject to fierce competition, and they could soon be dominated by global rivals. Policymakers may need to redefine the European Union's focus if it is to remain a competitive innovation player.

Intangible assets and innovation as seen through EIBIS data

Investment in intangible assets — such as R&D, software and databases, employee training and organisational capital — represents more than one-third of total investment. The EIBIS allows for a better understanding of overall developments by studying firm-level outcomes. According to EIBIS data, EU firms allocated 37% of their total investment to intangible assets in 2021, slightly above the United States average of 32% (Figure 26). Within the European Union, the share of investment spent on intangibles is lower in Central and Eastern Europe (24%) than in Western and Northern Europe (38%) or Southern Europe (37%).

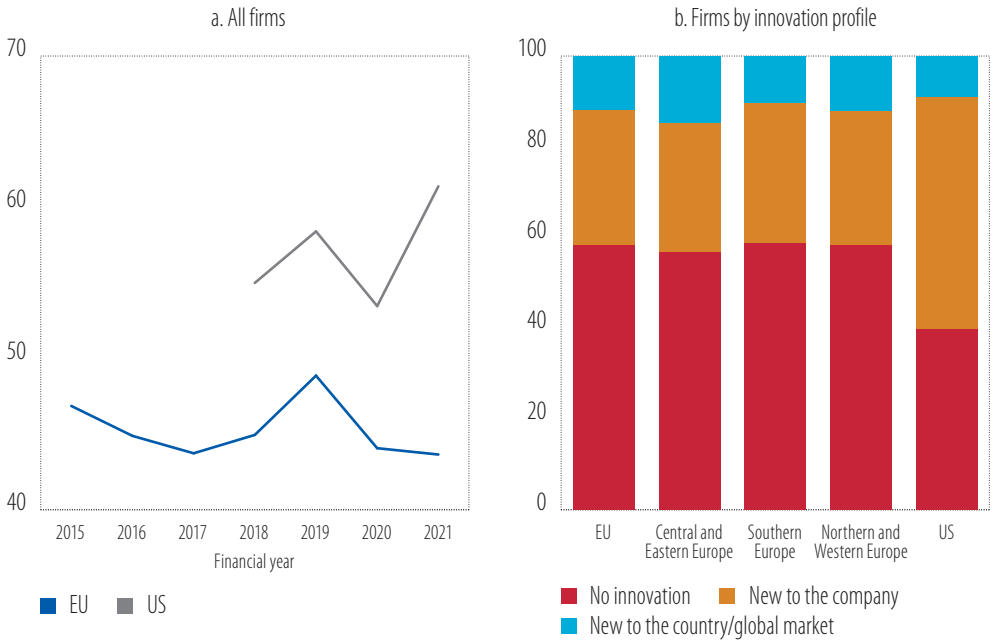
Figure 26
Investment composition in 2021 (% of total investment), **by region**



Source: *EIBIS 2022.*
Note: *Firms are weighted by value added.*
Question: *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?*

The European Union has a higher share of firms that do not innovate than the United States. This gap in innovation rates has grown over time (Figure 27a). Innovation does not have to come through products and services that are wholly new to a country or the global market. Firms can also adopt and adapt technologies that already exist in their market. In the United States, for example, the share of firms that invest in adopting products or services that are new to the company is significantly larger than in the European Union (Figure 27b). This difference in the share of adopters is the main driver of the innovation gap between the United States and the European Union.

Figure 27
Investment in innovation (% of firms)



Source: *EIBIS 2016-2022.*
Note: *Data on US firms are only available for 2018. Firms are weighted by value added.*
Question: *What proportion of the total investment in the previous financial year was allocated to developing or introducing new products, processes or services? Were the new products, processes or services that you developed or introduced new to the company, new to the country, or new to the global market?*

Box F
Intangible investment during the COVID-19 crisis[15]

Intangible capital acts as an important driver of productivity and economic performance in an increasingly knowledge-based economy. As intangible assets are closely linked to digital transformation (Van Ark, 2016; Corrado et al., 2017), innovative activity (Montresor and Vezzani, 2016) and firm resilience (Landini et al., 2020; Demmou and Franco, 2021), understanding investment dynamics in intangible assets is key to supporting the long-term growth of the EU economy.

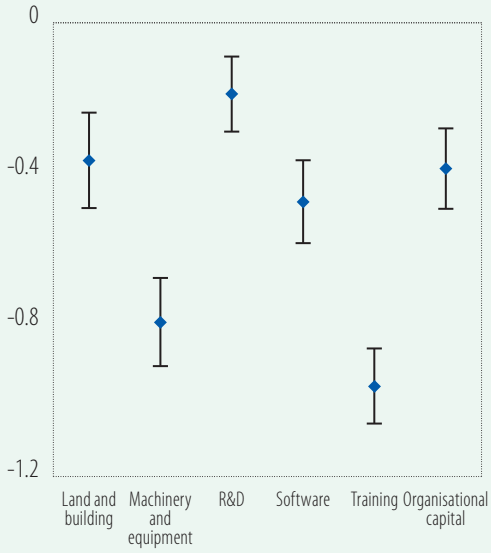
It is now well established that, during the global financial crisis of 2008-2009, intangible investment showed relative resilience compared to tangible investment, which declined substantially more (Corrado et al., 2016). However, evidence on the COVID-19 crisis is still scarce. This box seeks to address this gap by investigating the investment of firms in Europe across different assets. It also looks at the role of financial constraints and economic shocks during the pandemic.

Research conducted by the European Commission and the EIB find heterogeneity in the extent of decline in investment among both intangible and tangible assets (Figure F.1). R&D investment declined the least in 2020, by around 20% on average, while investment in training (an intangible asset) and machinery and equipment (a tangible asset) declined the most. The decline was smaller for investment in land and building, software and organisational capital. These results come from

15 This box was prepared by Peter Bauer (European Commission, Joint Research Centre).

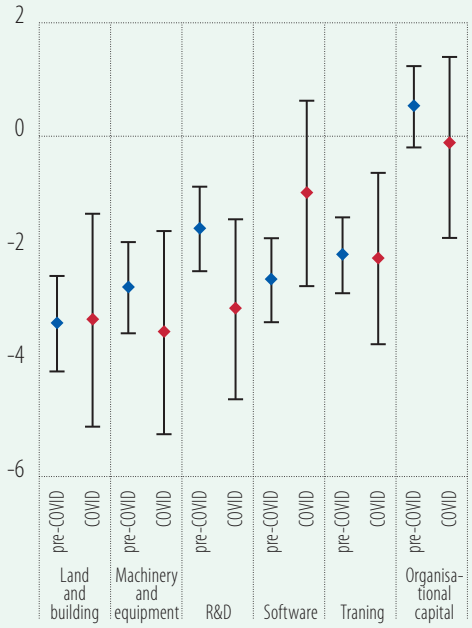
estimations that control for basic firm attributes (size, age, sector and country), and the findings remain largely the same regardless of the estimation method (regressions using pooled ordinary least squares (OLS) or firm fixed effect) or of the measure of investment activity (log investment, probability of investment).[16]

Figure F.1
Impact of COVID-19 on investment (change in logarithm)**, by assets**



Source: *Authors' estimates based on EIBIS 2021.*
Note: *Pooled ordinary least squares regressions. Lines denote 95% confidence intervals.*

Figure F.2
Impact of financial constraints on investment (change in logarithm)**, by assets**



Source: *Authors estimates based on EIBIS 2021.*
Note: *Two-stage least squared regressions. Lines denote 95% confidence intervals. Firms are defined as financially constrained if they report the availability of finance as a major obstacle to investment.*

We detect a statistically significant "small firm effect" for machinery and equipment, software and training — meaning that the smaller the firm, the larger the decline in investment activity. Part of the large adverse effect of the pandemic on investment stems from a big decline in firms' turnover during the crisis.[17] To shed more light on this aspect, we analysed the elasticity of investment to income by estimating the response of investment to a large (at least 25%) decrease in sales for firms in 2020.

We find that training, machinery and equipment, and software were the most sensitive to income shocks during the COVID-19 crisis, while investment in land and building, R&D and organisational capital were the least sensitive. Thus, the elasticity of investment to income shocks helps to explain the strong decline of machinery and equipment and the mild decline of R&D investment during the pandemic. The sensitivity of training can be associated with difficulties of in-person training due to restrictions on gatherings and social distancing rules.

16 As each year there are many firms that do not invest at all in certain assets, we measure the change in the amount of investment by expressing investment as log(investment+1). This way, our results can be interpreted as average percentage changes.

17 Another important factor could have been the increased uncertainty during the COVID-19 crisis. The analysis of this factor is outside the scope of this box.

We find that for almost all assets, pre-pandemic productivity shielded investment from the COVID-19 crisis. This is partly because the income of more productive firms declined less. After controlling for large drops in sales, the resilience provided by productivity remains significant for two key assets: R&D and training.

Regarding the role of financing, we find that financial constraints generally decrease investment. We define firms as constrained if they report the availability of finance to be a major obstacle to investment (Figure F.2). This effect was comparatively low for R&D before the COVID-19 crisis.[18]

In 2020, as a response to the COVID-19 shock, firms initially expected external finance to be less available, but policy support helped prevent that from translating into a higher number of financially constrained firms. However, the detrimental effect of financial constraints was still strong for investment in land and building, machinery and equipment, R&D and training. In some cases, notably for R&D investments, we see an increased sensitivity to financial constraints, although this change is not statistically significant. It is likely that the tightening of liquidity during the crisis (an important determinant of finance, especially for intangible assets) forced financially constrained firms to decrease their R&D investments.[19]

From a policy point of view, our results mean that, despite strong policy support that helped alleviate the financial constraints on firms, these constraints were nevertheless an obstacle during the COVID-19 crisis to investment in R&D and training — two vital intangible assets for long-term productivity growth.

Innovative firms resisted the recent crisis better (see also Box F). When looking at different sales profiles, the share of winners that saw their turnover increase from 2019 to 2022 is significantly higher among firms that introduced products or services that were new to the country or the global market. More than 44% of EU innovative firms can be classified as winners, compared to 35% of winners among adopters and 32% among firms that do not innovate (Figure 28).[20] At the other end of the sales spectrum, the share of firms affected by the COVID-19 crisis and the war in Ukraine (the categories "not yet recovered" and "newly hit") is 18% for innovators, compared with 21% for adopters and 25% for firms that do not innovate. The consequences of the war in Ukraine therefore appear to have hit the sales of active innovators less severely.

In response to the pandemic, innovative firms are more likely to invest in their digital transformation and to reconfigure their supply chain. A large share of firms invested to become more digital during the crisis and to transform their supply chains. Innovators are much more likely than non-innovative firms to do this (Figure 29), and the difference between innovation profiles is similar for US firms. Addressing barriers to digital infrastructure and skills in the European Union, both of which impede the adoption of digital technology, should be a priority if policymakers want to support digital transformation and bridge the growing corporate digital divide between the European Union and the United States (Rückert et al., 2021).[21]

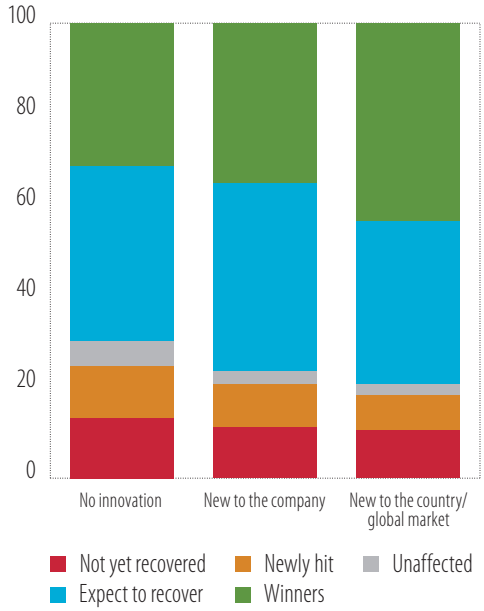
18 Endogeneity of financial constraints because of unobserved firm heterogeneity and reverse causality poses a challenge when estimating causal effects. To mitigate this problem, we applied an instrument variable approach. We used indicators of pre-existing financial fragility, like excess leverage and low cash, as instruments, as these are positively correlated with the probability of being financially constrained.

19 As indirect evidence for tight liquidity for financially constrained firms, we find that the profit situation deteriorated more among constrained firms during the pandemic, compared to non-constrained firms.

20 To simplify the exposition, Figures 28 and 29 only show the results for EU firms. The patterns are similar for the United States, although the sample size for US firms in the EIBIS is much smaller.

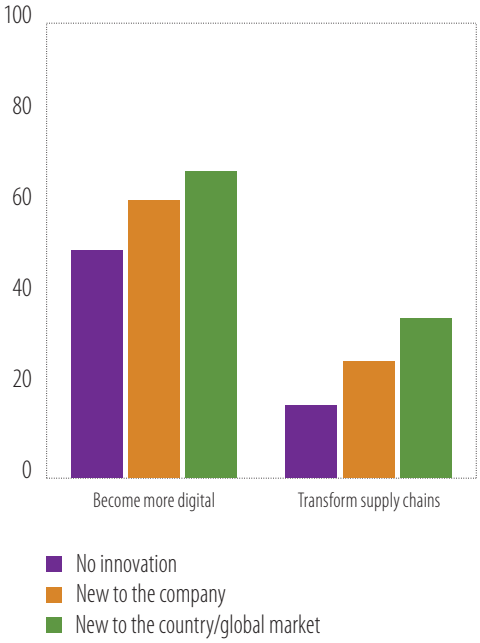
21 See also the discussion in Chapter 5 of this report.

Figure 28
Sales profiles and innovation in the European Union (% of firms)



Source: *EIBIS 2022.*
Note: *See Figure 16 for a definition of sales profiles. Firms are weighted by value added.*
Question: *Were the new products, processes or services that you developed or introduced new to the company, new to the country, or new to the global market?*

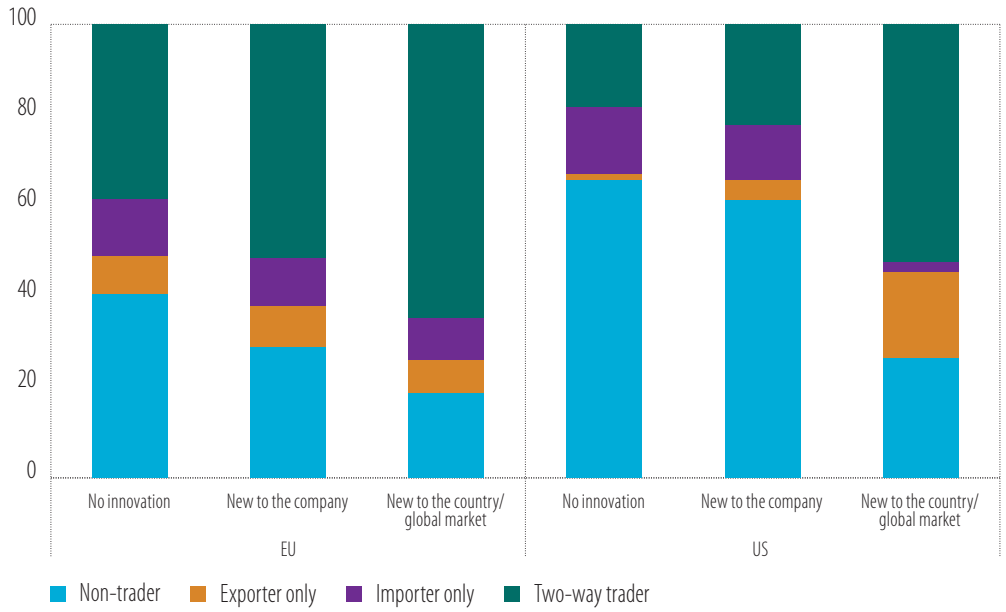
Figure 29
As a response to COVID-19, EU investment has become more digital and more focused on supply chains (% of firms)



Source: *EIBIS 2022.*
Note: *Two-stage least squared regressions. Lines denote 95% confidence intervals. Firms are defined as financially constrained if they report the availability of finance as a major obstacle to investment.*
Question: *Were the new products, processes or services that you developed or introduced new to the company, new to the country, or new to the global market? As a response to the COVID-19 pandemic, have you taken any actions or made investments to become more digital (e.g. moving to online service provision)? As a response to the COVID-19 pandemic, have you taken any actions or made investments to transform your supply chain or your outsourced activities (bring more stages to the same location or closer to your business's home country)?*

Innovative firms are more likely to engage in trade, by exporting or importing products and services. While 40% of non-innovative firms in the European Union do not engage in international trade, this share decreases to 29% for adopters and 19% for innovators (Figure 30). Similarly, the share of two-way traders (firms that exported and imported products and/or services) in the European Union is 65% for innovators and 51% for adopters, compared with only 39% for firms that do not innovate. Perhaps unsurprisingly, the share of non-trader firms in the United States is higher because of the larger size of the domestic market, but the trade patterns with respect to innovation levels are similar. These results are also in line with studies stressing that exporters tend to be more productive and innovative because they compete in international markets and invest in new products to maintain their market share (Melitz and Redding, 2021). However, the correlation between innovation activities and firm performance does not necessarily imply a causal link.

Figure 30
Trade and innovation (% of firms)



Source: *EIBIS 2022.*
Note: *Firms are weighted by value added.*
Question: *Were the new products, processes or services that you developed or introduced new to the company, new to the country, or new to the global market? In 2021, did your company export or import goods and/or services?*

Investment in climate change mitigation and adaptation rebounds

Climate investments are progressing incrementally, but they fall short of what is needed to transform economies and achieve carbon neutrality. The rebound observed in 2021 mostly benefited clean energy investments, which account for two-thirds of climate investments in the European Union, the United States and China. Energy efficiency investments regained momentum, driven by incentives in the construction sector and by dynamic sales of electric cars. In the current energy crisis, climate innovation — already bolstered by post-pandemic recovery packages — is critical for accelerating the commercialisation of rapidly emerging technologies, including energy storage and green hydrogen.

Investment in climate increased in 2021, after stagnating in previous years

After a slowdown in 2020, climate change investments rebounded strongly in 2021 in the European Union and the United States. European climate investments reached nearly EUR 290 billion in 2021 — a 28% rise from 2020 levels, according to the EIB database on climate change mitigation investment (see data annex). These were boosted by the large stimulus packages deployed in the aftermath of the pandemic, including the Just Transition Mechanism and the overarching NextGenerationEU plan as part of the European Green Deal (Figure 30). The increase in investment in 2021 was also helped by the adoption of the EU taxonomy for sustainable activities, and more broadly by the vast array of European-level and domestic policies to support net-zero climate objectives. Climate investments in the United States grew by 17% in 2021, but they still lag behind European spending.

Current spending on climate mitigation needs to increase significantly if carbon neutrality is to be reached by mid-century. 2% of GDP was devoted to climate mitigation in 2021. The havoc wreaked by the war in Ukraine and the new paradigm on energy security have temporarily shifted priorities in

public energy spending in Europe. As of November 2022, European governments had pledged over EUR 550 billion to cover households' and firms' ballooning electricity and gas bills. Further transfers from various packages are under consideration. Meanwhile, fossil fuel producers saw their net income rise by USD 2 trillion in 2022.

Beyond the immediate need to address the unfolding energy crisis, policymakers reaffirmed their commitments to climate objectives, paving the way for global clean energy investments to double by 2030, to about USD 2 trillion (IEA, 2022). However, USD 4 trillion in investment is needed globally by 2030 to meet the 1.5°C goal. The International Monetary Fund (IMF) and the IEA estimate that 0.6% to 0.9% of global GDP should be allocated to energy transformations over the next decade to meet climate objectives. Availability of financing notwithstanding, numerous investment barriers continue to block climate investments (Box G).

Box G

Barriers to climate investment

Investment barriers are specific factors that affect the cost of investing, the risk of investing and the level of the competition in a market. They are often location or country specific. The EIB's experience financing investment projects in all EU countries has allowed it to collect insight on the most relevant and common barriers to investment. In the European Union, four main types of factors can produce investment barriers:

(1) Regulation (regulatory uncertainty, regulatory fragmentation and administrative procedures)
(2) Market size and structure (with a lack of European Union-wide standards very often holding back investment projects in national markets that are still small and fragmented)
(3) Public sector promoter constraints (weak project planning and preparation capacity and difficulty coordinating funding resources)
(4) Access to finance

Regulation. The first obstacle for climate investors is related to the very definition of what a climate project is. The EU sustainable finance agenda contains a classification system defining economic activities that make a substantial contribution to environmental objectives under the EU taxonomy. However, the development of such a system is being hampered by a lack of understanding or ability to define the classifications. This situation should improve once the EU taxonomy and the sustainability-related disclosures under the Sustainable Finance Disclosure Regulation are fully in force at the beginning of 2023, but it will require an immense effort across the European Union to establish the information flows necessary to track green investments consistently.

Market size and structure. In line with the 2030 greenhouse gas reduction targets and the 2050 carbon neutrality objective, different industries' approach towards decarbonisation essentially determine key investment needs, and therefore set the boundary for the market size and structure for climate finance. Investment barriers in sectors with a pressing need for low-carbon investment include the following:

- For the most part, transformational technologies that permit **energy-intensive industries** to reduce their carbon emissions are not yet commercially viable. In other words, low-carbon alternatives remain more expensive than conventional processes relying on fossil fuels. The challenge to investment in low-carbon solutions is exacerbated by pressure from international competition, often from countries or regions with lower environmental and social standards.
- The fragmented nature and the large number of small producers in the **agriculture and food industries** present challenges for climate investment, as they must all move towards lower carbon production practices to drive overall improvement. Intermediated lending could facilitate the

development of advisory programmes at the national level to support changes toward lower-carbon, more sustainable practices. In addition, the industry also finds it difficult to identify and incorporate climate-related risks into the value chain. In this respect, investments made by competitors are the most important market signals, suggesting that the sector will move toward climate resilience relatively slowly until it reaches a critical mass of investment.

- The **transport** sector needs to achieve the European Union's 2030 climate and energy targets through a combination of decentralisation, decarbonisation (including electrification) and digitalisation. Passenger and freight rail projects are capital intensive, lengthy and complex. They are typically carried out by the public sector at the municipal or local level and are therefore exposed to public sector promoter constraints and limited access to finance. Alternative fuels (such as hydrogen infrastructure) to support transport activities are currently still in the early stages of development, with supply and demand of fuel cell vehicles currently at comparatively low levels.
- Meeting the current 2030 target may well require doubling or tripling current capacity for **renewable power generation**. Deploying such massive renewable capabilities is likely to pose challenges to system integration, local support and coordination between government agencies responsible for energy and climate policy. Investment barriers to renewable energies mainly concern development barriers. Permitting procedures are generally difficult and severe restrictions may be in place, which are partly a reflection of local opposition.
- **Energy efficiency** projects face problems of imperfect information. Energy prices are volatile while energy needs are determined by unpredictable factors like the weather. In addition, the variety of contractual relationships in the building sector (buyers and sellers, owners and renters, and borrowers and lenders) can reduce incentives to invest in energy efficiency, to the extent that owners do not have to pay energy costs for buildings that are rented out. These problems are magnified by high upfront costs and a multitude of parties involved in energy efficiency investments.
- **Public sector promoter constraints.** Adaptation to climate change is typically initiated, financed, and implemented by the public sector. However, national strategies often lack estimates of the adaptation investment need, and do not typically include concrete proposals for capacity-building exercises that would teach promoters to see how a project encompasses climate change. If local project promoters lack the ability to identify climate risks and to integrate greater resilience into project designs, identifying adaptation projects will be difficult. There may therefore be a gap between the development of national strategies and their translation into a pipeline of bankable projects.

For climate change mitigation, the main obstacles faced by local and regional authorities stem from a lack of awareness, capability and capacity to identify the investments needed. Climate financing classification and reporting takes resources, and authorities (particularly small ones) facing budgetary constraints may be unable to develop the necessary capacity. The aggregation of small-scale projects managed by different authorities into a larger portfolio remains a potential solution for connecting financing partners with climate financing opportunities.

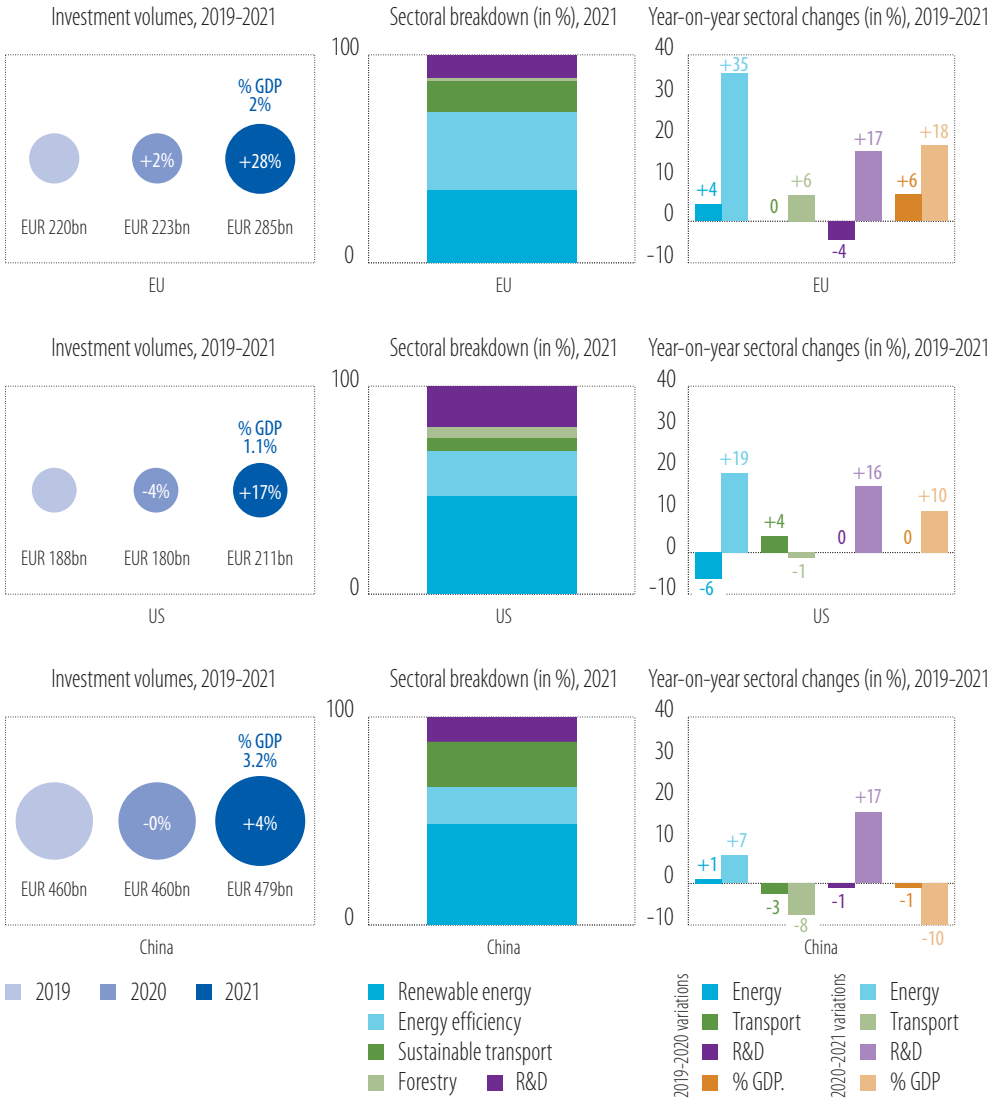
Access to finance. Information gaps (particularly for finance for small and medium firms) are one of the main barriers to green finance in general, and climate action in particular. The smaller the promoter and/or the project and the more there are, the more difficult it is for a financing institution to acquire the information necessary to classify an investment as green. If potentially viable green investments are not clearly identified, they may not benefit from tailored funding opportunities.

The EIB has observed growing interest among its intermediary clients, primarily banks, in opportunities to provide innovative climate financing products — products that could support energy efficiency upgrades, renewable power generation, green buildings, circular economy, green transport, climate-smart agriculture, etc. In fact, intermediaries in the European Union cannot afford to miss out on the transition to low-carbon and resilient economies. Climate-related risks may directly affect their clients' financial positions, making climate risk an important element of any credit decision. Furthermore,

financial intermediaries also need to understand the climate risks posed to their assets in general and design measures to mitigate them.

Despite this increased interest, climate change considerations are far from becoming mainstream business for commercial banks. Technical assistance and advisory support for banks is crucial to help intermediaries engage in green lending, and to build sustainable lending capacity. The EIB provides such support by developing advisory and support tools for financial intermediaries and by offering them specific advisory packages.

Figure 31
Climate change mitigation investments, 2019-2021



Source: *International Energy Agency, Eurostat, Joint Research Centre, World Bank, OECD and EIB staff estimates.*
Notes: *Data for investment in forestry in China were unavailable. Non-energy estimates for 2021, wherever missing, were derived from data on gross fixed capital formation in related sectors.*

The gap between European and Chinese climate spending is progressively closing as policy objectives diverge. The industry-led pandemic recovery and energy security concerns in China triggered a rebound in fossil fuel usage and investments in 2021, to the detriment of cleaner alternatives. After a year of stagnation in 2020, the volume of Chinese investments in climate mitigation increased slightly in 2021, rising 4% compared to 2020. China's commitment to reaching carbon neutrality before 2060 has not yet translated into a sizeable shift in investments. China needs USD 17 trillion in investments to meet its climate goals, but it lacks the predictable regulatory environment and good access to markets and finance required to unleash private sector participation (World Bank Group, 2022).

Some sectors that are key to climate mitigation objectives receive insufficient support, narrowing the odds of delivering the energy transition on time. With 60% of transport carbon emissions coming from heavy-duty transport, the deployment of sustainable transport solutions is not just critical to economic development, but also essential to carbon neutrality. And yet dedicated investments have levelled off in recent years in most regions and countries. In line with the aspiration of many Europeans to use trains rather than planes for short-distance travel (EIB, 2022b), railway developments are now a priority in the European Green Deal. The Connecting Europe Facility mobilised EUR 5.4 billion to help connect roads, railways, inland waterways, short-sea shipping routes, ports and airports across the continent. The forestry sector also receives insufficient support. The EU Forest Strategy for 2030, another contribution to the European Green Deal announced in July 2021, acknowledges the role of forests on the path toward carbon neutrality. It is based on the environmental, social and economic benefits of sustainable forest management.

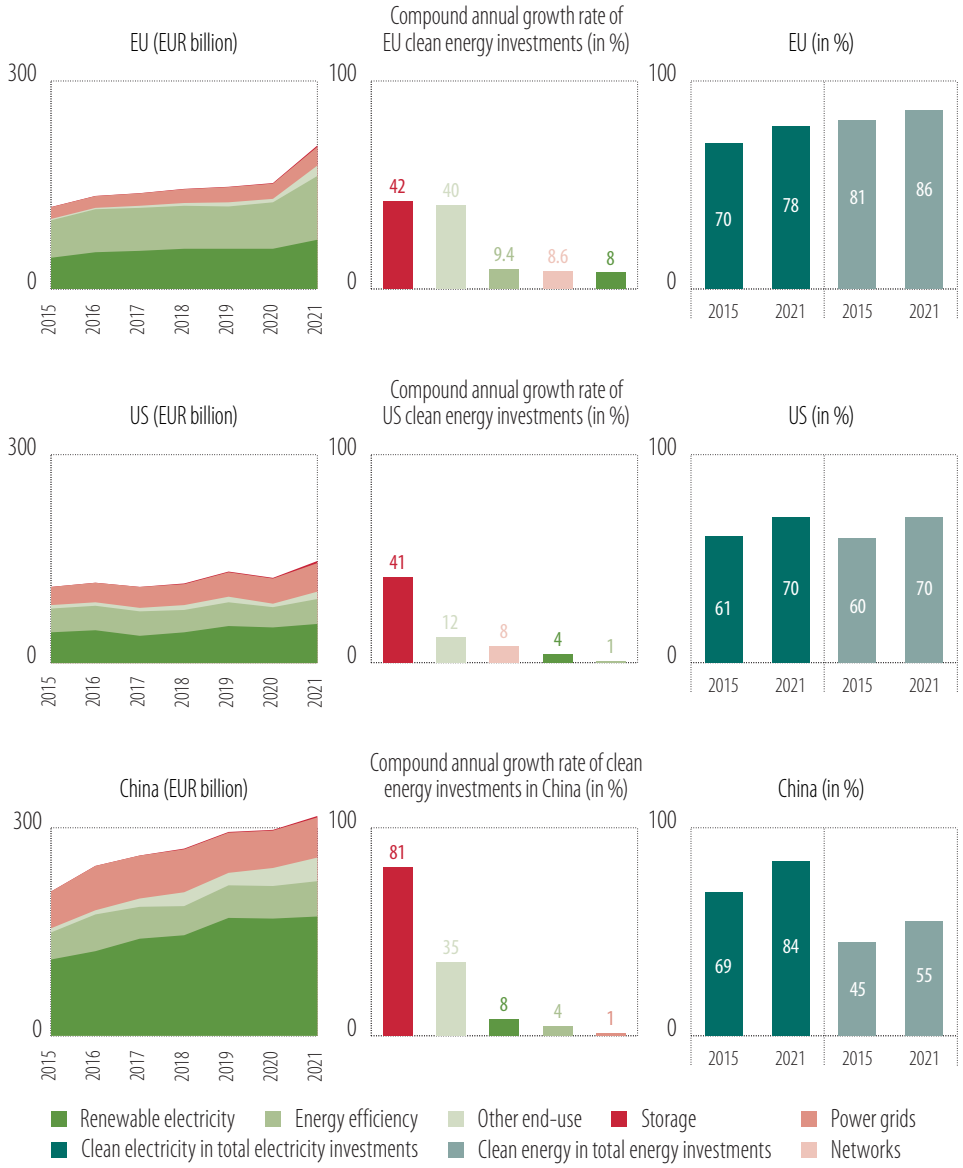
Electricity

Boosted by policy measures, spending on clean electricity projects accelerated sharply in 2021 even before the energy crisis. Over 70% of total climate investments in Europe, and 60-65% in the United States and China, were devoted to renewable energy and energy efficiency in 2021 (Figure 31). The increase in the European Union (35%) was notably helped by the adoption of the EU taxonomy for sustainable activities, a classification system establishing a list of environmentally sustainable economic activities. The taxonomy clearly identifies renewable energy and energy efficiency as the cornerstone of the bloc's energy strategy, as confirmed by the REPowerEU plan in response to the war in Ukraine (see Chapter 6). In the United States, the Inflation Reduction Act is expected to provide new impetus to clean energy investments. These strong policy signals and incentives, combined with a global shift towards more transparency and climate risk disclosure, encourage the alignment of corporate and financial strategies with net-zero objectives.

Solar and wind energy have become default options for clean energy investment, and for investors they remain the most attractive alternatives to fossil fuels. The volumes of financial support for wind and solar projects are now on par in Europe and the United States. These include production capacity increases and associated investments in upgrades of power transmission and distribution networks. From 2020 to 2021, renewable investments increased by almost EUR 20 billion in the European Union, twice the amount in the United States. Solar capacity additions in Europe have been growing consistently at 15% a year for the last three years. In cumulative terms since 2015, they have surpassed wind energy. This strong growth in wind and solar capacity results from favourable policy and regulatory environments, but also declining costs (Figure 32). Spending in China is still more than twice what it is in the European Union, however. Investments in renewable electricity levelled off in China because of further cost reductions in large-scale solar and wind projects, but 50% of new wind capacity globally (and 40% of solar) were built in China in 2021 (International Renewable Energy Agency (IRENA), 2022a).

The recent supply chain disruptions are unlikely to alter renewable energy's competitiveness in the medium term. The volume of solar panels imported to Europe from China (the dominant supplier globally) have increased 250% since the war in Ukraine began, reaching well above EUR 2 billion by mid-2022. However, the rise in material costs may affect the risk profile of some projects and act as a brake on clean energy adoption — but only temporarily, as policy frameworks and market conditions remain particularly favourable to solar and wind projects.

Figure 32
Climate mitigation investments in the energy sector, 2015-2021

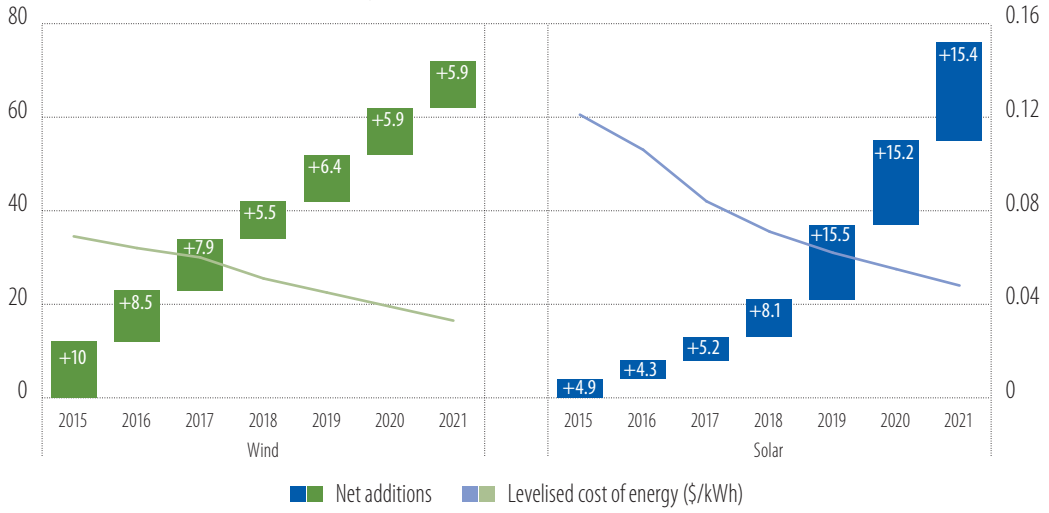


Source: *EIB staff estimates based on International Energy Agency data.*
Note: *For each column/country group, technology breakdowns of energy investments (first row) are followed by compound annual growth rates for key sectors and technologies pointing to fast-growing/emerging clean energy solutions (second row). The third row of indicators highlights the shift towards clean energy investments.*

Investors' appetite for energy storage options and clean fuels like green hydrogen appears to be growing. Energy storage technologies are often seen as the missing link between the deployment of intermittent renewables technologies — mainly solar and wind — and effective transmission to end-users. Spending remains low (less than EUR 2 billion in Europe in 2021), but it is growing rapidly (+40% every year on average in Europe and the United States since 2015, and up to 80% in China). There is also a strong political push to foster innovation and develop strategic industries through industrial coalitions (like the European Battery Alliance or the European Clean Hydrogen Alliance), to reduce dependence on non-EU suppliers and address energy security concerns exacerbated by the war in Ukraine. Support from institutional investors can help reduce the structural risks to innovative industrial projects.

Figure 33

Additions of wind and solar capacity in the European Union (left axis, in %)**, weighted average** (levelised) **cost of electricity** (right axis) **2015-2021**



Source: *IRENA (2022b).*

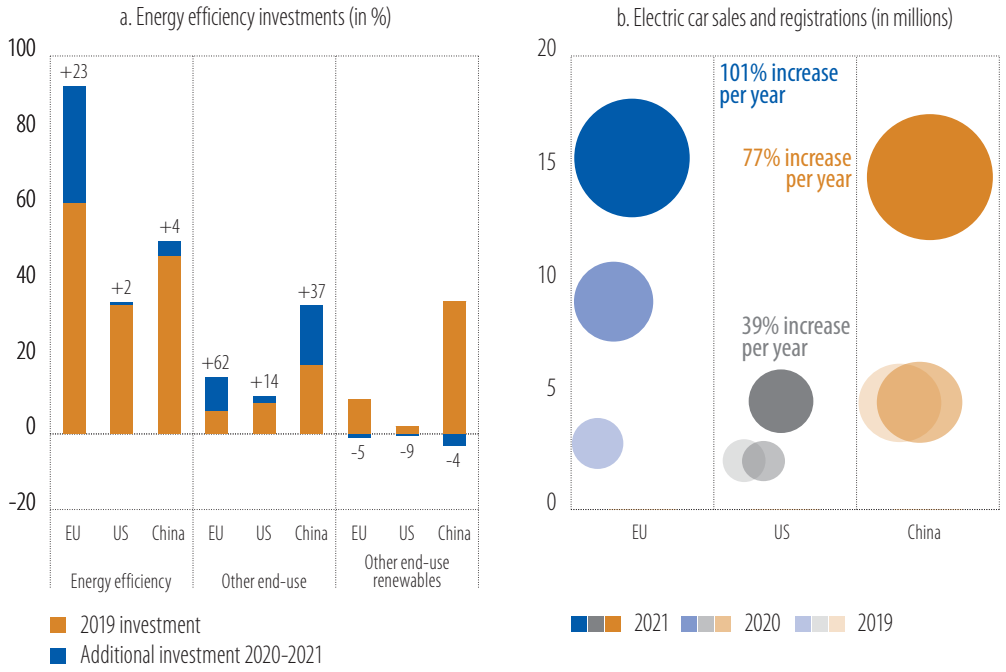
Chronic underinvestment still plagues reliable and dense power networks, which are essential for integrating large-scale renewable energy and providing quality electricity services. Russia's invasion in Ukraine turned the spotlight on the critical importance of reliable grids and cross-border interconnectors to lessen the risk of domestic electricity shortages. Investments to upgrade grids also need to keep pace with renewable energy investments. The European Union devotes just 13% of clean electricity spending to power grids — less than half the share in the United States. Recognising the need to modernise the power grid and enable more flexible management of the EU energy system, the European Commission designed an EU action plan to digitalise the energy system. The plan calls for investments worth EUR 556 billion by the end of the decade. Similar concerns are observed in the United States, where growing blackouts impede economic activity and less than 200 miles of electricity transmission lines were completed in 2021. The country is weighing USD 13 billion in grid modernisation projects, and the Biden-Harris administration awarded USD 3 billion to companies in October 2022 to supercharge the manufacturing of electric vehicles and grid infrastructure in 12 states.

Energy efficiency

European governments designed their recovery plans in 2020-2021 with a focus on energy efficiency, seeing it as economically and environmentally sound. Two-thirds of public spending on recovery were directed to energy efficiency in 2021. This was mainly driven by the retrofit of buildings in Europe, and to a lesser extent by efficiency measures adopted in industries (IEA, 2021) (Figure 34). Overall, energy efficiency investments in Europe grew 23% in 2021. New business models are emerging, stimulated by the implementation of stricter building codes, standards and labelling schemes. Supported by venture capitalists, energy efficiency startups use digital services to monitor energy consumption and deliver value to customers and energy system operators. In Europe, the constraints on energy supply and the hike in energy prices in the wake of Russia's invasion of Ukraine have only made energy efficiency and other energy saving measures more attractive. Energy savings are an integral part of the REPowerEU plan.[22] Early estimates suggest that gas demand was down 10% in Europe by November 2022, driven by the voluntary adoption of energy saving measures by certain large industrial energy consumers, reduced activity in some cases and households' response to spiking energy prices.

22 See Chapter 6 for details on targeted energy efficiency measures.

Figure 34
Increase in energy efficiency investments, electric car sales and registration, 2019-2021



Source: *IEA (2022). Bubble size indicates the volume of total car registrations.*

Electric vehicles have reached mass market in some countries, pulling carbon emissions down. With 20% of total sales and 2.3 million cars delivered in 2021, Europe is making headway in electric mobility. But China exhibited even stronger growth in 2021 (+37% and 3.3 million units sold). Globally, electric vehicles sales reached 6.6 million in 2021 and are poised to cross the 10-million-unit mark in 2022 despite supply chain disruptions, strict lockdowns in Asia and some uncertainty on car manufacturers' ability to meet demand (Bloomberg New Energy Finance (BNEF) Clean Energy Ministerial (CEM), 2022).

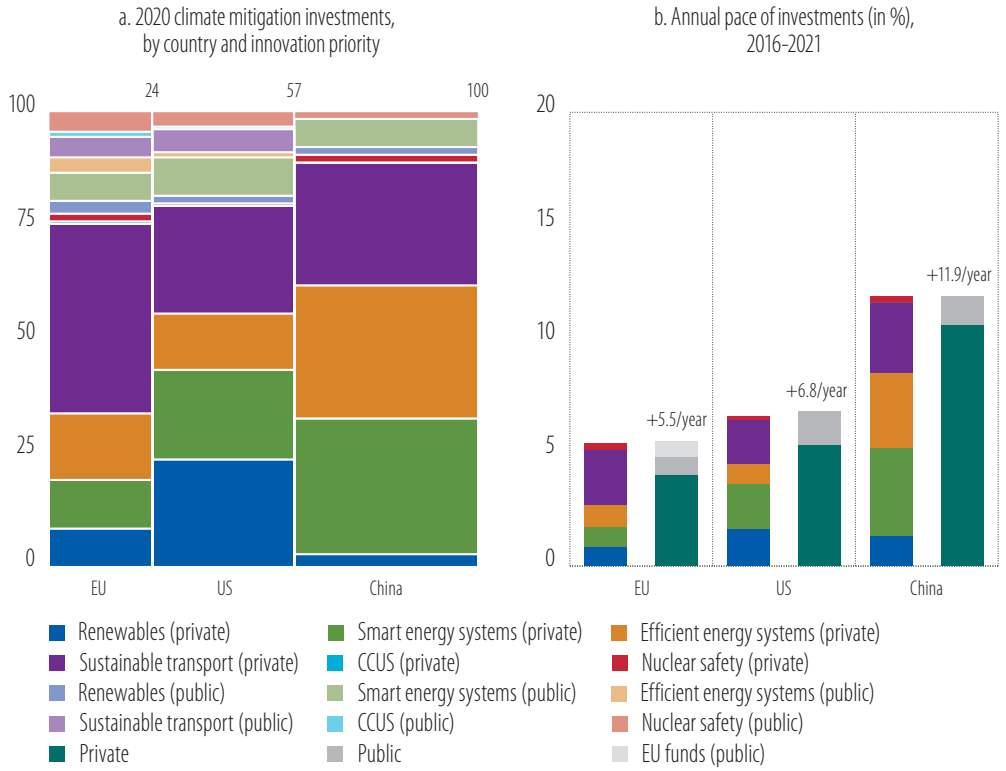
European R&D is particularly strong in sustainable transport

Climate innovation investments were part of government response to the pandemic, and are again taking centre stage during the energy crisis. After a year of stagnation in 2020, R&D spending bounced back and increased by 16-17% in Europe, the United States and China. The United States and China consolidated their positions as R&D leaders. About 18% of climate investments in the United States are devoted to R&D. China, however, is catching up and has increased spending by an average of 12% annually over the last five years. With an annual budget slightly above EUR 32 billion in 2021, Europe's support for climate innovation is losing some ground to its competitors (OECD, 2022). Preliminary estimates for 2021 R&D spending suggest a strong increase in sustainable transport in Europe, favoured by the Recovery and Resilience Facility. The transport sector was a key beneficiary of public spending on R&D in 2021 (+44% relative to 2020), in contrast with overall R&D budgets and energy-related R&D budgets, which grew 6-7%.

Corporate R&D in Europe is concentrated in industries that were hit hard by the COVID-19 crisis, causing the drop in overall R&D activity in 2020. In 2020, 12% of climate mitigation investment went to R&D, 85% of which was provided by the private sector. Only Germany, Denmark and Austria had dedicated 0.3% or more of their GDP to R&D spending. In 2021, business R&D in Europe showed signs of recovery, growing at faster pace than before the crisis (OECD, 2022).

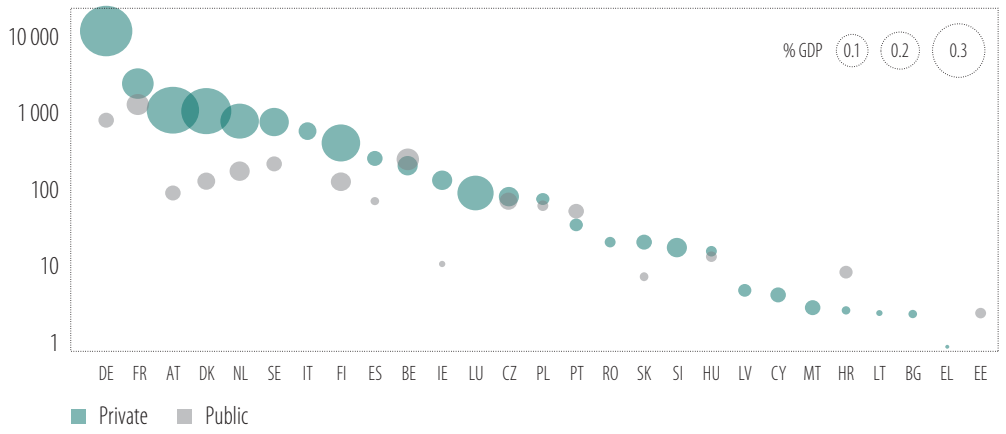
Patent data confirms the European priority of developing greener transportation and mobility, a key area shifting towards clean energy. 1.2% of the European patent portfolio (compared with 0.4% in the United States and 0.6% and China) is devoted to electric vehicles and the development of European supply chains, including manufacturing green materials and developing battery technologies and charging networks. Electrification and its enabling technologies — such as wind, solar, smart grids and fuel cells — are also the object of numerous European patent registrations.

Figure 35
Breakdown of climate mitigation investments, and annual pace of investments



Source: *Joint Research Centre.*
Note: *CCUS stands for carbon capture, utilisation and storage.*

Figure 36
Public and private R&D investments (EUR million) **in 2020, by country**



Source: *Joint Research Centre.*

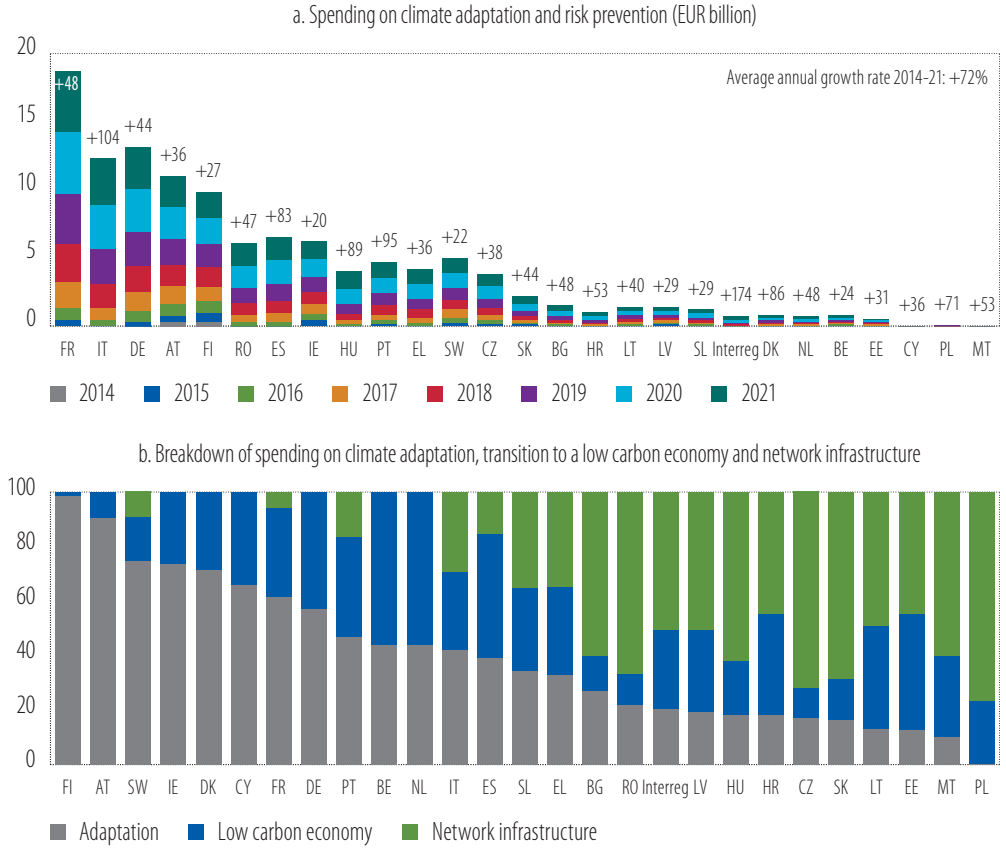
Financing of climate adaptation is gradually rising

The financing gap between climate mitigation and climate adaptation is closing only very slowly. Investors and decisionmakers are showing increasing awareness — and concern — about the economic and social impacts of climate change on livelihoods and economic activity. Rating agencies, banks and insurance companies are developing novel science-based methodologies and location-specific assessments to assess actual exposure to current and future climate risks. Yet, the global volume of investments devoted to adaptation projects accounts for less than 10% of global annual spending on climate (Climate Policy Initiative (CPI), 2021; United Nations Framework Convention on Climate Change (UNFCCC), 2021).

Financing from European structural and investment funds is growing for climate adaptation and risk prevention. The cumulative volume of investments grew yearly by 72% since 2014, reaching nearly EUR 120 billion. However, France, Italy and Germany alone accounted for one-third of total spending, and stark differences remain between EU countries (Figure 37). Until now, the bulk of adaptation funding was allocated to risk management measures in the agricultural and forest sectors. The climate resilience of infrastructure, which is often of national strategic importance and a pillar of economic activity, remains largely underserved. Adaptation funds are now on a par with spending on the low-carbon economy and the development of network infrastructure, but they mainly target Western European countries. The development of network infrastructure remains a priority in Central and Eastern European countries (chiefly Poland) to the detriment of adaptation measures and despite the region's acute exposure to future climate risks.

Figure 37

Spending on climate adaptation, risk prevention and the transition to a low-carbon economy



Source: *European Structural and Investment Funds.*
Note: *Numbers above bars in panel a show cumulative increase since 2014.*

Conclusion and policy implications

Investment in the European Union has come under serious pressure following a string of unfavourable developments. High energy prices are increasing inflation, directly and through second-round effects, as producers pass the rising costs on to their customers. This erodes real incomes and slows down aggregate demand, which in turn leads to lower investment. At the same time, a persistent and large gap in productive investment and in innovation between the European Union and the United States threatens to widen the productivity gap. Investment in innovation, intangible capital and advanced machinery and equipment is fundamental to enhancing productivity growth. The failure of many EU members, particularly in Southern Europe and in Central and Eastern Europe, to increase investment in these assets holds down productivity in their economies.

The surprising resilience of government investment might be threatened by the reintroduction of fiscal rules and the phasing out of stimulus measures. Government investment has been increasing over the past two years, fuelled by fiscal stimulus programmes and unfettered by EU fiscal rules. In some countries, particularly in Southern Europe, the rebound came after years of depressed levels of government investment. While the Recovery and Resilience Facility continues to provide a solid boost for countries that deliver on promised reforms and projects, investment momentum needs to be maintained if Europe is to secure its energy supply and facilitate the digital and green transition.

Using national and Recovery and Resilience Facility resources hinges on improving capacity. Available funds and implemented reforms are no guarantee of investment. Significant investment barriers impede the rollout of projects, including those in national recovery and resilience plans. Furthermore, the ability of local and national governments to identify and implement projects is uneven across the European Union and within countries, which also leaves available finance unused. Concerted policy effort, possibly coordinated at the EU level, is needed to address these obstacles to government investment.

Europe may be ahead in certain innovative domains, such as green innovation, but European policymakers must be vigilant to maintain dominance. Europe may find it difficult to remain on top in the areas in which it currently excels, particularly given the strong positions of the United States and China in the development of new digital technologies. The European Green Deal and the European Union's digital strategy are central to the recovery plan for Europe. Combined with the national recovery and resilience plans, these initiatives present a unique opportunity to transform the EU economy and make it greener, more digital and more innovative. European policies should also internalise the policies of other major economies. The US Inflation Reduction Act, for instance, raises concerns about whether the playing field in innovation will remain level, especially climate-related innovation. Such a lack of international policy coordination, especially among partner countries, threatens the openness of trade.

The European Union's current innovation strengths are just one step in the process, and policy intervention is needed to create, develop and roll out innovation quickly enough and at the right scale. It is especially important that the policy instruments — carbon pricing, regulation and public support for clean R&D — be deployed simultaneously and in a coordinated manner, as this would allow major synergies to be exploited. Intervention is needed to overcome inertia among investors and consumers and to stimulate demand for innovative green technologies. A coordinated push could increase firms' appetite for taking risks to develop technologies (such as hydrogen and carbon capture and storage) that Europe needs to reach carbon neutrality.

Policy coordination at the EU level is needed to address mounting downside risks to investment. Investment in the European Union is stifled by impediments that must be addressed, mostly through national policies and EU coordination. At the same time, EU members should strengthen project implementation capacity, especially at the local government level, so that allocated financing reaches the most urgently needed projects and is used efficiently. Targeted government investments must leverage the complementary abilities of the public and private sectors to boost private investment. Policies at the national and EU level that address high economic uncertainty are also crucial. Coordinating all these policies at the EU level would ensure an efficient and effective use of resources by creating synergies. EU level responses to the pandemic worked effectively, and they could provide guidance going forward.

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