2020

INVESTMENT REPORT
2020/2021

European Investment Bank
The EU bank

Building a smart and green Europe in the COVID-19 era

2021

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Investment report 2020/2021: Building a smart and green Europe in the COVID-19 era
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About the Report
The EIB annual report on Investment and Investment Finance is a product of the EIB Economics Department, providing a comprehensive overview of the developments and drivers of investment and its finance in the European Union. It combines an analysis and understanding of key market trends and developments with a more in-depth thematic focus, which this year is devoted to European progress towards a smart and green future in a post-COVID-19 world. The report draws extensively on the results of the annual EIB Investment Survey (EIBIS) and the EIB Municipality Survey. It complements 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 in the definition of its positioning, strategy and policy. The Department, a team of 40 economists, is headed by Debora Revoltella, Director of Economics.

Main contributors to this year's report
Report Director: Debora Revoltella
Report Coordinators and Reviewers: Pedro de Lima and Atanas Kolev

Introduction: Atanas Kolev.
Chapter 1: Atanas Kolev (lead author), Laurent Maurin (lead author), Koray Alper, Luca Gattini, Jochen Schanz and Patricia Wruuck.
Chapter 2: Atanas Kolev (lead author), Andrea Brasili, Peter McGoldrick and Jochen Schanz.
Chapter 3: Laurent Maurin (lead author), Joel Auber, Frank Betz, Rozalia Pal and Patricia Wruuck, together with Antonia Botsario, Salome Gvetadze, Helmut Kraemer-Eis, Frank Lang and Wouter Torfs (all European Investment Fund, Research and Market Analysis).
Chapter 4: Fotios Kalantzis (lead author), Andrea Brasili and Annamaria Tueske.
Chapter 5: Fotios Kalantzis (lead author) and Hanna Niczyporuk (New York University).
Chapter 6: Laurent Maurin (lead author), Giovanni Barci, Emmanouil Davradakis, Aron Gereben, Annamaria Tueske and Marcin Wolski.
Chapter 7: Christoph Weiss (lead author), Julie Delanote, Peter Harasztosi, Désirée Rückert, Antilia Virginie, Sara Amoroso (European Commission, Joint Research Centre, Box A), Petros Gkotsis (European Commission, Joint Research Centre, Box A) and Nicola Grassano (European Commission, Joint Research Centre, Box A).
Chapter 8: Julie Delanote (lead author), Désirée Rückert (lead author), Peter Harasztosi and Julie Callaert (ECOOM, KU Leuven, collaboration for PATSTAT data preparation, Box A).
Chapter 9: Peter McGoldrick (lead author), Maïa Debs, Julie Delanote, Atanas Kolev and Désirée Rückert.
Chapter 10: Patricia Wruuck (lead author), Aron Gereben, Peter McGoldrick, Désirée Rückert, Annamaria Tueske, Daniel Wetzel (International Energy Agency, Box B) and Marcin Wolski.

Scientific advisory committee: Giorgio Barba Navaretti (Università degli Studi di Milano), Eric Bartelsman (Tinbergen Institute), Catherine L. Mann (Citi), Steven Ongena (University of Zurich), Pier Carlo Padoan, Peter Praet, Jan Svejnar (Columbia University) and Reinhilde Veugelers (KU Leuven).

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Executive summary

Post-pandemic: Stagnation or transformation?

Europe faces a choice. The recovery from the coronavirus pandemic provides a unique opportunity for transformation – the innovative retooling needed to thrive in the new, more digital world created by the pandemic, while also limiting climate change and preparing for its impact. It is an opportunity to set Europe firmly on a path to carbon neutrality by 2050 and shore up its global leadership in smart-green technology. It is an opportunity to repair the damage wrought by the pandemic and to strengthen social cohesion.

Yet there is also a serious risk. The uncertainties and financial strains created by the pandemic could keep the EU economy from embarking on the necessary transformation. The dangers are numerous: massive public spending is too untargeted; Europe falls behind the new wave of digitalisation; it fails to make the transition fast enough; and it loses the advantages of its leadership in green technology. Failing to live up to these challenges means more than just a longer recovery. It means that Europe's sustainability, competitiveness and prosperity might be impaired for decades to come.

This report is about the investment needed to achieve the smart and green transformation of the European economy. It is about progress so far – the fallout from the pandemic and what is needed to get back on track. It examines the state of investment and investment finance for climate change mitigation and for the adoption of digital technologies. It looks at how Europe is positioned at the critical intersection of green and digital innovation, the role of investment by municipalities, and the risks and opportunities of the twin digital and green transition[1] for social cohesion. Throughout, the report examines the latest impact of the coronavirus pandemic and the urgent policy response needed.

Investing for the climate transition

In 2019, European investment in climate change mitigation increased gradually. In the EU27, this investment grew 2.7% from a year earlier to EUR 175 billion. The strongest growth was recorded in renewable energy generation, while investments in energy efficiency appeared to stagnate.

European investment in climate change mitigation is well behind that of China, but ahead of the United States – although the contexts are very different. China invested 2.7% of gross domestic product (GDP) in climate change projects, ahead of 1.3% in the European Union and 0.8% in the United States. However, the European Union has already gone much further in reducing emissions per unit of GDP. In a sense, Europe has already picked much of the "low-hanging fruit," and its efforts increasingly have to focus on harder-to-reduce emissions.

The gap between Europe's climate objectives and realised climate investment is growing. Since 2016, climate change mitigation investment has declined marginally as a percentage of GDP and overall investment, a trend that is likely to continue in 2021. According to the European Commission's latest impact assessment, investments in the continent's energy system would need to rise from an average of 1.3% of GDP per year over the last decade, to 2.8% of GDP over the next decade if the European Union is to meet its goal of cutting greenhouse gas emissions by 55% by 2030. Adding investments in transport brings the total over the next decade up to 3.7% of GDP per year. European investment in climate change mitigation is still insufficient.

1 A term used by European Commission, the twin transition refers to the EU goals of carbon neutrality and digital leadership.

In the coming decade, the focus has to shift from investment by energy producers to investment by energy consumers, including firms, households and municipal authorities. Of the additional investments needed in the next decade, 65% to 75% are expected to focus on improving building insulation, upgrading industrial processes, purchasing more efficient equipment and investing in new transport technologies.

The European Investment Bank Investment Survey (EIBIS) provides a window into climate-related investment by European firms:

- **23% of European firms say that climate change and related weather events have already had a major impact on their business,** vs. 14% in the United States. Another 35% of European firms report climate change effects to be minor.
- **Just over half of EU firms do not think the transition to a net-zero emission economy will affect their operations over the next five years, and of those that do, the majority see the transition as an opportunity.** The firms that expect the transition to have an impact say it could stimulate demand and improve their reputation. Firms are more likely to see the effect on their supply chain as negative, however, and energy-intensive firms expect more negative effects overall.
- **45% of EU firms have invested in climate change mitigation or adaptation measures (vs. 32% in the United States), but fewer plan to do so in the next three years.** The investment figure varies from 50% in Western and Northern Europe to 32% in Central and Eastern Europe. A slightly lower 40% of European firms are planning to invest in climate measures in the next three years. A majority of European firms, 75%, say uncertainty about regulation and taxation is impeding climate-related investment.
- **The proportion of EU firms reporting investment in energy-efficiency measures increased to 47%,** up almost 10 percentage points over 2019. The average share of investment devoted to energy efficiency rose from 10% to 12%, with large firms and manufacturing firms more likely to invest.

While more than half of municipalities have increased climate change mitigation investments over the past three years, two-thirds still consider the level of investment to be inadequate. The EIB Municipality Survey 2020 reveals that 56% of municipalities increased climate investment, but 66% consider their climate investment over the last three years to be inadequate. For investment in climate change adaptation, 44% increased investment and 70% consider investment to still be inadequate. This suggests that climate adaptation investment could be a more pressing issue in the future.

Investing for digital transformation

Europe's future prosperity depends on leading the next wave of industrial transformation: digitalisation. The digital revolution has already transformed industries, production processes and ways of living and working, but many of these shifts are only just beginning. As with previous technology waves, taking an early lead can be critical for lasting competitiveness. Yet with the global innovation and technology landscape changing rapidly, Europe risks becoming entrenched in its position as a follower on digitalisation.

So far, the impact of digitalisation has been largely benign. Technological waves, like the first industrial revolution, have driven massive changes in the nature of work, its location and the skills people need. Digitalisation has already caused a shift towards high-skilled occupations, with these jobs tending to cluster in favoured urban areas, particularly capital city regions. EIBIS data present interesting evidence. Firms that have adopted digital technologies are also more productive, more innovative and more likely to export. They are creating more employment than non-digital firms and also pay higher wages on average. Digitalisation has provided a strong stabilising effect during the COVID-19 crisis.

But a painful process of re-adjustment awaits firms and regions that lag behind. A trend towards economic and geographical polarisation is emerging, contrasting the digital leadership of some firms

and regions with the slow progress of others. Job growth in recent years has been driven by higher-skilled positions. In the near future, the accelerated loss of low and medium-skilled jobs through automation could create a massive need for re-skilling.

The adoption of digital technologies by EU firms is growing, but it has not yet closed the gap with the United States. By 2020, 37% of European firms had still not adopted any new digital technologies, compared with 27% in the United States. Encouragingly, the proportion of digital firms in the European Union grew by nearly 5 percentage points over the 2019 level, but the United States saw a comparable increase. The gap with the United States is particularly marked in the construction and service sectors, and in the adoption of technologies associated with the internet of things.

Firm size and market fragmentation appear to be holding back digital adoption in Europe. High fixed costs and financing obstacles for intangible assets often make it easier for large firms to invest in digital technologies. Adoption rates for micro and small firms are notably lagging on both sides of the Atlantic. The comparatively small average size of European firms – itself a partial reflection of the continued fragmentation of European markets along national lines, including for digital services – is likely contributing to the continent's low digital adoption rates.

Municipal investment in digital infrastructure is advancing, but disparities could result in further polarisation. Over the last three years, 70% of European municipalities increased investment in digital infrastructure. Looking forward, municipalities state that digital remains a top priority, alongside social and climate-related investments. But there are strong regional disparities in the perceived adequacy of municipal infrastructure investment. A lack of digital infrastructure is seen as a major obstacle for investment by 16% of EU firms, vs. only 5% in the United States. There is also some evidence that digital adoption by firms is higher in municipalities that have better digital capacities and infrastructure.

Europe is losing ground within a rapidly changing global innovation landscape. While still at the forefront of technology, the European Union is investing less in research and development (R&D) as a percentage of GDP than other major economies, and China is emerging as a major player. Europe's weakness lies in its lower business R&D spending. European companies are among global R&D leaders in various traditional industries, but are less present in fast-growing digital sectors such as software and computer services, where Chinese firms are starting to challenge the United States. The European Union also does not appear to be generating many new innovation leaders, especially in the digital sector, potentially jeopardising its long-term competitiveness.

The green-digital nexus: How is Europe positioned?

Digital technologies will be critical to the climate transition, and innovation at the intersection of digitalisation and decarbonisation will be paramount. Examples of enabling digital technologies include smart urban mobility and smart grids, precision agriculture, sustainable supply chains and environmental monitoring. The growth of teleworking during the pandemic illustrates how economic processes and products can increasingly be dematerialised. Innovation that uses digital technologies to achieve greener processes is of particular strategic importance for both future sustainability and competitiveness.

Europe is a global leader in green innovation, and even more so in innovation that is both green and digital – despite the United States' leadership in most digital domains. According to the most recent data, Europe registered 50% more patents in green technologies than the United States, with Japan and China further behind. Moreover, Europe registered 76% more patents that combined both green and digital technologies than the United States, and four times more than China. Likewise, while the top global companies for digital innovation are largely American – with potential challengers from China – the top innovators for green technologies and technologies that combine green and digital elements tend to be European companies, with Japan in second place.

European firms lead the United States for green investment and digital adoption by green firms. Compared to the United States, European firms are less likely to have adopted digital technologies, but are more likely to invest in measures for mitigating or adapting to climate change. The share of firms that make green investments and are also digital adopters is also marginally higher in Europe (32% vs. 28% for the United States).

At the intersection of green and digital technologies, leading early in innovation may create a winner-takes-all effect. The development of green technology still offers great opportunities. Firms that have innovated in this sphere see the climate transition as leading to more dynamic markets, with more competitors entering, but not necessarily with a loss of competitive advantage for themselves. In addition, green-digital innovators are more likely to enjoy a wider, more global playing field. Such potentially large markets for green and digital innovations offer enormous possible rewards, perhaps leading to winner-takes-all dynamics for Europe.

However, Europe's leadership in green-digital innovation could easily be lost. When looking at how much patents are cited by other innovators, Europe's green-digital patent portfolio has a higher impact than all other regions. However, this impact per patent is still higher in the United States. Europe's relative weakness in general digital innovation and its dependence on digital innovations from elsewhere could potentially undermine its position. Nevertheless, one of the key strengths of Europe lies in the transport sector. There, Europe leads not only in green and green-digital innovation, but also in digital innovation overall.

How has COVID-19 changed the economic landscape?

When the pandemic struck, investment had been strong in most of Europe, but had abruptly begun to slow. In 2019, aggregate investment in the European Union grew around 3% from a year earlier, outpacing growth in real GDP. The rate of investment at the end of 2019 was above its long-term average in all areas of Europe except Southern Europe. However, intensifying international trade disputes and weakening global trade started to weigh on that growth. On the cusp of the coronavirus outbreak, concerns were mounting about the stalling of trade-oriented economies – notably Germany's.

The outbreak of the pandemic in Europe in mid-March had immediate and dramatic consequences for investment:

- **Investment contracted precipitously, along with other economic activities, as a direct result of lockdown restrictions.** This effect was mostly felt in the second quarter of 2020, when investment fell 19% compared with a year earlier, as most restrictions were lifted by the summer.
- **Economic sentiment deteriorated strongly, with firms adopting a pessimistic outlook for the year ahead.** Firms' perceptions of the economic climate had already turned negative in 2019. Those sentiments took a further dive with the arrival of the pandemic. Overall expectations of sector-specific business prospects and the availability of internal and external finance also turned negative.
- **Uncertainty about the future rose to become a major deterrent to investment.** Uncertainty indicators spiked at the beginning of the pandemic. Although Europe's determined economic policy response succeeded in calming short-term fears, a high degree of uncertainty about the future course of the pandemic and the resulting economic crisis has remained. Unsurprisingly, uncertainty now stands out as the most serious barrier to investment, being mentioned by 81% of EIBIS respondents.
- **EU firms revised down short-term investment plans, adopting a wait-and-see attitude.** Some 45% of firms expect to reduce investment in the coming year, while only 6% expect to increase it, a dramatic reversal of the relative optimism seen in recent years. Of those firms that decided to invest less because of the pandemic, half said they were postponing investment and another 40% said they were changing or re-scaling their plans.

- **Climate change investment will not be spared.** 43% of firms that plan climate-related investment in the next three years say the pandemic will negatively affect their investment plans. In general, utility-scale projects (such as windfarms) are expected to remain resilient in the short-term, but smaller scale investments in renewable energy and energy efficiency, which are linked to spending by households and firms, are expected to fall.

The pandemic also raised firms' expectations about the need to digitalise and innovate to adapt to the future. The belief in the need to digitalise holds even as firms curtail investment and optimism declines.

- **Half of European firms foresee an increase in the use of digital technologies** in the future as a specific result of the pandemic. The proportion is even higher among firms that have already adopted digital technologies.

- **More than one-third of firms expect the pandemic to impact their supply chains or the products and services they offer**, underlining the need for adaptation and innovation.

- **Some 20% of firms foresee a permanent reduction in employment,** suggesting that a significant number of firms are pessimistic about their ability to "bounce back" once the pandemic recedes.

The impact of the crisis on firms' financial situations bodes ill for investment, the recovery and Europe's structural green and digital transformation in the medium term. The policy response to the COVID-19 crisis has so far succeeded in maintaining firms' access to short-term credit. Nonetheless, the massive demand shock has cut firm revenues dramatically, particularly during phases of strict lockdown. Small and medium-sized enterprises (SMEs) have been particularly hard hit. A conservative estimate puts the loss of firms' net revenue at nearly 13% of GDP in the first phase of the crisis. Firms could cover an estimated 3 percentage points of this shortfall with the buffers of cash and other liquid assets they built up before the pandemic. To cover the rest, however, they will have to reduce investment or increase borrowing. EIBIS data show that firms have consistently used internal resources to finance around 60% of investment. If they maintain this pattern, investment would have to drop by some 6.4% of GDP, equivalent to a 48.5% fall in corporate investment relative to 2019, with corporate debt rising by an estimated 3.2% of GDP. An alternative scenario, in which corporate borrowing is doubled, still sees firm investment fall by a quarter. Modelling based on historical responses of corporate investment to demand shocks, and the size of the COVID-19 shock, also suggests that a reduction in investment within this range is to be expected.

The crisis-driven expansion of government debt could pose a medium-term threat to much needed public investment. Across the European Union, public debt is forecast to reach 95% of GDP by the end of 2021, an increase of 15 percentage points since the start of the pandemic. With the fiscal rules of the European Union's Stability and Growth Pact temporarily suspended and interest rates expected to remain very low, constraints on public spending are still limited. Nonetheless, as the global financial crisis demonstrated, times of strong fiscal stimulus have very often been followed by periods of sharp fiscal correction that tend to impact public investment disproportionately.

Post-pandemic, Europe's digital and green transformation will be even more pressing, yet the investment needed to drive that transformation is at risk. Europe faces a critical decade for the success of the climate transition and for maintaining its ability to complete technologically. The pandemic has even intensified pressure for digitalisation and for innovation to adapt supply chains and product portfolios to the "new normal" that will prevail. Yet, the pandemic has also created severe obstacles to the investment surge that is needed for recovery and transformation. These obstacles include uncertainty and the legacy of the pandemic lockdowns on firms' ability to finance future investment. Decisive, forward-looking intervention will be needed.

Action for a green, smart and cohesive Europe

Long-term vision is needed to lead Europe out of the crisis. The pandemic represents an almost unprecedented shock to European and world economies. A massive short-term emergency response was needed. In Europe, policymakers have done well to limit the immediate economic ramifications of the shock, partly by ensuring short-term liquidity is available to help businesses to survive. Going forward, however, Europe needs to enact a long-term vision on the green and digital transformation. The pandemic and its effects are an opportunity to address the long-term challenges that Europe faces. Not doing so would be counterproductive, potentially undermining the immediate economic recovery.

Overcoming policy uncertainty is essential to unlocking investment, particularly for the climate transition. The recovery of corporate investment will depend, in part, upon a concerted policy response that instils confidence in European businesses about the trajectory of the recovery and the constancy of policy support. Firms see uncertainty about regulation and taxation as the greatest obstacle to climate-related investment. An ambitious yet predictable carbon-pricing (or taxation) regime would do much to provide businesses with the reliable information they need to invest. The surge in R&D in renewable energy during the global financial crisis – driven in part by the EU Climate and Energy Package – demonstrates how concerted policy could spur innovation while also acting counter-cyclically to help the economy recover.

Greening and digitalisation present opportunities to create new jobs – even in the short-term. One fear is that the digitalisation and climate transitions will destroy jobs, just when Europe is trying to recover. The transitions will drive a shift in the kind of skills demanded and lead to the reduction of some kinds of employment – more routine jobs via automation and jobs in carbon-intensive industries. Yet the transitions will also create jobs, and the overall impact on employment could be positive. In the shorter-term, the urgent need for a surge of investment in building renovations, the adoption of digital technologies and infrastructure improvements, including at the municipal level, could provide the kind of counter-cyclical employment boost the economy needs.

Policy actions need to address regional disparities and promote social cohesion. Across Europe, differences in progress on digitalisation and climate-related investment are huge, with firms and municipalities in Western and Northern Europe often very advanced, and many cohesion regions at risk of being left behind. At the same time, job losses through automation and decarbonisation will not be felt equally across regions, with the risks of this twin transition tending to concentrate in Central and Eastern Europe. Policies that actively foster social cohesion are needed, such as measures to promote employment, facilitate the reallocation of workers, advance decent work and offer local opportunities for displaced workers. On the positive side, the most at-risk regions also tend to present some of the greatest needs and opportunities for investment for energy-efficiency improvements to buildings, other forms of decarbonisation and digitalisation. These are areas where Invest EU and the Just Transition Fund can play an important role.

Inclusion and cohesion will depend on active support for re-training and the propagation of digital skills. The digital and green transitions will drive the changing demand for skills. The limited availability of skilled staff remains the second most important barrier to investment (reported by 73% of European firms) in the EIBIS survey. With 42% of the EU population lacking basic digital skills, reforming adult learning programmes and broader participation are needed to deal with the risks of a growing gap in workers' skills and further polarisation of the labour market. Online learning creates new opportunities, but it must be coupled with investment in quality education to address inequalities and provide a foundation for life-long learning.

Public investment is needed and should be sustained, despite the financial wound left by the pandemic. Public investment was on a mild upswing before the pandemic, but still below 20-year average levels. This upswing helped infrastructure investment to rebound slightly after years of contraction. Most European municipalities have increased infrastructure investment over the last three years and plan further rises, as they think the current level of investment is still inadequate. Public investment has a vital role to play in

the green and digital transitions, complementing and facilitating private investment, but that spending could be jeopardised by the rise in public indebtedness caused by the pandemic. This time should be different, however. Ultra-low interest rates allow for very cheap public borrowing and have made debt cheaper to service, yet so far the savings generated have mainly supported current expenditure, not investment. Government investment is near a 25-year low, following years of fiscal consolidation. Years of underinvestment have caused a build-up in infrastructure investment needs. Above all, the challenges of decarbonisation and digitalisation require a boost to public investment that cannot be delayed without massive damage to Europe's long-term sustainability and competitiveness.

Support for corporate finance will need to shift from short-term measures to funding that encourages investment and innovation, including more equity or equity-type finance. At the onset of the crisis, the key priority was to immediately help cash-strapped firms. With the summer reopening of Europe's economies, support shifted to ensuring the proper flow of credit by providing funding and guarantee products for banks. This support has remained essential during the second infection wave. In the post-crisis environment, however, more equity-type products like venture debt will be needed. Equity finance is better adapted to absorbing losses and supporting risk-taking activities, including innovation. Continued support for the Capital Markets Union 2.0 project is crucial.

To spur climate investment, greater transparency is needed on the impact and risks of climate change. The climate transition will require the mobilisation of private finance on a massive scale. Initial interest in the private sector is promising, but limited. Funds focusing on environmental, social and corporate governance investment are in demand and some new markets, such as green bonds, are developing. However, growth remains slow and the premium paid for green investments remains tiny. Uncertainty surrounding true environmental risks and their impact on financial assets is preventing investors from being more discerning. Enhanced information, along with the development of simple and transparent standards, such the EU Taxonomy for sustainable activites, should help spur investor demand. At the same time, banks have a major role to play in Europe's largely bank-based financial system. Central banks and national supervisors are pushing banks to better price climate risks into their loans, while also encouraging the investors to delve more deeply into the risk. Enhanced disclosure guidelines and the increased awareness of climate stress have led to a wider spread in borrowing costs between green and brown loans and bonds, which will increasingly support the greening of the economy.

A coordinated EU response could catalyse the transformation. Investment in one region or EU member has significant spillover effects for neighbouring regions and countries. With resources available from the municipal to the European level, coordination is essential to maximise the synergies of such investment. The coordinating role of European policy can help to reduce policy uncertainty and instil a vision of a digital, net-zero carbon future. EU support is needed to create the conditions for more equity-based finance for businesses and to provide clarity on carbon prices, green financial products and the climate-related risks that banks are exposed to. EU support, such as the Just Transition Fund, is also needed to address the wide divergence in regional progress on the digital and climate transitions, and the regional inequalities that these transitions could exacerbate.

Debora Revoltella
Director, Economics Department
European Investment Bank

Introduction

The coronavirus pandemic swept across Europe with a ferocity and speed that caught EU governments by surprise. Facing a vertiginous rise in infections and deaths, governments took drastic action to halt the virus's spread by severely limiting people's movement. Those restrictions essentially froze the European economy, and it fell to policymakers to keep its heart beating. Initial attempts to curtail the spread of the coronavirus in early March fell short, and governments found themselves facing a health crisis unlike anything they had ever seen before. As the number of cases and COVID-19-related deaths surged across the European Union, governments took sweeping measures to flatten the curve of new infections and to ease mounting pressure on national health systems. These measures, however, have strangled economic activity. The consequences for employers and employees would have been catastrophic – worse than any modern-day crisis – if policymakers had not stepped in with sweeping measures to limit the economic shock.

The economic policy response was swift and unprecedented. Monetary authorities, national governments and European institutions took concerted action to contain the economic damage and to deliver a quick and comprehensive response. Cash-strapped businesses were injected with funds and central banks ensured that credit flowed freely. Financial regulators pushed for widespread moratoriums on debt repayments and supported massive loan-guarantee programmes. Millions of jobs were saved thanks to programmes to subsidise employment through short-time work schemes. The European Central Bank (ECB) and national monetary authorities also backed up the financial system by providing sufficient liquidity and smoothing the path for public and private debt issuance.

The short-term response to the pandemic proved essential to limiting the fallout, but those short-term measures must be aligned with policies that help the European Union meet its long-term challenges. The partial economic rebound over the summer attested to the success of the policy response in the first half of 2020. While the broad response proved instrumental in stemming the decline in economic activity, it also sucked up substantial public resources. EU government debt increased by 8.4 percentage points to 88% of gross domestic product (GDP) from the first to the second quarter of 2020. The European Commission expects debt to GDP to reach 94% by the end of 2020. A second wave of contagion and lockdowns in the autumn further exacerbated the crisis. The resulting uncertainty raises questions about the sustainability of governments' blanket support for the private sector. Massive government stimulus, along with weakening private-sector fundamentals and incentives, could potentially derail the European Union's drive to address its two main challenges – climate change and digitalisation. Aligning short-term support during the crisis with long-term objectives is crucial.

The Investment Report 2020-2021: Building a smart and green Europe in the COVID-19 era **focuses on the two major structural challenges for Europe – digitalisation and climate change.** It is organised into two parts. The first part outlines trends and developments in investment in the European Union, while the second focuses on the structural challenges of climate change and digitalisation. The experience of the pandemic has stressed just how difficult, but important, it is to address these two issues. The International Energy Agency estimates that greenhouse gas emissions in 2020 will be 8% lower than in 2019 – the largest recorded annual decline. While the decrease is encouraging, it is nowhere near the European Union's target of a 55% net reduction of carbon emissions by 2030. If anything, the crisis has illustrated the fundamental economic overhaul needed to meet the challenge of climate change. The COVID-19 experience has also confirmed that, going forward, rapid digitalisation is indispensable. The digital capabilities of individuals, firms and governments were key to Europe's resilience during the pandemic. In the future, growth, innovation and even climate change will increasingly depend on digital interaction. At the same time, digitalisation and climate change adaptation and mitigation will require major structural changes and will challenge social cohesion. Addressing these challenges in a timely manner could maximise the potential benefits of the transition.

The analysis provided in the report stems from three in-house surveys. The EIB Investment Survey (EIBIS), whose fifth annual survey was conducted in the summer of 2020, adds valuable information about the impact of the coronavirus pandemic. The survey's climate module was extended, and it provides unique information on the impact of climate change on firms' decisions. Following the EIB Municipality Survey in 2017, a second survey in 2020 focused on the infrastructure investment decisions of EU cities and municipalities, and asked how climate change was influencing their decisions. The third survey, run online in cooperation with Ipsos, collects companies' assessments of their efforts to introduce environmental innovations, the motivations for doing so and the obstacles encountered.[1]

The report begins with a detailed analysis of the impact of the pandemic on the economy, overall investment and corporate investment and finance. Chapter 1 sets the scene with an overview of the economic environment, the impact of the pandemic on real economic activity and the financial sector and the economic policy response. It outlines the extraordinary decline in economic activity resulting from government measures to curb the spread of the pandemic and the corresponding swift policy response. It stresses the importance of EU-wide policy initiatives that have the potential to change economic policymaking in the European Union.

Investment in the European Union fell precipitously in the second quarter of 2020. Chapters 2 and 3 home in on corporate investment and investment financing, presenting the main results of the EIBIS 2020. The chapters outline the extraordinary decline in investment triggered by elevated uncertainty and the imposed restrictions on economic activity, even though credit flowed freely and governments and the European Union provided substantial policy support. Despite these supportive measures, investment activity could remain subdued beyond the pandemic because of an erosion in firms' ability to self-finance their activities. To counteract a longer slowdown, policy support should evolve in stages. Governments, which started by providing liquidity at the onset of the pandemic and then maintained the flow of credit, now need to focus on enhancing the types of financing available for firms by providing more equity products.

The scale of the policy response risks weighing on government investment. The global financial crisis showed that large fiscal stimulus could be followed by a sharp fiscal correction in which government investment falls substantially. The temporary suspension of EU fiscal rules and the massive intervention of the ECB have eased the pressure on governments this time around, allowing them to maintain focus on productive public investment. The benefits should be considerable, since government investment often has a catalytic effect on private investment and positive spillovers to the rest of the EU economy.

Investment in climate change mitigation remains insufficient to achieve the ambitious EU target of achieving carbon neutrality by 2050. Chapter 4 outlines recent investment trends in climate change mitigation and adaptation. While it acknowledges the recent uptick in climate-related investment in the European Union, it stresses the need for further substantial increases if the European Union is to meet its goal of carbon neutrality. To accelerate investment, EU governments and the private sector have important roles to play. Governments will have to scale up investment, but perhaps more importantly, their policy mix should shift towards incentives that will boost investment in climate action. Incentives are crucial because most of the investment needed to make the economy carbon neutral will have to come from the private sector.

The transformation of the economy is a major opportunity for all firms. Chapter 5 focuses on the outstanding climate challenges facing the corporate sector. It probes the degree of awareness of EU firms and their willingness to deal with the effects of climate change. The chapter stresses that firms' decisions to invest in climate-related measures will affect their competitiveness and determine whether they play an active or passive part in the transformation. Half of the firms in the European Union are investing in climate measures, and they show a stronger propensity to do so than their counterparts in the United States. That said, the pandemic might derail some firms' investment plans, despite the significant

1 More information about the surveys is available in the Data annex of the report.

spending needed to achieve the European Union's ambitious targets. These developments underline the importance of the European Green Deal as a catalyst for the green transition. The green deal provides a coherent plan for defining investment in climate change mitigation and adaptation and lays out proper incentives for the public and private sectors. Businesses say they need clarity on the climate. Regulatory uncertainty and taxation are cited as the main impediments for climate-related corporate investment, according to 73% of EU firms.

The financial sector is an important enabler of the green transition. Chapter 6 points out that investor interest is gradually shifting towards companies with clearly defined sustainability goals, but many issues remain. For instance, the uncertainty surrounding the true green content of financial assets reduces investors' ability to assess their merits. Enhanced information and the development of simple and transparent standards should alleviate major impediments to stronger growth. The important role played by banks in the European Union will require enhanced disclosure about the exposure of bank assets to climate risks.

The digital transformation is taking centre stage, affecting virtually all sectors of the economy. The global innovation landscape is changing rapidly due to the growing importance of digital technologies and the emergence of China. Chapter 7 notes how European firms are lagging when it comes to innovation in the fast-growing digital sectors such as software and computer services, which may create challenges for long-term competitiveness. Furthermore, European firms are not only trailing in digital innovation, but also in digital adoption. In the European Union, 37% of firms remain non-digital, compared with 26% in the United States. Firms say that access to digital infrastructure is more restricted in the European Union compared with the United States. Higher rates of digital innovation and adoption are linked to greater job creation and resilience, but also to higher investment in climate change mitigation and adaptation – investment that is crucial for achieving ambitious European climate targets.

Innovation in green technologies will play a key part in the transition to a carbon-neutral economy. Current technologies are insufficient for meeting the climate goal without significant disruptions to lifestyles in advanced economies or development in emerging economies. Hence, innovation is essential to producing the clean technologies needed for a smooth transition. Chapter 8 builds on an analysis of patent data and the results of the online survey with Ipsos on green innovation to study the important symbiosis between digital and green technologies. The authors stress that technological advances will need to permeate every aspect of our lives, from energy systems to materials and land use, if we are to successfully navigate the transition to carbon neutrality. Digital technologies are expected to make a major contribution to these innovations.

The European Union is currently leading the way in the joint development of green and digital technologies. The transition will require more than creating knowledge. That knowledge will also have to be shared and adopted. The European Union also seems to excel in knowledge diffusion compared to global peers, but this diffusion tends to remain within national borders.

Efforts by cities and municipalities will be instrumental in building a digital and green future. Chapter 9 shows that local government investment in green and digital infrastructure is important for pulling in private investment in climate measures. Gaps in green and digital infrastructure vary across the European Union and exacerbate regional inequality.

The report concludes by studying the impact of digitalisation and the green transition on social cohesion. Chapter 10 looks at how digitalisation and the green transition will create and destroy jobs – while at the same time changing the relative importance of occupations. That upheaval will cause significant shifts in demand for labour, with profound social and economic consequences. This shift is likely to affect regions and countries in the European Union differently, with some parts at greater risk. Dealing with these risks will require strong local governments that can identify future job opportunities, provide adequate support for individuals and devise strategies to transform and revitalise local economies. Providing workers with the necessary skills is essential to managing the disruptions of the twin green and digital transition and to maximising its benefits.

Throughout the report, EU countries are often grouped into three regions with common features. Central and Eastern Europe contains the countries that have joined the European Union since 2004 and that rely substantially on EU cohesion and structural funds. Cyprus, Greece, Italy, Malta, Portugal and Spain form the Southern Europe group. The remaining EU countries are in Western and Northern Europe. While geographical location defines the groups, the countries within each group share many common structural economic characteristics, thereby justifying the regions' usefulness in economic analysis.

Corporate investment is likely to fall at least **25%** after one year of the crisis

7% to 9%

fall in real output over the course of 2020

3% to 3.4%

of GDP is the **expected increase in public investment** from 2019 to 2021

79% to 95%

is the expected increase in the government debt-to-GDP ratio from 2019 to 2021.

55% of **EU firms** **cut employment** in the first half of 2020

Extraordinary policy support is keeping credit flowing

Firms' sentiment

- on **external finance** conditions **-2%**

- on **internal finance** conditions **-22%**

PART I

Investment and investment finance

Chapter 1

The macroeconomic environment

The measures taken to fight the coronavirus pandemic have severely disrupted the global economy. Trade and investment channels have been interrupted, the movement of people has been seriously restricted, and businesses have been forced to operate at reduced capacity or to temporarily abandon their operations. Confidence levels have fallen markedly and labour markets have frozen. Prior to the second lockdown, the International Monetary Fund (IMF) and other institutions were already expecting gross domestic product (GDP) in the European Union to shrink by 6% to 8%, a fall unrivalled since the Great Depression.

In Europe, the policy response has been swift and unprecedented. Monetary policy, national fiscal policies and European economic policy have all contributed to circumventing the economic fallout. The response from EU institutions, Member State governments and the European Central Bank (ECB) was quick and comprehensive. To some extent, the magnitude and nature of the action are a game-changer for Europe. An obvious example is the joint issuance of debt securities by Europeans – a crisis response that was very well received by the markets.

Subsequent virus waves remind us that pandemic concerns will dwarf most of the other policy issues until a vaccine is widely distributed, which won't be until well into 2021. Policy measures were designed in emergency situations, but second lockdowns around Europe illustrate that a series of waves cannot be ruled out. Because the side-effects of the lockdown measures might be expected to intensify as the crisis becomes more protracted, there is good reason to revisit policy measures to fine-tune the balance between short-term support and longer-term programmes. In addition to shoring up short-term demand, the policy package can become truly instrumental in ensuring the success of the three pillars of the recovery: resilience – greening – digitalisation.

Introduction

In 2019, the European economy was gradually slowing down after six years of relatively weak expansion. The slowdown could be traced back to more sluggish international trade resulting from tensions between the United States and some of its main trading partners. Just as the export-oriented engines of European growth were running out of steam, the coronavirus pandemic broke out. The virus spread quickly around the globe, forcing governments to take sweeping measures in an attempt to arrest it. The associated restrictions brought whole swathes of the EU economy to a near complete standstill with severe implications for consumer spending, investment and overall economic activity. The ECB deployed a major policy package in response, and this time, domestic fiscal policies and European policy also joined forces to safeguard the European ecosystem during the lockdowns imposed in the various countries.

This chapter sets the stage for the analysis provided throughout this report by giving an overview of the economic situation at the outbreak of the pandemic. The first section outlines the macroeconomic environment in Europe and the world in the first half of 2020, focusing on the link between EU economies, global growth and international trade. The second section details the latest developments in real GDP growth and labour markets in the European Union. Four boxes provide further detail. Box A quantifies the likely effects on GDP of the re-introduction of government restrictions in the fourth quarter of 2020. Box B frames the economic shock due to the pandemic in a historical perspective. Box C outlines the challenges to European social protection systems posed by the pandemic. Box D discusses the use of short-term working schemes in the European Union during the crisis. The third section focuses on financial developments and the fiscal and monetary policy response to the considerable economic shock. Box E in this section outlines EU banks' credit exposure and policy responses. The chapter ends with concluding remarks and policy implications.

The cross border environment in Europe and the world

The COVID-19 crisis erupted in the beginning of 2020, when the world economy was already slowing as uncertainties and geopolitical and trade tensions mounted. The pandemic was, by its very nature, unexpected. The virus emerged in China and quickly spread to the rest of the world. It propagated quickly within Europe as a result of the closer integration of economies through trade and personal travel. This section explores the cross-border dimension of the crisis, focusing on the European economy and stressing the need to protect the long-term integrity of the single market.

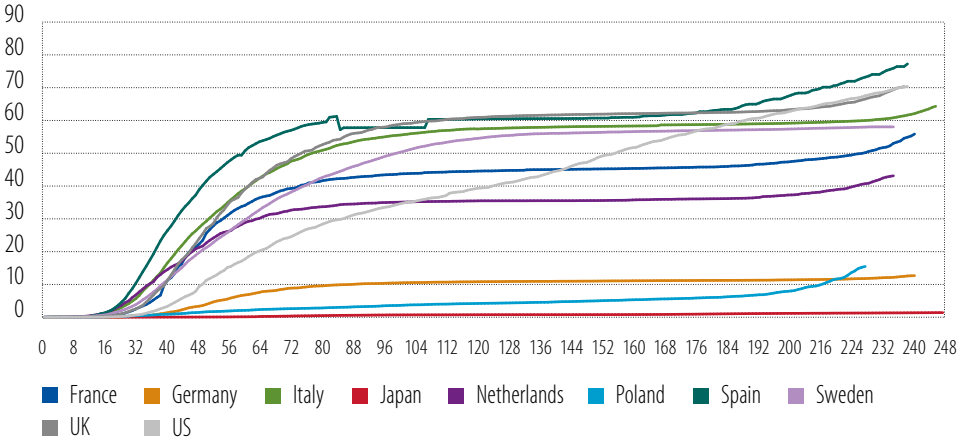
Using lockdowns to flatten the curve

COVID-19 is a genuinely global shock to the world's economy. By its very nature, the original pandemic shock was unrelated to the structure of the world's economies. Its origin was independent from economic policies, but the policies put in place to limit the virus's spread had economic implications. Most countries implemented lockdowns and restricted the free movement of people within national territories and across borders. Infection waves were not fully synchronised across continents, but they tended to be relatively closely aligned within Europe, with its highly integrated landscape.

The first wave hit Europe towards the end of the first quarter of 2020 and the second wave in the beginning of the fourth quarter. Figure 1 shows the trend in COVID-related deaths in the world's major economies. In the second wave, the rise in the death rate seemed to be less acute as countries are better prepared thanks to the lessons learned from the first wave. However, the implementation of a second lockdown in most European countries serves as a reminder that the situation will remain problematic until a vaccine is distributed to a large share of the population.

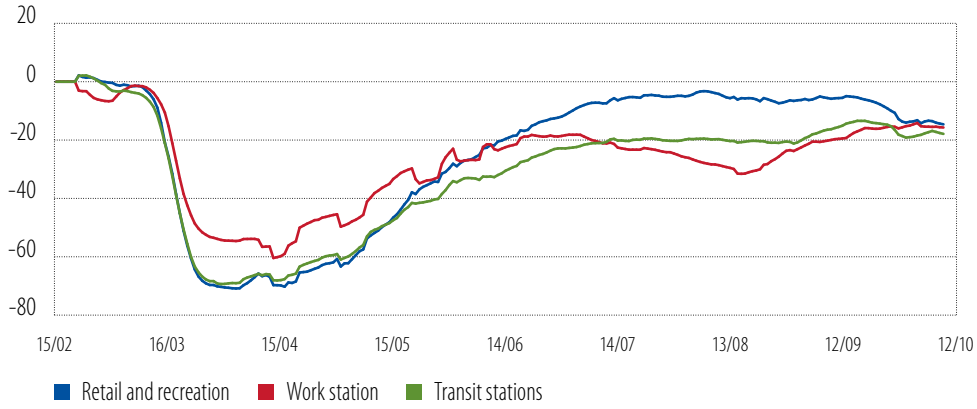
Imposing lockdowns has, so far, been the policy option to curbing the increase in infection rates and avoiding bottlenecks in the health system. The chain of events is as follows. Higher infection numbers help the virus spread. This increases the likelihood of vulnerable people becoming infected, who, more than other people, may require hospitalisation in intensive health care units. Given the limited number of spaces, the system can quickly be stretched to its capacity, driving the fatality rate up substantially. To avoid this, lockdown policies, with varying degrees of strictness, have been implemented across the world to flatten the curve. As shown in Figure 2, these policies drastically limit freedom of movement and require some shops and public places to be closed.

Figure 1
Fatality rates (COVID-19 deaths per 100 000 inhabitants)



Source: *European Centre for Disease Prevention and Control (ECDC) and EIB calculations.*
Note: *Last record 3 November 2020.*

Figure 2
Google mobility indicators (EU average)



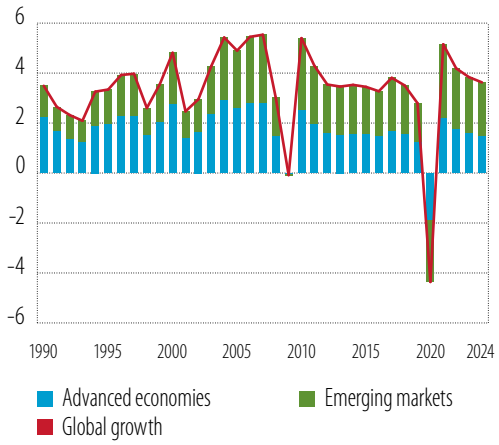
Source: *Google Community Mobility Reports and EIB calculations.*
Note: *Last record 2019. GDP weighted. The reports chart movement trends over time by geography, across different categories of places. Mobility is compiled in deviation from a baseline day, defined as the median value from the five week period 3 January – 6 February 2020.*

Lockdown policies took a toll on economic activity, and in 2020 global trade and world GDP collapsed. It is not only Europe, but the entire world economy that has been hugely affected. In its October 2020 World Economic Outlook, the IMF forecasts that global real GDP will contract by 4.4% in 2020, and rebound in 2021 (Figure 3). Emerging market economies are facing an extremely challenging situation, with GDP declining in 2020 for the first time since the early 1990s, if not earlier. This is in stark contrast with the global financial crisis. In addition to the toll on public health, emerging economies have had to deal with the losses in domestic activity caused by containment measures, plummeting foreign demand, collapsing commodity prices and disappearing capital flows.

Prior to the second wave, a relatively swift rebound in worldwide economic activity was still expected. The IMF October 2020 World Economic Outlook was prepared and issued well before the second wave of infection and lockdown in Europe, and pointed towards a relatively swift rebound in the world economy. However, the arrival of the second wave means that it will take longer for economies to begin fully functioning again, which is not expected before a vaccine is widely distributed. As the crisis may last well into 2021, some emerging economies very dependent on tourism may well suffer two consecutive years of ultra-weak activity.

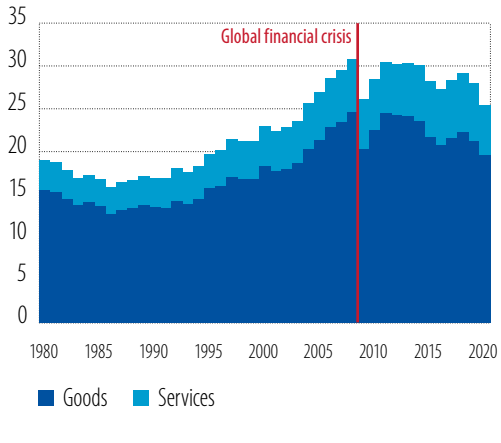
The pandemic hit some European economies harder than others. It is not fully understood how the virus spreads, but in Europe higher infection rates triggered more stringent lockdowns, which weighed on individual economies. Other factors were also at play, such as the composition of GDP and the share of tourism (Sapir, 2020). The COVID-19 crisis will most likely lead to structural changes in the economy as some sectors decline or remain lacklustre for a long time (including international travel and tourism, or transport services as people turn more to remote working and therefore commute less) while others expand to support new lifestyles (such as telecoms, and, more broadly, digital activities). Given the differences in the composition of European economies, some economies are likely to be more affected than others.

Figure 3
Composition of global growth (% and percentage points)



Source: *IMF October 2020 World Economic Outlook (WEO) and EIB calculations.*
Note: *Projections over 2020-2024. Last record 2024.*

Figure 4
Global exports in the world economy (exports over GDP, %)



Source: *IMF October 2020 WEO and EIB calculations.*
Note: *Last record 2020, partially projected.*

During the second wave, governments have tried to rebalance the economic costs of lockdown policies. After the first wave, the strategy of limiting the spread of infection by testing and isolating positive cases was stepped up, but so far, this strategy has not sufficed. At the onset of the second wave, bars and restaurants were closed in most of Europe, followed by the introduction of curfews, and then lockdowns.

The longer the crisis, the deeper the scars. Infection waves may continue until a vaccine is widely distributed. Relatively good news was reported in the beginning of December with several vaccines approved for use by medical authorities in various countries. In the best case scenario, however, the mass production and administering of a vaccine will take months, which means the crisis is likely to continue well into 2021. The longer the crisis, the deeper the scars, and the greater the increase in corporate and government borrowing. Meanwhile, as the pandemic wears on, containment policies will inevitably continue to immobilise the economy, while public support will focus on maintaining the ecosystem and limiting capital erosion (Lagarde, 2020).

A protracted drag on external trade?

Prior to the crisis, globalisation was at a standstill. The reasons for the halt in the ascent of globalisation are numerous: fears stemming from the global financial crisis, the trade war between the United States and China, the maturing of the Chinese economy, the limits to manufacturing growth and the stronger development of services, and receding multilateralism. As a result, the GDP-to-external-trade ratio had flattened somewhat since 2008, as shown in Figure 4.

The COVID-19 crisis may further dampen the long-term prospects for external trade. With the crisis, firms have taken on-board the need to increase the resilience of their production chains. They have started rethinking their global value chains, no longer focusing simply on maximising returns but also looking at how they can reduce risks by increasing the strength of their networks. Governments are also likely to take on greater weight in the post-pandemic economy with increased public spending, partly to reinforce healthcare systems (Organisation for Economic Co-operation and Development (OECD), 2020b). Finally, countries may reallocate the production of products deemed strategic to guarantee national independence (medicines and health equipment for instance).

What impact will the pandemic have on globalisation vs. regionalisation? How will the rethinking of resilience vs. cost change global supply chains? Bonadio et al. (2020) estimate that the impact of foreign lockdowns accounted for one-third of the total pandemic-related contraction in global GDP. However, the immediate impact of the crisis on the redefinition of supply chains appears to be limited, as it takes a lot of time and effort to find different suppliers of comparable quality. Car manufacturers, for example, cannot simply move from China to another country with low labour costs and expect to find manufacturers of, say, airbags that can meet the same quality standards quickly.

The COVID-19 crisis, however, will have a permanent impact. It is magnifying the effects of existing mega-trends: the new industrial revolution, growing economic nationalism and the drive for sustainability. The extent of the COVID-19 crisis's disruption to working practices and behaviour patterns seems substantial. Companies have accelerated the digitalisation of their supply chains and customer channels, and many are moving faster in adopting artificial intelligence and automation. Other changes in the workforce are also afoot.

The pandemic may accelerate longer-term shifts toward shorter and less fragmented value chains (United Nations Conference on Trade and Development (UNCTAD), 2020b). Industry 4.0 is pushing the move towards automation and smart technologies in manufacturing and industrial processes (Baldwin, 2019), along with growing economic nationalism and the need to make human activity more environmentally sustainable and less resource dependent. These trends are set to reduce gross trade in the global value chain, limiting the circulation of intermediate inputs and final products in the medium term. These trends will also lead to further concentration in the value added in certain geographic areas. As another consequence, production will shift from global to regional and sub-regional value chains. Automation and reshoring will see an upswing to increase flexibility and reduce the risks that firms face during a global shock. These trends are driven by considerations related to the resilience and robustness of supply chains, not national protectionism.

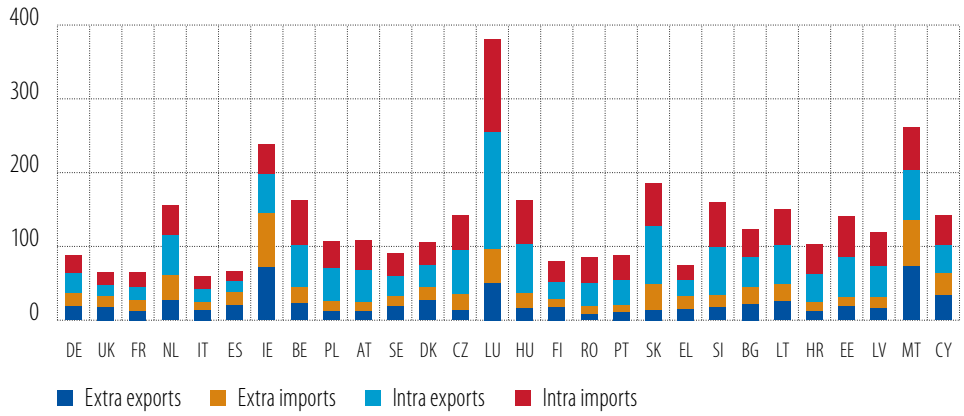
Maintaining cross-border transport infrastructure is key to ensuring good conditions for the economic recovery. Much-reduced mobility has put transport infrastructure at risk. The air transport of passengers

and goods is a core component of the world's economy. According to Airport Council International, traffic at Europe's airports decreased by 73% in September 2020 compared to a year earlier. More than one-quarter of Europe's airports are at risk of insolvency if passenger traffic does not start to recover by the end of 2020. While these airports are mainly regional, larger airports are affected too. The sudden spike in their debt levels – an additional EUR 16 billion for the top 20 European airports – represents 60% of their average debt in a given year. Internal transport infrastructure is also at risk. According to Eurostat, the number of rail passengers was cut in half in the majority of EU Member States in the second quarter of 2020, compared with the same quarter a year earlier.[1]

Protecting the single market and reducing the spillover of negative effects

European economies are more open than other advanced economies. Export dependence, defined as the share of exports and imports to GDP, is above 66% in Germany and higher than 40% in France (Figure 5). Overall, external trade in goods and services accounts for 27% of euro area GDP, a share that rises to 45% when including trade among EU members. The European economy is therefore highly integrated and maintaining cross-border movement is key to its functioning, more so than elsewhere in the world. Regions located close to borders also rely heavily on commuting foreign workers to function (Figure 6). Taking into account the implications of cross-border mobility restrictions is therefore of paramount importance, and the corresponding policies must be developed at the European, and not just the local, level. A major risk is that uncoordinated lockdowns lead to repeated virus outbreaks and, in turn, further lockdowns across Europe, resulting in steeper declines in GDP (Kohlscheen et al., 2020).

Figure 5
External trade in goods in EU economies (% GDP, 2019)



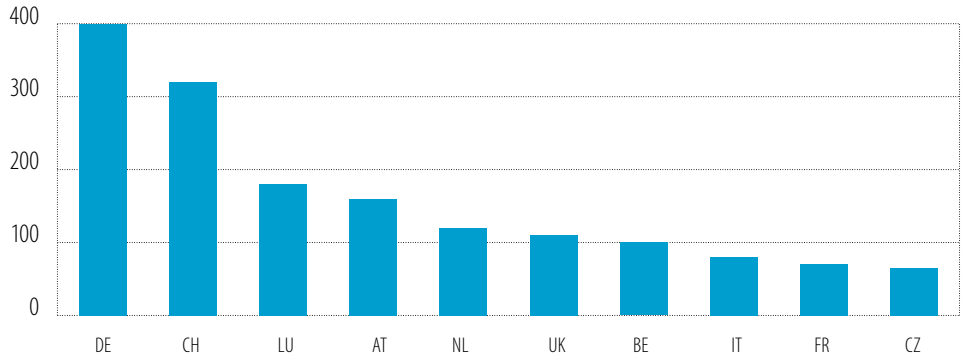
Source: *EIB Economics Department calculations based on Eurostat.*
Note: *Last record 2019.*

Guaranteeing a level playing field and preventing increased divergence within Europe are essential. Given asymmetries in financial conditions, the European single market is at risk and widening disparities should be avoided. In Figure 7, we correlate the decline in GDP with GDP per capita for EU economies. While EU countries have been affected to different extents – the decline in GDP following the first wave ranged from zero to 14% – the impact is unrelated to countries' relative wealth. It would have been reasonable to expect the capacity of hospitals and health services to be related to income per capita, with poorer countries less able to provide medical assistance and therefore implementing longer and more stringent lockdown policies to prevent the rapid saturation of the medical system. While this factor

1 The largest decrease in the number of rail passengers was in Ireland (-94%), followed by France (-78%), Spain (-78%), Luxembourg (-78%) and Italy (-77%).

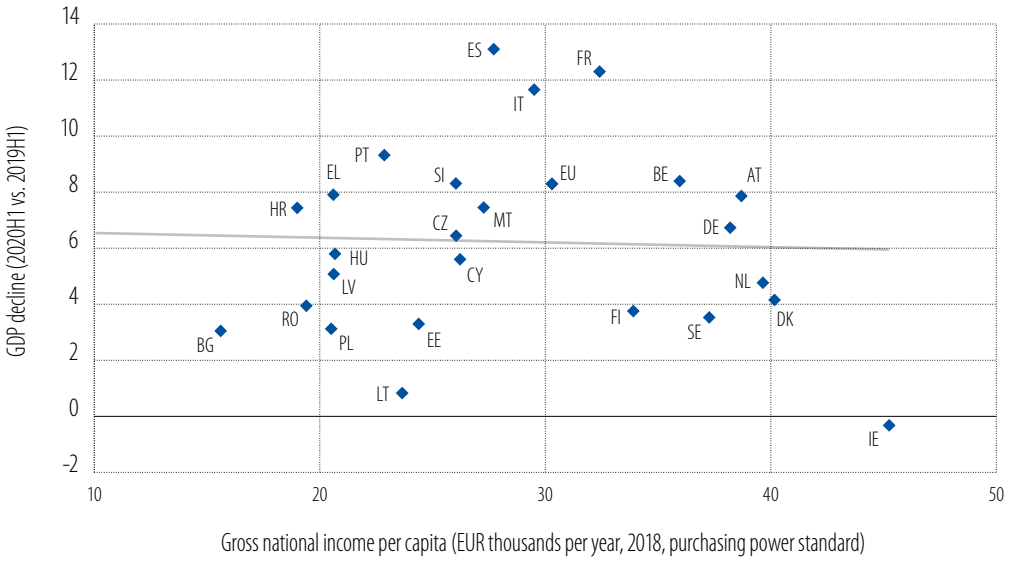
may have played a role, many others were also at issue. Ultimately, and fortunately, the magnitude of the shock was unrelated to the level of economic development. Preventing a widening of divergences in Europe after the pandemic will be critical.

Figure 6
Cross-border workers (country of work, thousands, 2018)



Source: *European Commission, 2019 Report on intra-EU Labour Mobility.*

Figure 7
EU economies: Income per capita and ouput decline during the first wave



Source: *Eurostat and EIB calculations.*
Note: *Last record, October 2020.*

A strong EU response is needed to avoid second-round effects and negative spillovers. Above and beyond the policy measures of individual Member States, a strong need exists for a common, mutually reinforcing EU response to the crisis. European economies are strongly interconnected and a shock experienced in any member spreads to the rest of the European Union through labour movements, value chains, terms of trade and external demand. These spillovers can be fairly significant. In addition to the direct impact of the crisis, a 1% change in the GDP of Germany, France, Italy and Spain results in a further indirect change in the euro area's GDP of 0.25%, 0.2%, 0.1% and 0.1 % respectively, merely on account of trade spillovers in the euro area (ECB, 2013).

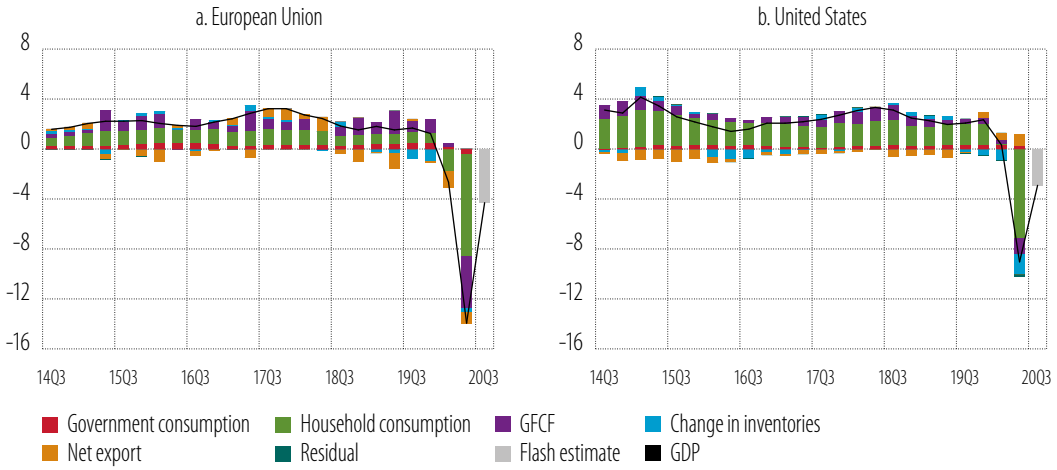
Similarly, a positive shock in any EU country triggers favourable effects throughout the European Union. The impact of EIB loans is a good illustration of how interdependent EU economies are. Macroeconomic modelling by the Economics Department of the EIB Group together with the Joint Research Centre of the European Commission shows that, in the long run, indirect effects can be substantial. Cross-country spillovers in the European Union explain, on average, 40% of the impact of EIB investment on jobs and GDP in EU members. While smaller and more integrated countries gain more in relative terms, large EU countries also benefit greatly from positive spillover effects. In Germany, for instance, spillover effects account for more than 30% of the total impact of EIB investment on jobs (EIB, 2018).

Latest developments in the real European economy

EU GDP shrank massively in the first half of 2020

Growth in most EU economies slowed in 2019, especially in the second half of the year (Figure 8a). Slowing exports and a drawing down of inventories dragged down growth in real GDP in a majority of EU Member States. Declining international trade throughout the year, the result of intensifying trade tensions between the United States and its key trading partners, was the most likely reason (UNCTAD, 2020a). The US economy was affected by these developments too, but growth there remained well above the European Union's because of a strong increase in private consumption (Figure 8b).

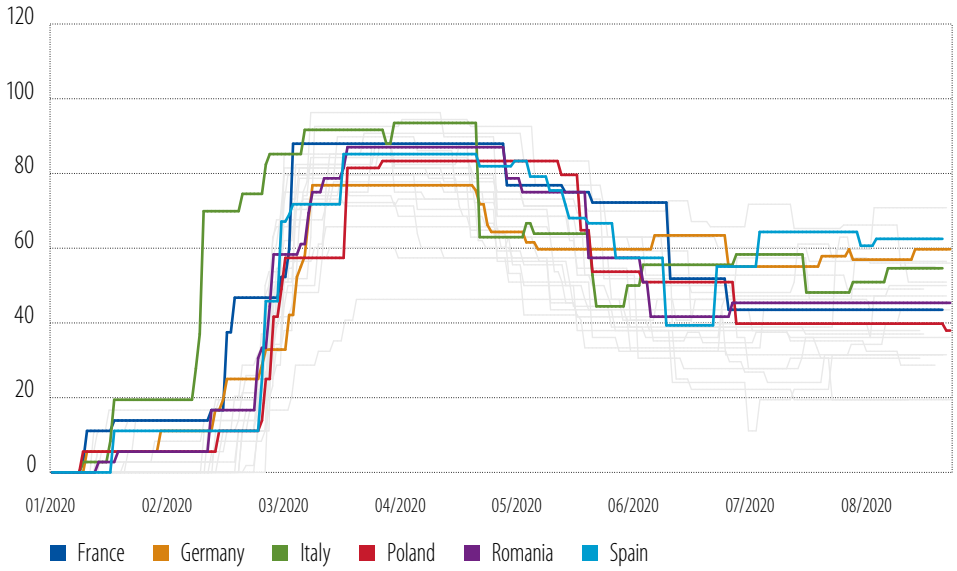
Figure 8
Real GDP and contribution of aggregate demand (% change vs. the same quarter in the previous year)



Source: *Eurostat, OECD national accounts and EIB staff calculations.*
Note: *Data for Q3 2020 are preliminary: Eurostat flash estimate for the European Union, and US Department of Commerce advance estimate for the United States. No breakdown of the components of aggregate demand components is provided GFCF stands for gross fixed capital formation.*

In the European Union, the impact of the pandemic was already evident in the first quarter of 2020. Although sweeping measures to contain the spread of the coronavirus were introduced in the last two weeks of the first quarter, consumer spending and net exports declined significantly, causing a drop in real GDP in almost all EU members, particularly in Southern and in Western and Northern Europe. Nearly all EU members restricted the non-essential movement of people and closed most shops, along with schools and national borders, mid-March. Gatherings with people outside the household were also restricted. In most countries, the harshest measures lasted throughout April and for much of May. Figure 9 plots a stringency index of the measures taken by EU governments.

Figure 9
Stringency of government measures across the European Union



Source: *Oxford COVID-19 Government Response Tracker, Blavatnik School of Government.*

Real GDP fell precipitously in the second quarter of 2020, as economic activity was stifled by government restrictions across the European Union (Figure 9). The overall decline in real GDP in the European Union was more than 11% relative to the first quarter of 2020 and was the largest decrease in a single quarter on record. The falloff was clearly caused by government measures to contain the spread of the virus, and the decline varied widely across Member States. It was smallest, on average, in Central and Eastern Europe where real GDP in the second quarter fell by 9.7% relative to the first quarter. In Western and Northern Europe, it fell by 11.5%, while in Southern Europe the decline was nearly 15%. By way of comparison, the decline of real GDP in the United States in the second quarter was about 9%, compared to the first quarter.

EU GDP increased 13% in the third quarter of 2020 compared to the second quarter, recovering some of its losses. This increase is not surprising as most EU governments relaxed restrictions on movement and economic activity substantially in the third quarter. The biggest increases were in France, Spain and Italy, where GDP had declined by more than the EU average. While substantial, the increase in the third quarter still left EU real GDP 4% lower than the level in the same period a year earlier.

Significant declines in private consumption drove the decline in real GDP in the second quarter (Figure 10). Constrained private consumption accounted, on average, for about two-thirds of the total decline in GDP. Lower consumption represented around one-third or less of the total decline in only four countries.[2] In addition to the restrictions on shopping, private consumption most likely declined because many workers were uncertain about their jobs. In the European Commission's Business and Consumer surveys, measures – such as unemployment expectations or respondents' expectations for their financial situation in the next 12 months – indicated consumer anxiety (Figure 11a).

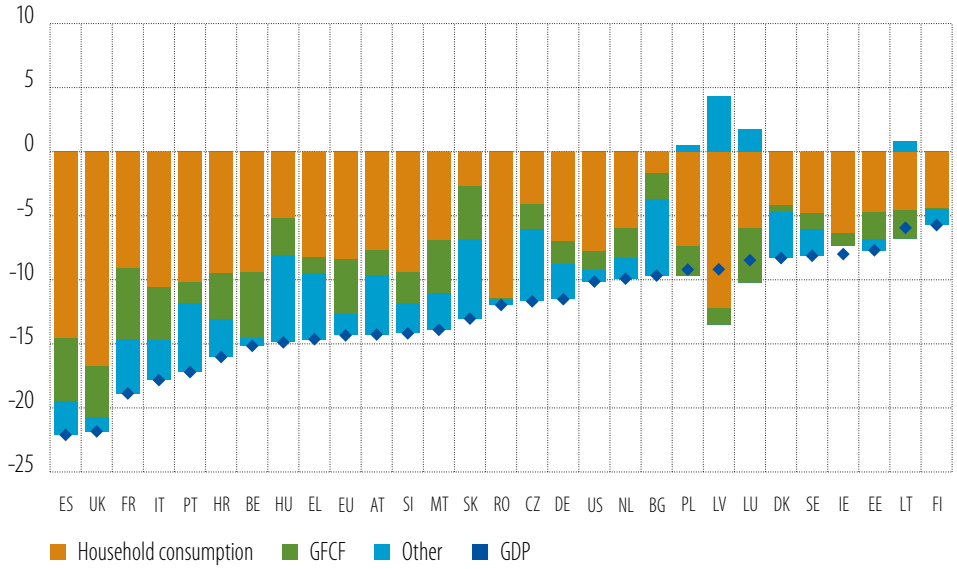
The decline in investment was the second largest cause of the overall contraction in the European Union's GDP. Investment accounted for about one-third of the decrease, compared with only 14% in the United States. Within the European Union, the depth of the decline varied widely, ranging from just

2 Bulgaria (18%), Hungary (35%) and Slovakia (21%) introduced relatively weak restrictions on shops and the Czech Republic (35%) allowed shops to re-open as early as 9 April.

below 2% in Finland to 50% in Luxembourg. In general, the contribution of investment to the fall in GDP was higher in Western and Northern Europe (34%) than in Southern (21%) and Central and Eastern Europe (19%). Uncertainty is very likely to have played a larger role in the contraction in investment than government restrictions. Chapter 2 provides a more in-depth analysis of this drop in investment.

Figure 10

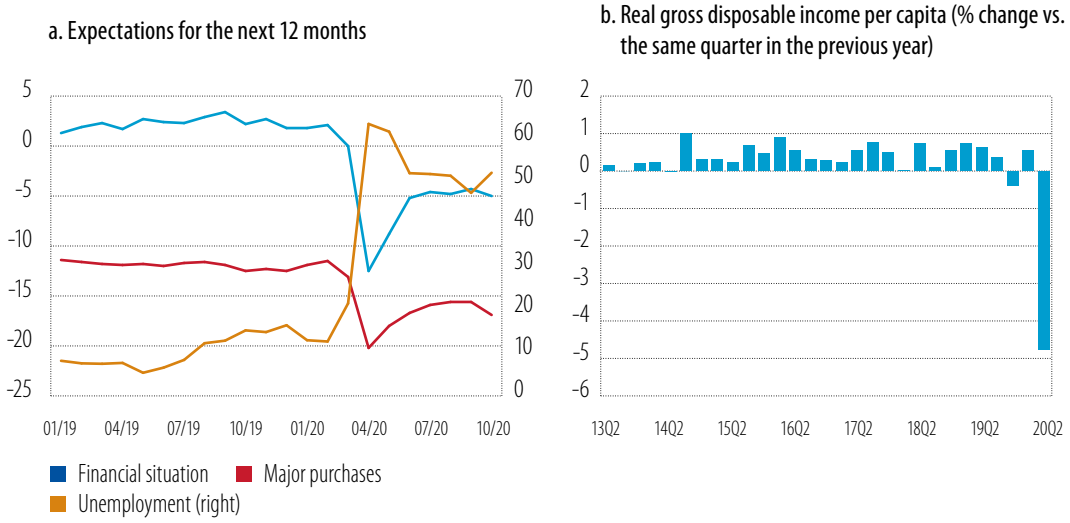
Real GDP change in H1 2020 and contribution of aggregate demand (percentage change in Q2 2020 vs. Q4 2019)



Source: *Eurostat, OECD national accounts and EIB staff calculations.*
Note: *Other includes government consumption expenditure, net export and change in inventories.*

Figure 11

Consumer expectations for the next 12 months and real disposable income per capita



Source: *European Commission's Business and Consumer Surveys and Eurostat.*

Expectations about future consumption do not suggest a rapid recovery in GDP (Figure 11a). Consumers' expectations about their financial situation and their willingness to make major purchases in the next 12 months improved to some extent in June and July. Those expectations stabilised in August and September, but they were well below levels seen before the pandemic. The expectations started to deteriorate again in October as the pandemic intensified again across EU members. Disposable income per capita fell sharply in the second quarter of 2020, and this decline will affect consumer spending, especially for lower-income, liquidity-constrained households (Figure 11b). Such developments in income and consumer expectations make a quick rebound in consumer spending somewhat unlikely, even though strict government restrictions on movement have been largely avoided in the fourth quarter of 2020. The corporate sector is not optimistic about investment either, as discussed in detail in Chapter 2. The economic recovery is therefore likely to be more gradual and prolonged (Box A).

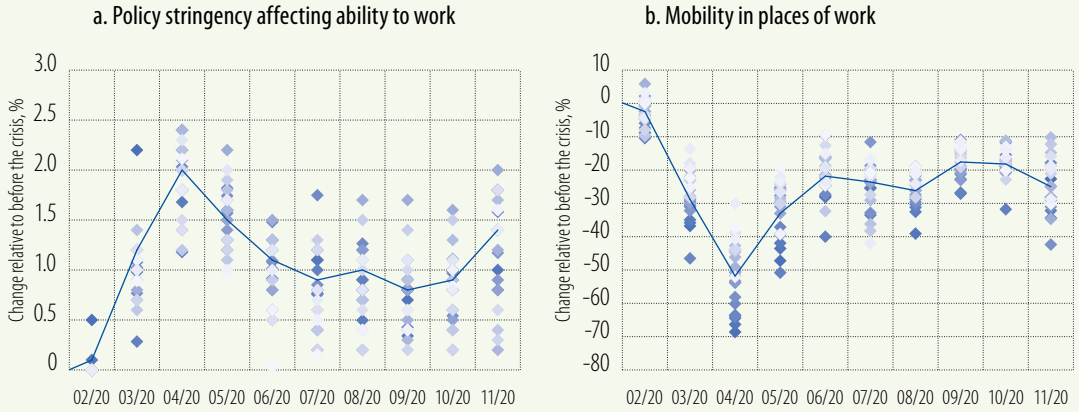
Box A

Real-time monitoring of the pandemic's impact

Since the start of the pandemic, new data sources have become available that help assess economic activity in almost real time. Oxford University coordinates an effort to compile daily indicators of policy stringency (Blavatnik School of Government, 2020). Google provides daily measures of the extent to which people, under these restrictions, are still going to work (Google, 2020). Policies and mobility vary substantially across EU Member States but still show a common pattern (Figure A.1).

Figure A.1

Indicators of policy stringency and mobility trace the impact of the first and second waves of the pandemic, with significant diversity across EU countries



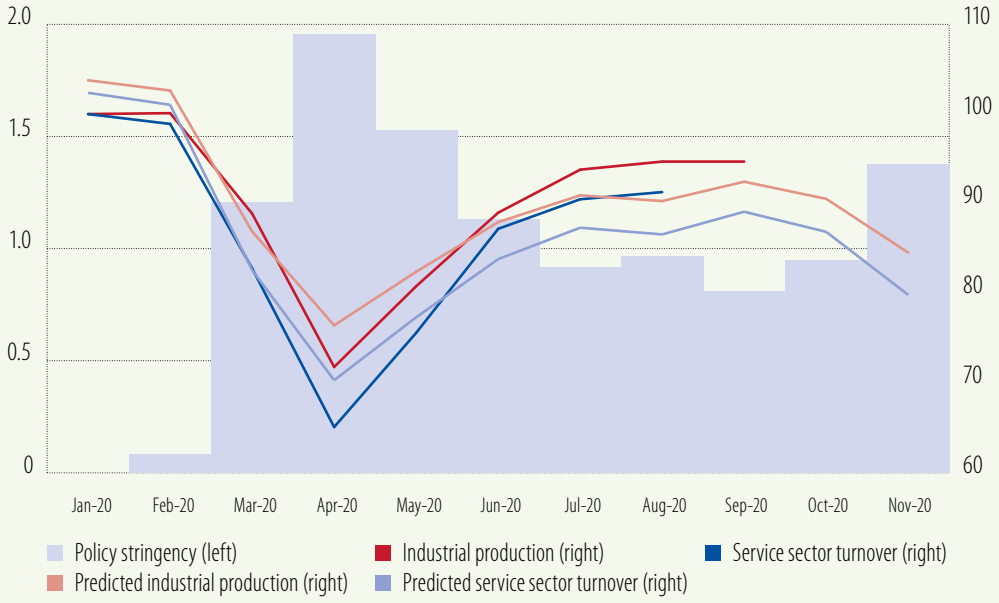
Source: *Blavatnik School of Government (2020), Google (2020), and EIB staff calculations.*
Note: *Monthly averages of work-related measures of policy stringency and mobility. Each diamond shows an EU country. Lighter shades result from overlapping diamonds.The lines shows the GDP-weighted EU averages. Data were collected on 23 November.*

These indicators help assess economic activity using relatively simple econometric specifications. We base our assessments on pooled linear regressions of economic activity (industrial production or service sector turnover) in EU members on visits to places of work and on a composite indicator of policy stringency (Table A.1). The policy stringency indicator is an average of the extent to which workplaces, schools and public transport are closed, the stringency of stay-at-home requirements and restrictions on movement within the country. The regressions are weighted by active population and contain country fixed effects.

Assessments based on these indicators suggest that EU GDP declined by about 1-2% in October and 5-6% in November. Industrial production and service sector turnover, used here as monthly proxies for GDP, move closely in line with the policy index (Figure A.2, dark blue and red lines). Our forecasts suggest that by November, the start of the second wave had undone most of the recovery witnessed since May (Figure A.2, light blue and red lines). Google's mobility indicator points in the same direction but suggests a somewhat smaller decline in activity. Given that a substantial relaxation of policies in December seemed unlikely, EU GDP may fall in the fourth quarter by about 3-4% vs. the third quarter, leaving GDP about 7-9% below its pre-crisis level.

Figure A.2

The pandemic's second wave appears to reverse the summertime recovery



Source: *Blavatnik School of Government (2020), Eurostat, and EIB staff calculations.*
Note: *Forecasts computed using pooled, population-weighted regressions of industrial production and service sector turnover on a work-related subset of Oxford stringency indices and on country fixed effects. Data as of 23 November 2020.*

Table A.1

Regression specifications and results

Dependent variable	Level of industrial production[1]		Level of service sector turnover[1]	
	(1)	(2)	(1)	(2)
Impact of a 1 point increase in the policy stringency index	-14.0 [-16.0, -11.0]		-16.5 [-20.6, -12.2]	
Impact of a 1 point increase in mobility		0.64 [.55, .73]		0.7 [.61, .79]
R2	73.5%	74%	84%	89%
N	223	199	80	55

Source: *EIB staff calculations.*
Note: *[1] Seasonally and calendar day adjusted. 95% confidence intervals in square brackets.*

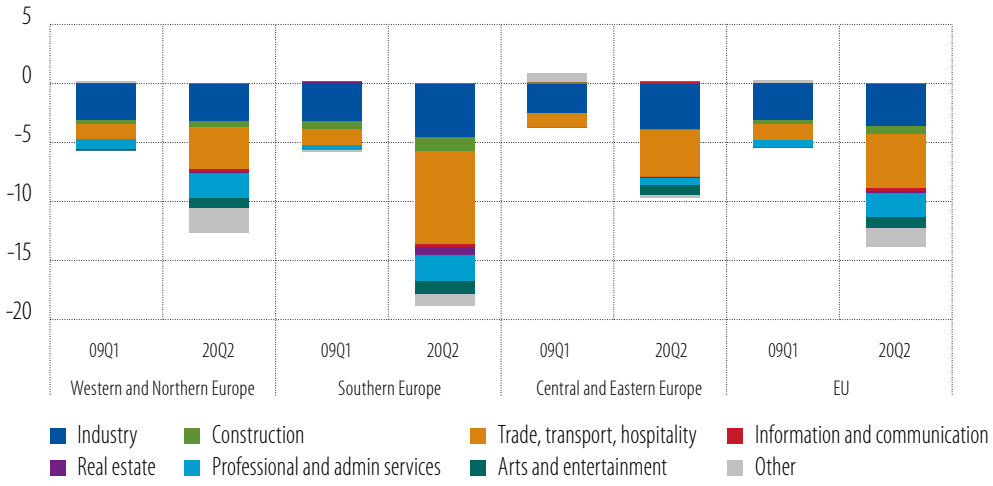
As long as compliance with restrictions is high, the policy stringency indicator appears more useful than the mobility data in assessing economic activity. Google's mobility indicator can be seen as a

measure of compliance with the restrictions and might therefore be a more direct measure of activity. However, the mobility indicator shows pronounced seasonal variations, which detract from the underlying momentum in activity. For example, it declined during the summer holidays in August. And so far, surveys do not seem to suggest that compliance with restrictions is significantly declining in EU countries (Institute of Global Health Innovation, 2020).

The impact of the coronavirus pandemic varies substantially by sector. Sectors that rely significantly on physical presence, including passenger transport, the arts, entertainment, tourism and hospitality, were hit the hardest, declining by some 30% in the second quarter of 2020 from the first quarter. Others, such as agriculture, finance or real estate, contracted by 3% or less over the same period. The distribution of the economic impact across the various sectors was very different during the global financial crisis, when EU manufacturing sustained the largest decline – nearly 20% in the first quarter of 2009. The drop in other sectors remained relatively contained at near or below 6%.

The sectoral distribution of the decline will have a decisive impact on the speed of the economic recovery in the near to medium term. The industrial sector's share in the overall decline in 2020 is the same as during the global financial crisis, while that of services is much higher (Figure 12). Given that a large part of the contraction in services is due to their being delivered in person, as is the case in passenger transport or accommodation, the recovery of a large part of the services sector will remain subdued until the pandemic is reined in, especially as many government restrictions on economic activity were being reintroduced in the fourth quarter of 2020. On the other hand, the recovery of the industrial sector, where manufacturing dominates, is dependent on the upturn in international trade. The different speeds of recovery exhibited by manufacturing and services became clear over the summer when the industrial sector bounced back fairly quickly, while certain services lagged significantly behind.

Figure 12
Gross value added of all industries (% change vs. the same quarter in the previous year)



Source: *Eurostat and EIB staff calculations.*
Note: *The regions of Europe are referred to simply as Western and Northern, Southern, and Central and Eastern in subsequent charts throughout the Investment Report.*

The speed of the recovery is likely to be uneven across the European Union. The decline in services, especially trade, transport and hospitality, is much larger in Southern Europe than in the rest of the European Union. Because these services represent a large share of the economies of Southern Europe, they will weigh significantly on the recovery, both weakening it and stretching it out over time.

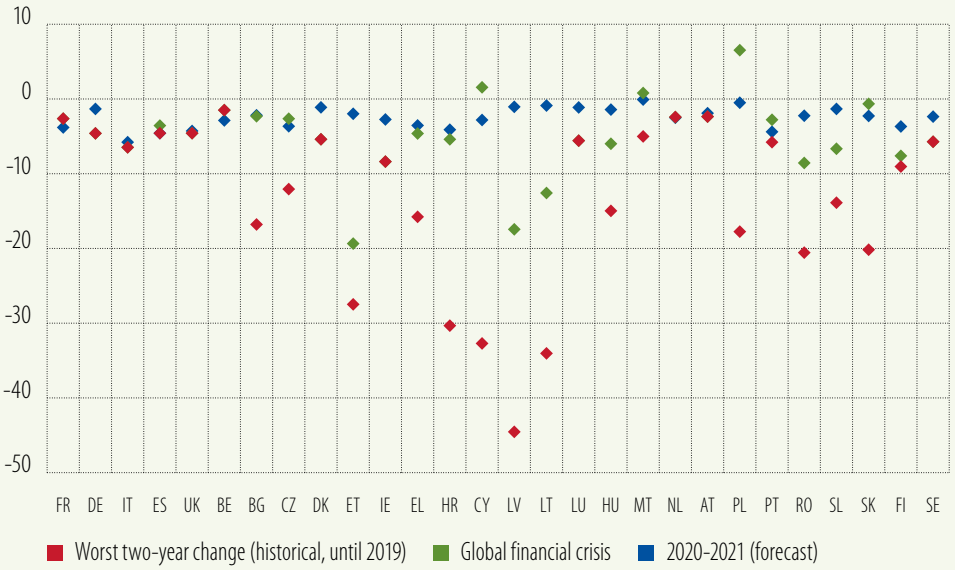
Box B

The pandemic's impact on GDP: A historical perspective

The extent of the expected economic decline in 2020-2021 rivals the steep drop in activity that followed the global financial crisis. It is therefore worth comparing the intensity of the ongoing economic crisis to the global financial crisis, which could provide insight into the likeliest paths to recovery. To this end, this analysis compares the expected decline in GDP in 2020-2021 (defined as the COVID-19 recession) with the worst two-year cumulative losses in GDP and with the global financial crisis for individual countries. One obvious caveat is that the 2020 and 2021 forecasts might turn out to be quite different from the actual data given the high uncertainty surrounding the recovery.

Figure B.1

Cumulative two-year contractions – comparison with the global financial crisis

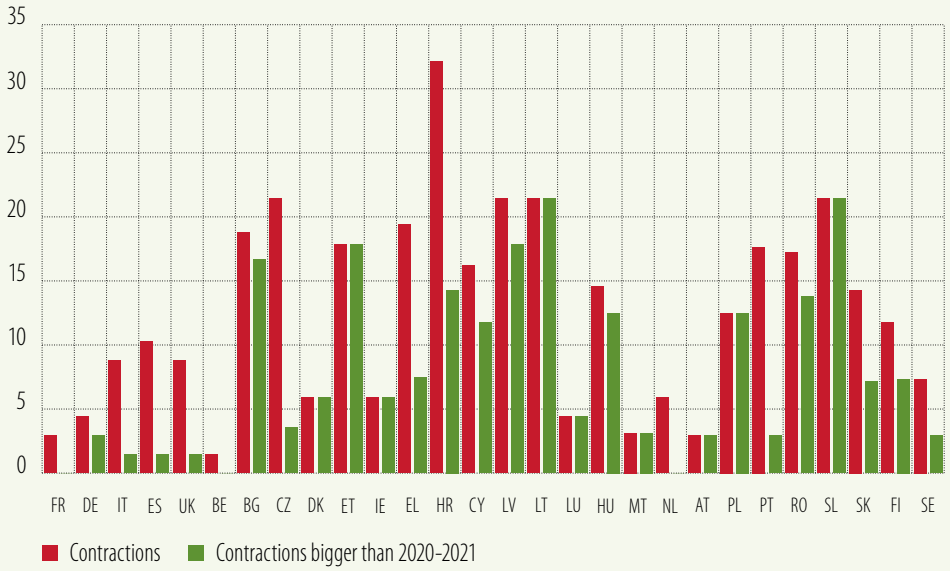


Source: *Penn World Table, Eurostat, IMF and EIB staff calculations.*
Note: *GDP forecasts for 2020 and 2021 are based on the European Commission's July 2020 forecast and the IMF's June 2020 WEO update (IMF, 2020b). For almost all advanced economies, the starting year of the analysis is 1950. However, for some countries, data only becomes available as late as 1990 (such as for many Central and Eastern European countries).*

The global financial crisis is identified as the worst crisis in post-World War II history for many countries in Western and Northern Europe (Figure B.1). In Southern Europe, it sits close to the COVID-19 crisis. The expectations of a rebound in 2021 make COVID-19 a relatively short-lived recession. This latter forecast is also based on the assumption that the health crisis will be resolved in 2021.

Figure B.2 illustrates the comparison from a different angle. The vertical axis shows the percentage of two-year cumulative decline and the percentage of those contractions that are worse than the 2020-2021 result for the total sample. In general, the figure depicts the well-known fact that mature economies are more stable and less susceptible to frequent declines in output. For nine countries, all two-year periods of contraction were harsher than the 2020-2021 crisis. The countries of Central and Eastern Europe experienced dramatic losses after the fall of Communism with the entire economic system wiped out, which explains why for most of them the decline in 2020-2021 is smaller than previous declines. For Southern European countries, however, the decline from the pandemic stands out as one of the harshest contractions since World War II.

Figure B.2
Frequency of contractions and worse-than-2020 contractions (in %)



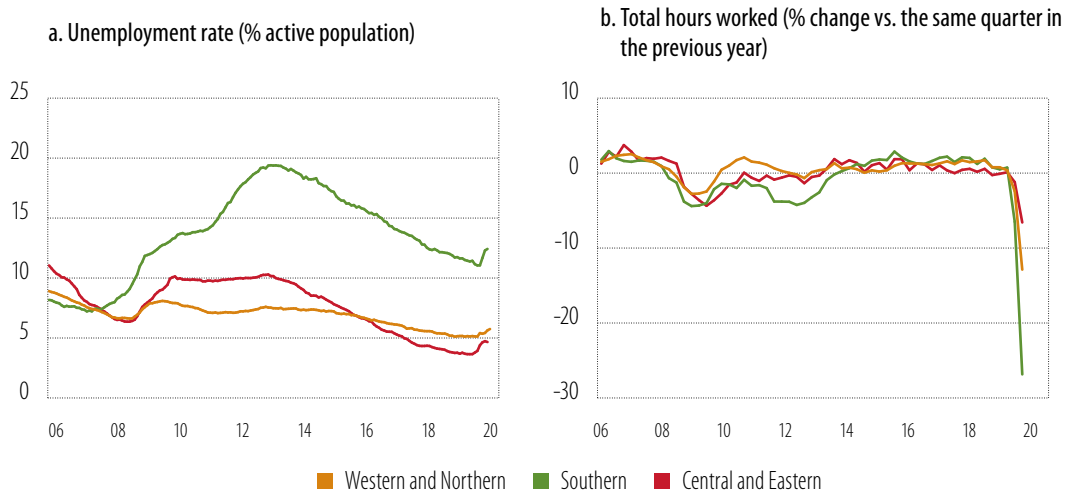
Source: *Penn World Table, Eurostat, IMF and EIB staff calculations.*
Note: *GDP forecasts for 2020 and 2021 are based on the European Commission's July 2020 Forecast and the IMF's June 2020 WEO update (IMF, 2020b). For almost all advanced economies, the starting year of the analysis is 1950. However, for some countries data availability starts as late as 1990 (such as for many Central and Eastern Europe countries). The green bar shows the number of contractions that are bigger than the 2020-2021 decline as percentage of all years in the sample. When the two bars are equal, all contractions until 2020-2021 have been worse than the current contraction.*

Aggressive policy measures soften the blow of unemployment across the European Union

Labour productivity, measured as GDP per hour worked, slightly increased in the second quarter of 2020, in contrast to a large decline in GDP per employee. While the cyclical nature of labour productivity is an empirical fact, the significant difference between the change in GDP per employee and that of GDP per hour worked is unusual. In the second quarter of 2020, EU GDP per hour increased by 0.3% relative to the same period of 2019, whereas GDP per employee fell 11.5%. A difference of this scale was not seen even at the peak of the recession following the global financial crisis. In 2009, for instance, EU GDP per hour fell 1.2%, while GDP per employee declined by 2.6%. The difference in 2020 indicates the extent of the employment subsidies that most EU governments made available to businesses in the second quarter of 2020.

Massive government support kept the increase in unemployment relatively contained at the end of the third quarter of 2020 (Figure 13). The unemployment rate rose by about 0.5 percentage points in Western and Northern Europe and Central and Eastern Europe (Figure 13a). The increase was higher in Southern Europe (1.5 percentage points). The United States saw an increase of 4 percentage points over the same period with a peak of 10 percentage points in April. The difference between the two sides of the Atlantic can be mostly explained by significant differences in labour-market institutions and also by substantial government financing of policies to retain labour (Box D). The effect of government measures can also be indirectly gauged by comparing the contained increase in unemployment with the steep decline in total hours worked across the European Union (Figure 13b). This suggests that if employment was not subsidised, the increase in unemployment would have been much greater (Box D for caveats).

Figure 13
Unemployment and total hours worked



Source: *Eurostat and EIB staff calculations.*

Increasing risks of a slow recovery and a substantial increase in government indebtedness do not bode well for the unemployment outlook in the near term. General government debt in the European Union increased by 8.5 percentage points of GDP to 88% from the first to second quarter of 2020 as the pandemic intensified. The sharp increase in debt is likely to curb governments' ability to act as decisively should the pandemic's second wave require further restrictions in the fourth quarter of 2020 or first quarter of 2021. With a stalled recovery and, possibly, a weaker fiscal response, unemployment is bound to increase significantly. Higher unemployment will exert additional pressure on social protection systems to extend their remit to parts of the population not covered by current programmes (Box C).

Box C
Social protection systems and the COVID-19 shock: Adapting short- and long-term support

Social protection systems play a central role as stabilisers when economic shocks occur. Unemployment benefits are clearly countercyclical but other forms of social spending such as pensions or sickness benefits also contribute to maintaining households' disposable income in times of economic stress. Structurally, social protection systems help to reduce the incidence and depth of poverty, improve the health of the population and facilitate access to education.

The stabilising effects of social protection systems are stronger in higher-income countries due to the size and composition of spending. EU Member States with higher incomes spend relatively more on social protection and typically place greater emphasis on sickness, family and unemployment benefits (European Commission, 2019). Following the global financial crisis, social protection expenditure increased, reflecting in particular the higher spending on unemployment benefits following the shock to the economy.

The pandemic prompted unprecedented policy action to support firms and households. The introduction and/or extension of short-time work (government programmes that subsidised the salaries of workers whose hours were temporarily reduced for economic reasons) is a distinctive feature of this crisis (Box D) but all governments have gone further. Their action includes providing easier access to regular support instruments in the event of unemployment or sickness, a stronger emphasis on safety and health protection at workplaces, increased support for parents staying at

home or additional child/family allowances. In addition, housing has emerged as a key area in limiting the negative social impact of the pandemic, with policymakers introducing measures to protect tenants and mortgage holders, such as support for payment moratoriums, suspension of evictions, or subsidies for rent and utility bills.

The pandemic highlighted some of the existing gaps in social protection systems. A lack of access can reduce their effectiveness in protecting people when they lose their jobs and income, fall sick or experience poverty. Typically, unemployment benefits and short-time work tend to be geared towards those on full-time permanent contracts. In contrast, non-standard workers, including the self-employed or those on part-time or fixed-term contracts, may lack adequate income protection and often face a higher risk of losing their jobs. Pre-crisis estimates suggest that non-standard workers are 40-50% less likely to receive income support during the periods they are out of work, and even if they do, the benefits tend to be less generous (OECD, 2019). Incentives for employers to use short-time work for non-standard staff are likely lower, particularly if firms expect some of the impact on employment to be permanent (see analysis in Chapter 2).

The prevalence of non-standard work differs across EU countries but is particularly frequent in certain sectors hit hard by the pandemic, such as hotels and restaurants or the arts and entertainment. Challenges for social policy mount in countries in which employment in these sectors is higher and non-standard employment more prevalent. Several Southern European countries appear to have a particularly high share of vulnerable workers (Figure C.1, upper-right quadrant). By socio-demographic group, women and younger workers seem more vulnerable and have a higher probability of being non-standard workers. Moreover, informal workers are a particularly vulnerable group with few entitlements and often have limited scope for claiming benefits.

Figure C.1

Total employment and non-standard employment in activities most affected by the pandemic

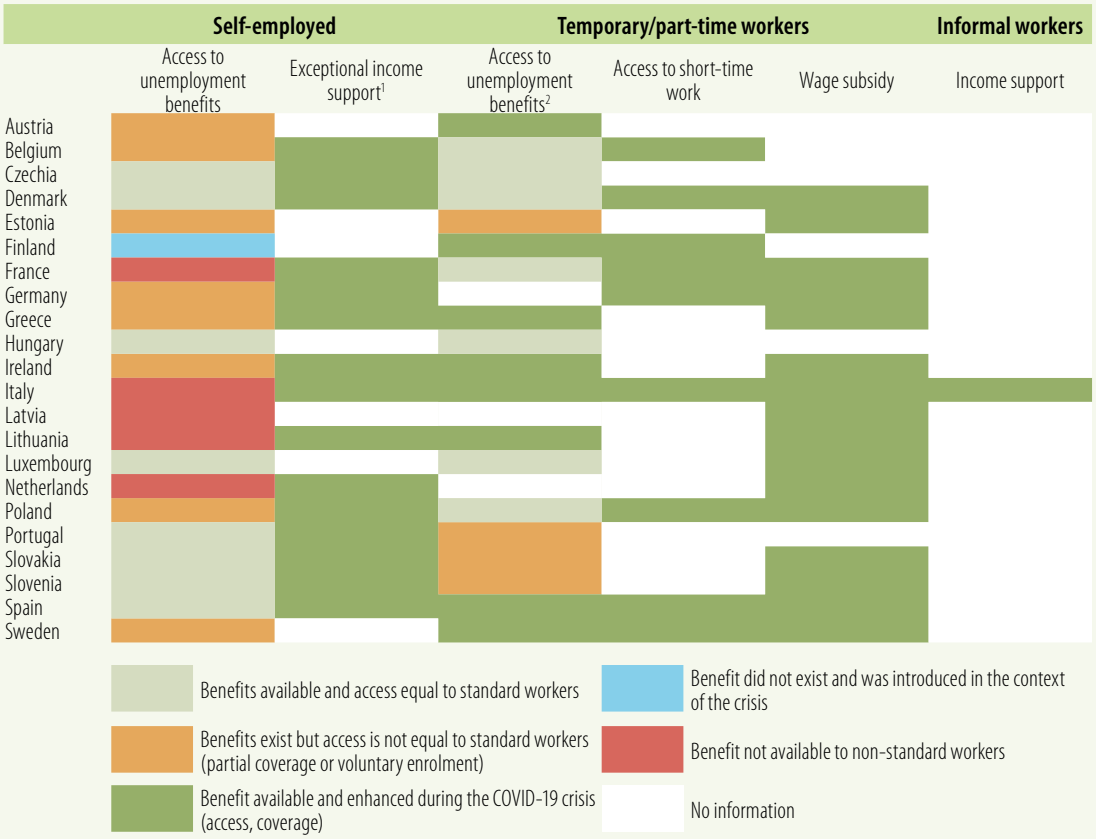
Source: *OECD (2020a), OECD Annual National Accounts; EU Labour Force Survey Database; and OECD calculations, EIB Economics Department.*

Note: *Black lines indicate the EU average. Non-standard workers include those on temporary contracts or in part-time jobs, and the self-employed. Activities affected most by containment measures include wholesale and retail trade, accommodation and food services, real estate services and construction, professional service activities, other service activities and the arts, entertainment and recreation. See OECD (2020a) for further explanation.*

Strengthening non-standard workers' access to regular benefits and facilitating their inclusion in short-term work schemes have been a feature of COVID-19 policy responses, as a result of the spotlight cast by the pandemic on the existing gaps. Some countries have introduced special sectoral support and/or targeted measures for vulnerable groups. In Spain, for example, temporary workers whose contracts expired during lockdown before they reached the minimum contribution period for unemployment benefits received provisional allowances (ECIJA, 2020). Moreover, several countries have acted to support freelance workers and the self-employed. Relatively few actions have focused on informal workers (Table C.1).

Table C.1

Support for non-standard and vulnerable workers in the pandemic: Income replacement and support measures in EU Member States



Source: *OECD (2020a).*
Note: *[1] Includes lump sum or temporary income replacement schemes; [2] access relative to standard workers assessed on the basis of the gap in the probability of benefit accessibility.*

The pandemic is affecting social protection systems in the short term and may have long-term effects. Some of the measures introduced to protect workers are temporary, such as support for the self-employed via lump sum transfers, "employer salaries" or sectoral aid packages (such as for hospitality and the arts and entertainment). Other changes, for example improved access to benefits for temporary or part-time workers, might become permanent. They could be a step towards a gradual "update" of social protection systems to respond to more structural shifts in employment patterns linked to factors including developments following the global financial crisis and digitalisation. Closing some gaps could help to address the issue of rising inequalities that predated the pandemic, and prevent a further widening in its aftermath.

For housing, measures such as eviction suspensions or payment moratoriums are temporary and geared towards protecting vulnerable parts of the population. However, the pandemic has increased awareness of imbalances in this area. Inequalities in access to affordable, quality housing have widened in recent years, with rising housing costs contributing to the financial vulnerability of many households. Demand for housing is widely expected to receive a structural boost from the pandemic. Against this background, housing policy measures aiming to improve supply and guarantee well-functioning housing markets remain a key area for addressing inequalities.

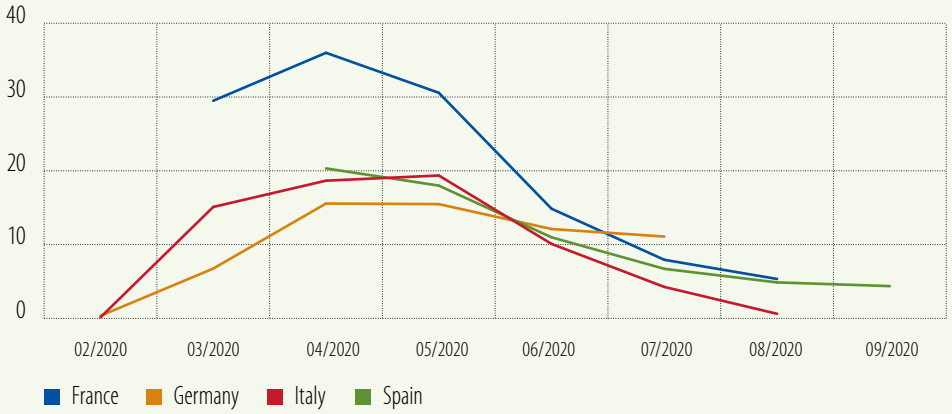
Box D

How significant are the benefits of short-time working schemes for firms?

Participation in short-time work (STW) increased sharply as economic activity collapsed in the second quarter of 2020. STW schemes are part of a series of measures that provide support to firms (such as grants, equity injections, and loan guarantees) and households. At the end of May 2020, about one-third of employees participated in STW schemes in Austria, France and the Netherlands, and one-fifth in Germany, Spain and Ireland (OECD, 2020c). As economies recovered, participation declined (Figure D.1).

Figure D.1

Participation in short-time working schemes peaked during the lockdowns, percentage of employees



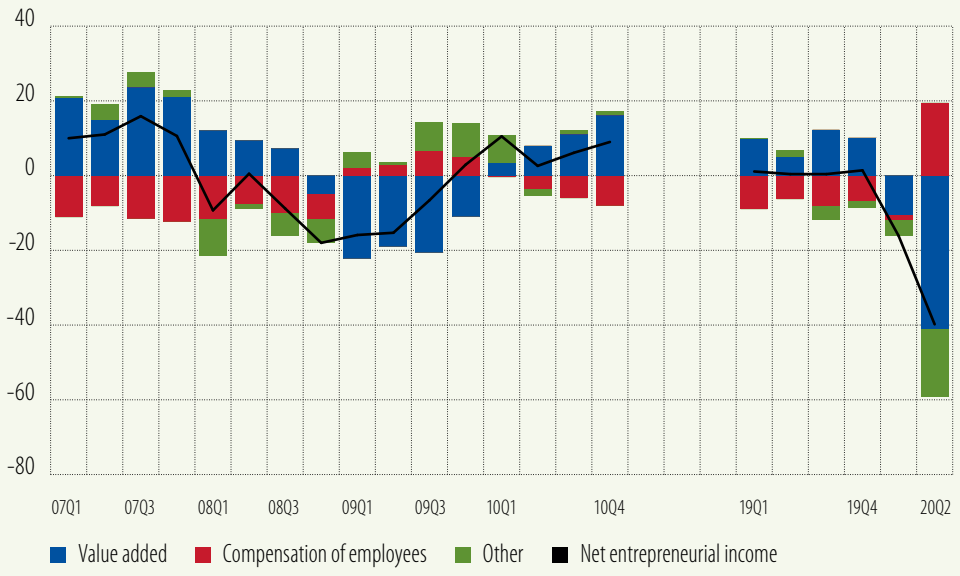
Source: *For total employment (2019), OECD (2020b). Country-specific sources are Nombre de salaries effectivement places en activité partielle; DARES (2020), Situation sur le marché du travail durant la crise sanitaire au 29 septembre 2020 for France; Empfänger von Kurzarbeitergeld, Bundesagentur für Arbeit (2020), Monatsbericht zum Arbeits- und Ausbildungsmarkt, September for Germany; Personas incluidas en un Expediente de Regulación Temporal de Empleo (ERTE), end of month, Gobierno de Espana (2020), Afliliacion a al seguridad social, Balance mensual de la afiliación, 2 October for Spain; N. salariali Covid-19 erogate direttamente dall'INPS (CIGO, fondi di solidarieta, CIGD), Instituto Nazionale Previdenza Sociale (2020): "Integrazioni salariali Covid-19 erogate direttamente da INPS," 1 ottobre for Italy.*

The benefit that a firm derives from an STW scheme depends on how it would have behaved had the scheme not been offered. A key question is whether a firm only retained staff because it participated in the scheme or whether it would have retained the staff anyway. One factor influencing a firm's response is the availability and cost of other mechanisms for adjusting its payroll. A firm operating under stringent employment protection laws and with contracts allowing it to adjust the number of employee hours might have retained staff even in the absence of the STW scheme. The same might be true of a firm employing highly skilled staff that are expensive to re-hire.

The evidence for firms' response to STW schemes is mixed.[3] At the macroeconomic level, STW schemes appear to have helped avoid layoffs by increasing flexibility in the number of hours worked (Abraham and Houseman, 1994; Arpaia et al., 2010). From a microeconomic perspective, the effect of STW schemes is more difficult to demonstrate, not least because firms that have other ways of adjusting their payroll are less likely to adopt STW schemes (see Lydon et al., 2019 for evidence). For example, Kruppe and Scholz (2014) find that German firms participating in STW schemes during the 2007-2009 crisis reduced their headcount by about the same amount as those not participating. Against this background, we discuss the benefit of STW schemes for two scenarios representing firms at the opposite ends of the spectrum.

For firms that participate in the STW scheme but would have retained and paid in full their employees even in the absence of the scheme, the benefit is equal to the scheme's transfers. A rough estimate of these transfers is the share of wages replaced by the STW schemes. This varies by country. For most, it is around 50% to 80% of the wages that employees lose because their working hours are reduced (Mueller and Schulten, 2020). The transfer is also reflected in institutional sector accounts. The drop in employee compensation raised entrepreneurial income growth in the second quarter of 2020 even more than during the financial crisis in 2009 (Figure D.2).

Figure D.2
Falling employee compensation added to entrepreneurial income



Source: Eurostat and EIB staff calculations.

For firms that would have laid off staff without the scheme, the benefit is about equal to the frictional costs of firing existing employees and hiring replacements once demand picks up again. Assume that if the firm had laid off staff, its salary payment would have fallen by the same amount that it receives in transfers when participating in the STW scheme and retaining its staff. In that case, participation in the scheme only saves the costs associated with firing and re-hiring employees. These costs, however, can be substantial. Estimates come in at about half of a worker's annual salary, with significant variations across jobs and countries. Firing costs are typically in the range of one to five months of salary for OECD countries, depending on job tenure and the circumstances of dismissal (OECD, 2020b). Hiring

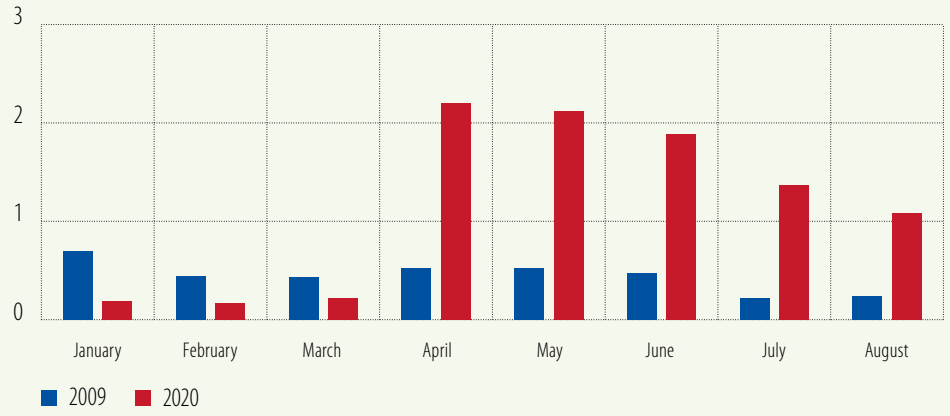
3 See also European Network of Public Employment Services (2020) for an overview.

costs, for recruitment and training, greatly depend on the position to be filled. Muehlemann et al. (2016) find that hiring costs are about two months' salary for skilled German workers, while Blatter et al. (2012) estimate the costs at about three to four months' salary for skilled Swiss workers, ranging from about one month for a medical assistant to six months for an automation technician. The bulk of these costs are associated with training (see also Manning, 2011, for an overview).

Aside from these direct effects, STW schemes are likely to generate indirect benefits for firms by stimulating aggregate demand. Like other schemes that insure against a sudden decline in income, STW schemes transfer funds to cash-constrained firms and households, whose marginal propensity to spend is likely to be higher than that of those funding the transfers. As a result, aggregate demand is likely to fall less than without the scheme.

Relative to the 2008-2009 recession, the benefits firms derived from STW schemes in the current crisis increased because the schemes were more generous. As a result, take-up has been much higher during the COVID-19 crisis than the 1% to 3% of employees observed in most EU countries in 2009 (Hijzen and Venn, 2011 and European Network of Public Employment Services, 2020). Indeed, a few countries, such as the United Kingdom, introduced STW schemes only in 2020. The schemes were made more generous for several reasons. First, economic activity collapsed as lockdowns were imposed, leaving firms with no time to prepare. In contrast, the 2007-2008 global financial crisis reached its peak with the insolvency of Lehman Brothers in September 2008 and only gradually started to affect real economic activity over the following six months. Second, uncertainty about the depth of the economic crisis was considerably higher in 2020 (Figure D.3). This greater uncertainty has increased the option value of temporarily supporting firms that might become profitable again after the crisis subsides. Third, in many EU countries the decline in output has been more broadly spread out during the COVID-19 crisis than in 2009, when the service sector fared better than construction and manufacturing (Figure D.4). The risk that STW schemes discourage workers from finding jobs that are more productive in other sectors therefore appeared smaller than in 2009.

Figure D.3
Standard deviations of consensus forecasts of euro area GDP growth in 2009 and 2020



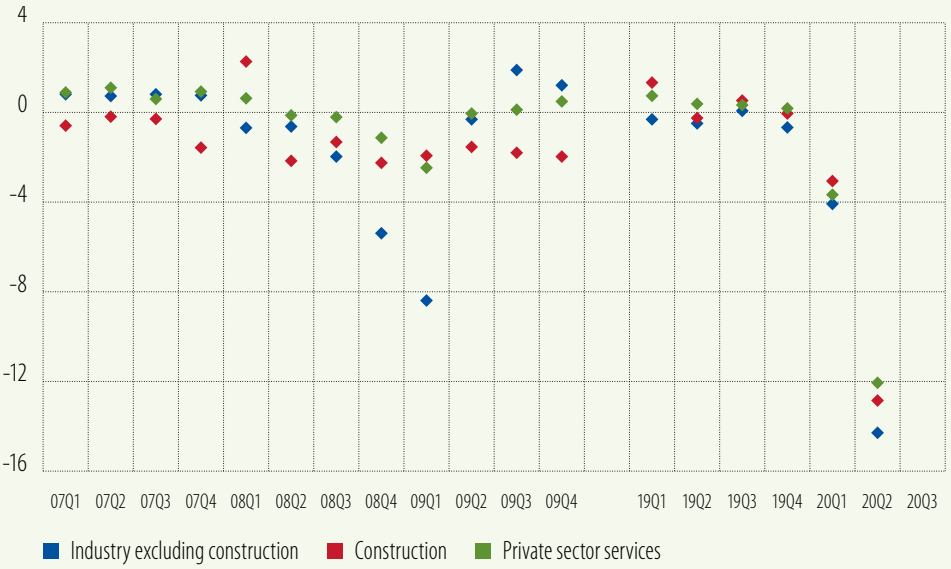
Source: *Consensus Economic Forecasts.*
Note: *Forecasts were made in the month shown and were for the annual GDP growth in 2009 and 2020, respectively.*

Over time, the unintended effects of STW schemes may become more apparent. As countries emerged from lockdowns over the summer, participation in STW schemes declined. With the health crisis continuing, however, a number of countries extended their schemes (including Germany, France and the Netherlands). This raises the risk that in some sectors, firms that continue to participate in STW

schemes might become unviable because demand for their products has declined permanently. For example, demand for office space and public transport may not fully recover. In addition, the cost of discouraging workers from finding jobs that are more productive may soon increase.

Figure D.4

Euro area GDP declined more sharply during the pandemic than in 2009



Source: ECB data warehouse.

Schemes may therefore need to be recalibrated to contain their unintended effects, and they must continue to reflect the institutional and market environment of the various countries, as well as the unfurling of the health crisis. In general, directing the STW schemes towards the sectors worst hit by government measures and promoting the mobility of workers from subsidised to unsubsidised jobs could help mitigate the schemes' unintended effects.[4]

Financial developments and policies

Compared to the global financial crisis, the COVID-19 crisis took hold against the backdrop of already ultra-accommodative monetary policies and apparently smaller and very limited fiscal space. However, major steps had been taken to increase the resilience of Europe and its institutions: the creation of the European Systemic Risk Board and the three European Supervisory Authorities,[5] the setup of the Single Supervisory Mechanism and other building-blocks of the banking union, and the establishment of the European Stability Mechanism. Contrary to what might have been expected prior to the crisis, policy support unfolded massively and swiftly. As the eradication of the virus and the return to normal take longer than previously thought, this support may be recalibrated to ensure it can continue while minimising its side-effects.

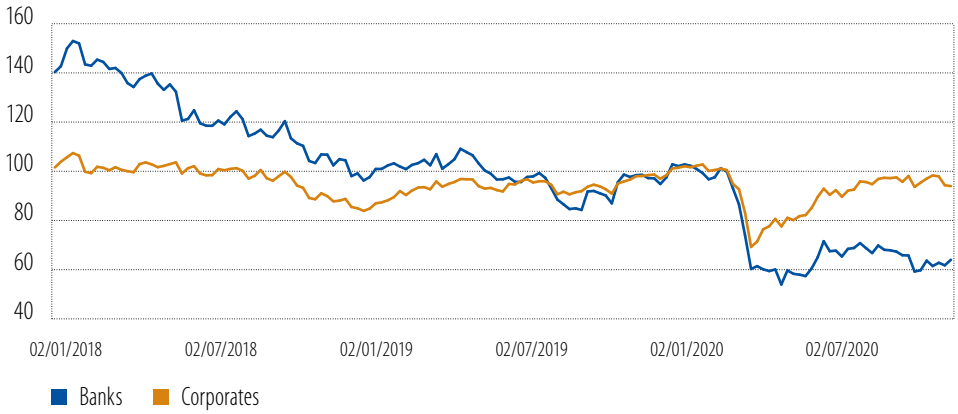
4 See OECD (2020c) for suggestions of how STW schemes could be recalibrated.

5 These are the European Banking Authority (EBA), the European Securities and Markets Authority (ESMA) and the European Insurance and Occupational Pensions Authority (EIOPA).

An unprecedented crisis

The COVID-19 crisis is not a normal recession but a halting of activity triggered to prevent a public health disaster. The policy response has therefore had to be different. The purpose is to limit social distress and avert unnecessary bankruptcies that could hold back the recovery. Monetary and fiscal policies have cushioned the blow, mainly by providing financial assistance to companies and workers.

Figure 14
Corporate and bank stock prices (European Union, 100=Dec. 2019)



Source: *Refinitiv and EIB calculations.*
Note: *Last record, 4 November 2020.*

The initial contraction could have easily turned into a financial collapse. At the onset of the crisis, the stock market plunged, with corporate stock prices indices plummeting by 35% and bank stocks by 40% as investors fled to safer assets (Figure 14). However, a massive and unprecedented response by central banks and governments prevented a financial collapse from compounding the freefall in output. Share prices recovered strongly for corporate stocks, whose performance was uncoupled from bank stocks. Nine months after the start of the crisis, in late November 2020, bank stocks are still 30% below pre-crisis levels. In the longer term, banks´ profitability is likely to remain subdued, given the persistent low interest rate environment that is squeezing net interest income and the returns from maturity transformation.

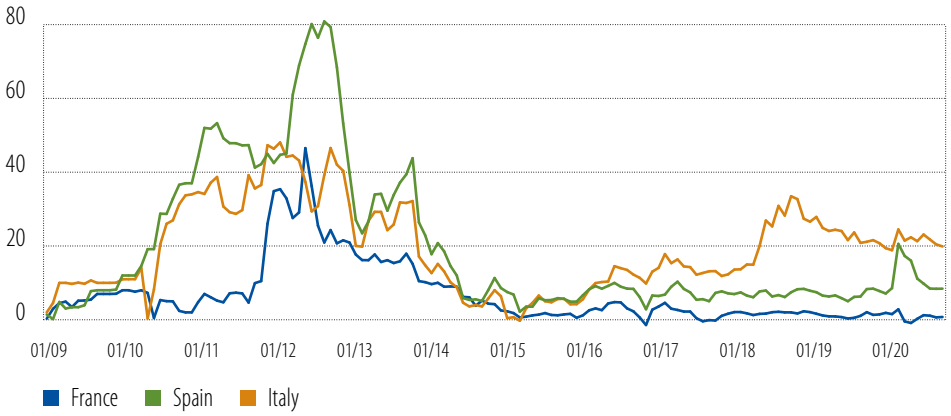
The ECB swiftly dispelled initial fears about the integrity of the euro area. In Figure 15, we plot quanto CDS spreads, or the difference between credit default swap quotes in US dollars and euros. The resulting measure is an indication of the risk associated with the break-up of the euro area as perceived by investors.[6] In contrast to what happened during the sovereign debt crisis, the quanto CDS spreads did not escalate for the three major sovereigns – France, Italy and Spain – compared to Germany, and stayed almost unchanged compared to the period prior to the COVID-19 crisis. This suggests that the ECB's response was perceived as bold enough to support the integrity of the euro area.

Lower inflation for longer. At its onset, some analysts argued that the crisis could have a negative or positive impact on inflation (Shapiro, 2020). Since the lockdown has resulted in both an adverse supply shock and an adverse demand shock, inflation could theoretically have responded either way. In the first few months, however, inflation slowed down sharply across Europe, and the decline was due to other factors than the most volatile components, such as energy (Figure 16). In the long term however, the risk

6 More precisely, we plot the difference between the quanto CDS yield for France, Italy and Spain and that for Germany – this measurement of the benchmark euro area sovereign debt market is less prone to worries about whether the liquidity of sovereign CDS contracts is the same across the currency spectrum. The use of certain countries' quanto CDS relative to Germany is based on the idea that the spread would be close to zero if the market perceived the risk of a break-up of the euro area as minor (de Santis, 2015).

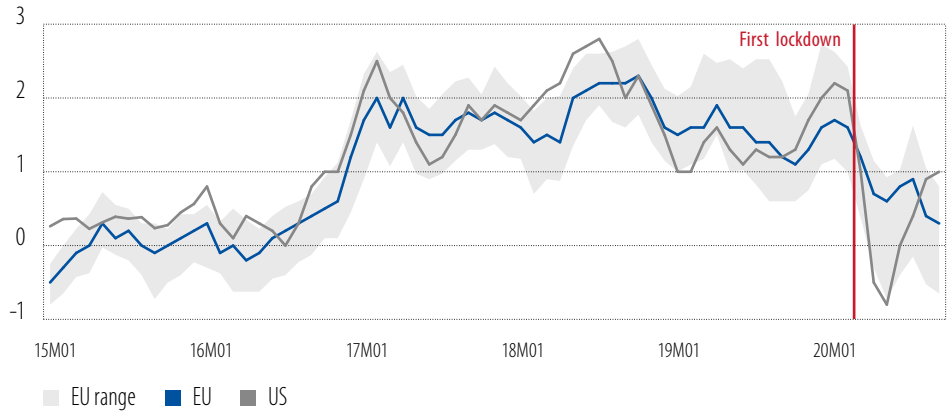
of inflation rising beyond its target is substantial given the amount of liquidity injected in the system. Moreover, as public debt accumulates, monetary policy may well give way to fiscal constraints (come under fiscal dominance), if rate hikes are seen as doing too much damage to public finances.[7]

Figure 15
Quanto CDS spreads (basis points)



Source: *Refinitiv and EIB calculations.*
Note: *Last record, October 2020.*

Figure 16
EU Harmonised Index of consumer prices and dispersion (annual rate, %, and interquartile quartile range, in percentage points)



Source: *Eurostat and EIB calculations.*
Note: *Last record September 2020.*

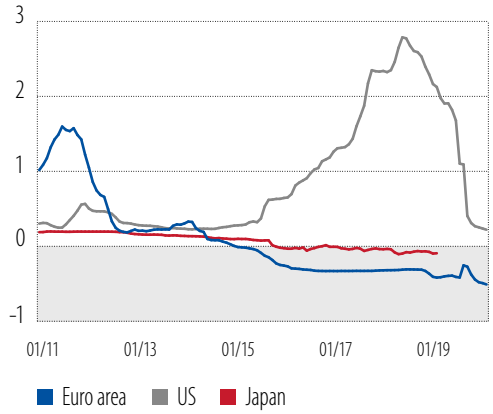
Major central banks entered the crisis with little leeway for lowering short-term policy rates. Figure 17 plots the interbank money market rates for the three major advanced economies. While the US Federal Reserve had embarked on tightening its monetary policy, the ECB and Bank of Japan were already deploying negative short-term rates close to the effective zero lower bound. Consequently, only the United States had some latitude to use standard monetary policy to support the economy. From February 2020 until October 2020, the effective federal funds rate decreased by 150 basis points in the United States.

7 When public debt amounts to 100% of GDP, a 100 basis point increase in the short-term rate passed through the long-term rates increases interest expenses for governments by 1% of GDP each year in the long term.

Long-term rates also were already low prior to the crisis. Several structural drivers were already fuelling the downward trend in long-term interest rates (Figure 18). While monetary policy can be a contributor, demographic changes are a major cause. As the populations in advanced economies age, the balance between the various age groups in these populations shifts, affecting the overall supply of savings. Middle-aged individuals tend to save and provide funds to the rest of the economy, while the young and the old tend to spend more than their disposable income and demand funds. As a result, the real interest rate that balances the overall supply of savings with the demand for investment is affected by the relative size of these age groups (del Negro et al., 2018).

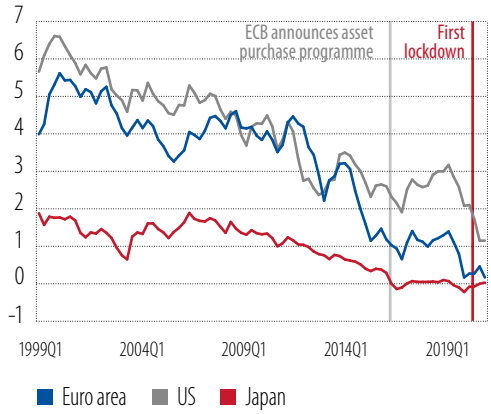
Long-term rates are most likely to remain low for longer, and might even drop further. While the rapid and unprecedented collapse of production, trade and employment may be reversed when the pandemic eases, historical data suggest that long-term economic consequences could persist (Jordà et al., 2020). Among these are a prolonged period of depressed real interest rates – akin to secular stagnation – that may linger for a long time. Chudik et al. (2020) estimate that the pandemic will likely drive long-term interest rates in the advanced economies about 100 basis points lower than their pre-COVID-19 lows over the next few years. This is because the crisis raises precautionary savings and dampens investment demand.

Figure 17
Short-term interest rates in selected advanced economies (% per year)



Source: *Refinitv and EIB calculations.*
Note: *Last record October 2020.*

Figure 18
Long-term interest rates in selected advanced economies (% per year)



Source: *Refinitiv.*
Note: *Last record November 2020.*

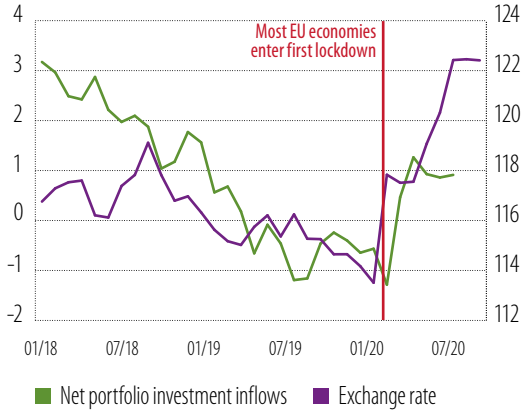
With increasing capital inflows and an appreciating exchange rate, Europe is perceived as resilient. Figure 19 plots net portfolio inflows in the euro area and the euro effective exchange rate. Since the start of the crisis, both have clearly been on a positive trend. From February 2020 until October 2020, the effective exchange rate of the euro, the exchange rate against a basket of currencies, increased by 7%. The stronger exchange rate partly reflected the trend in cumulative annual capital flows, which increased by more than 2% of GDP over the same period, with a shift from net outflows to net inflows. These developments suggest that during the crisis, the European Union's performance, which was partly the result of the policy response, was perceived as credible and reassuring by international investors. Over the same period, the European Commission issued the first tranche of bonds to finance the SURE instrument (Support to Mitigate Unemployment Risks in an Emergency) and the recovery plan. The issuance was a major success, and was largely oversubscribed. This bodes well for the future of these bonds as a potential safe asset for investors, and also for the financing of the green transition.

A central bank with two arms

For the first time, the ECB acted both on monetary policy and on financial prudential policy. To ensure financial prudency, macro and micro policy measures were deployed. Following the global financial crisis, the ECB became in charge of the micro-supervision of euro area banks while the European Systemic Risk Board (ESRB) was created to coordinate macro-prudential policies across Europe. The COVID-19 crisis provided the first opportunity to coordinate these two types of policy intervention at the European level.

Figure 19

Net portfolio inflows and euro exchange rate (% GDP and index, 100=1999Q1)



Source: *ECB and EIB calculations.*
Note: *Last record November 2020. An increase reflects an appreciation. Net portfolio inflows are reported using a 12-month moving average.*

Figure 20

ECB lending to euro area credit institutions (in billions of euros)

Source: *EIB Economics Department calculations based on IMF WEO.*
Note: *Last record 2019.*

On the monetary policy side, the ECB deployed several measures to support banks' liquidity. At the onset of the crisis, new non-targeted, longer-term refinancing operations were launched, the interest rates in targeted longer-term refinancing operations were lowered and collateral measures were eased (for a comprehensive presentation, see Lane, 2020). In June 2020, 742 European banks tapped the ECB's TLTRO III for EUR 1.3 trillion. The multiyear loans are offered to banks at interest rates below the ECB's main deposit rate, sometimes as low as minus 1% if certain conditions were met.[8] In net terms, after adjusting for the repayment of maturing loans, the June operation provided a liquidity injection of EUR 158 billion. From the start of the crisis until September 2020, liquidity injections for banks in the euro area almost tripled, increasing by almost EUR 1.2 trillion (Figure 20). The ECB also decided on a new series of non-targeted pandemic emergency longer-term refinancing operations (PELTROs) to support liquidity in the euro-area financial system and to help preserve the smooth functioning of money markets by providing an effective liquidity backstop.

The ECB also strengthened its asset purchase programme. At the beginning of the crisis, the ECB increased its asset purchase programmes by EUR 870 billion (more than 7% of the euro area's 2019 GDP) until end-2020. The Pandemic Emergency Purchase Programme (PEPP), a new programme with an envelope of EUR 750 billion, was created, with eased conditions for eligibility. In June 2020, the programme was extended until June 2021 at least, with its envelope raised to EUR 1.35 trillion and maturing principal payments reinvested until the end of 2022 at least.

8 The condition aims at avoiding banks' deleveraging. To benefit from the cheapest funding, the corporate loan book of banks has to remain above a certain benchmark during the horizon of the liquidity provided by the central bank. The dual-rate system was introduced in June 2020.

On the prudential regulation side, several measures were decided by the ECB, the European Commission and supervisory authorities to provide temporary capital relief for banks. Banks were allowed to operate below the level of capital defined by the Pillar 2 Guidance for the capital buffer and the liquidity coverage ratio. Supervisory flexibility regarding the treatment of non-performing loans was allowed and the capital requirements for market risk were reduced. To counteract the potentially destabilising impact of the more stringent banking regulations that were on the horizon, the implementation of certain new measures was frozen or postponed (ECB, 2020d).[9]

This extensive set of monetary and prudential measures proved very effective in keeping credit flowing. The coronavirus recession has resulted in large-scale changes to the balance sheets of euro-area banks. Corporate borrowers frontloaded their liquidity needs by taking out loans and placing the financing obtained in liquid assets, mostly held in commercial bank accounts. Banks significantly increased their funding from central banks while also building up their liquidity buffers there. The funding markets for banks have not shown the major signs of the distress they exhibited during the global financial crisis. In addition, most EU national governments provided state guarantees for bank loans, mainly targeting small and medium-sized enterprises (SMEs). In some countries these guarantees amount to more than 20% of GDP and represent over half of the existing stock of loans to non-financial corporations.

Fiscal policy

In Europe, central banks have retained their key roles, but are no longer the only major players. This time, governments and the European Commission have acted swiftly and strongly to cushion the economic shock caused by the pandemic with fiscal measures. Around EUR 2.7 trillion will be mobilised in response to the pandemic. This amount includes national liquidity measures, including the schemes approved under the temporary EU state aid rules, and measures taken under the flexibility arrangements of the EU budgetary rules (general escape clause).

Policymakers have fully grasped their crucial role in mitigating the impact of the crisis, avoiding a prolonged and painful slowdown and supporting a rapid and strong recovery. Government policies are key to stemming the amplification of the demand-side shock, and can help cushion the impact on the long-term potential output of EU economies. Within the European Union, governments have taken a wide array of measures to support households and firms. Support at the European level comes on top of these national measures and helps to preserve a level playing field as governments' capacities to respond to the shock are not equally distributed across the European Union. The option of common support instruments continues to be important in light of the varying capacity of Member States to weather a further economic shock brought about by a second wave of infections. These common support instruments are also crucial to avoid repeating the pattern of the Europe's last crisis, which was followed by a prolonged period of subdued investment and widening divergence (Anderson et al., 2020).

Economic and fiscal policies have also been set up at the EU level. A temporary Support to Mitigate Unemployment Risks in an Emergency (SURE) instrument was designed to provide Member States with temporary funding of up to EUR 100 billion by covering part of the cost of creating or extending national short-time work schemes. In addition, direct EU budget support of up to EUR 70 billion will be made available, mainly through the Coronavirus Response Investment Initiative. The initiative uses unspent EU cohesion funds and allows for greater flexibility and more upfront spending by providing 100% EU financing for measures to fight the crisis. Through the European Guarantee Fund, the EIB Group can support up to an additional EUR 200 billion of liquidity and risk finance, targeting SMEs in particular. The

9 The proposed changes to Capital Requirements Regulation (CRR) in the bank regulatory framework to avoid pro-cyclicality: implementation of the Basel III standards has been deferred to provide additional operational capacity for banks and supervisors. Standards for revised risk: the leverage ratio buffer and Pillar 3 disclosures have been deferred by one year to 1 January 2023. Transitional arrangements for the output floor have also been extended by one year to 1 January 2028. The Basel Committee on Banking Supervision (BCBS) and supervisory authorities also acted to mitigate unintended consequences of the accounting framework on banks' capital position. Under the IFSR 9 Expected Credit Loss (ECL) approach, a system-wide rise in credit risk can prompt a large increase in loan-loss provisions and weigh on capital across banks. The BCBS decided to adjust, on a temporary basis, how additional provisions would flow through to capital. Corresponding legislative proposal on the CRR/CRD review published by the European Commission.

European Stability Mechanism (ESM) also introduced a Pandemic Crisis Support credit line. The credit line includes a liquidity facility of up to a maximum of 2% of Member States' GDP. The facility can be drawn in several tranches until the end of 2022 at least, representing a maximum of EUR 240 billion.

The NextGenerationEU recovery plan tops up the immediate crisis response. The NextGenerationEU recovery plan aims to raise money by temporarily lifting the limit of 2% of EU gross national income it is allowed to raise for its own funds. The change enables the European Commission to borrow EUR 750 billion on the financial markets. This additional funding will be channelled through EU programmes and repaid over a long period of time through future EU budgets. In addition, the Commission has also proposed a revamped long-term EU budget and will dedicate some of its own resources to round out the NextGenerationEU programme.

Public debt is on the rise, but this is not the most pressing issue. The October 2020 IMF Fiscal Monitor estimated that the global fiscal response to the pandemic totals an unprecedented EUR 10 trillion, about 12% of the world's GDP (IMF, 2020c). The pandemic will continue to drive up public debt, which the IMF expects to reach 99% of GDP in 2020 and to stabilise at around 100 % of GDP by 2025. The IMF urges governments to maintain/extend support at least into 2021 to sustain the recovery and limit long-term scarring. Investment should therefore focus on health, education, digitalisation and green infrastructure to address climate change and future pandemics.

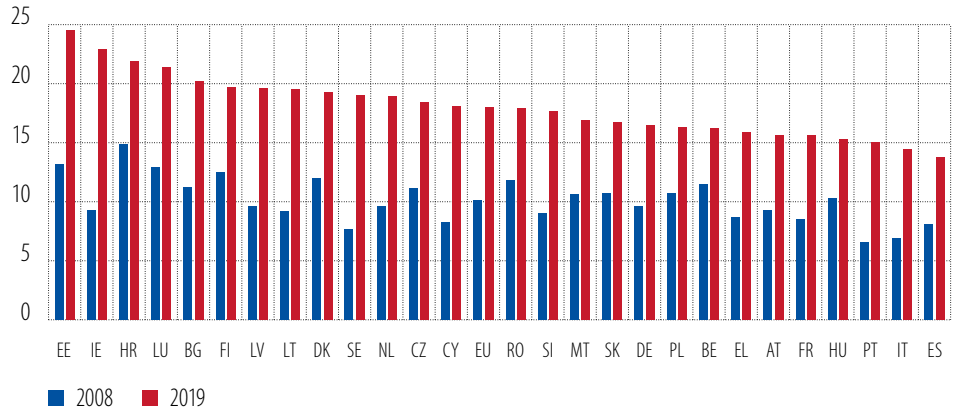
After the crisis, the attention will need to shift towards boosting the recovery by ensuring that the pandemic's legacy does not weigh on economic activity. Creating a favourable environment for private investment and fostering structural change will be important. In the EU context, it is important that the recovery plan be combined with measures that tackle the key structural challenges that Europe faces, such as climate change, digitalisation and inclusiveness.

With non-performing loans looming, are financial markets correctly pricing risk?

The EU banking sector entered the COVID-19 crisis on a stronger capital footing than after the global financial crisis. The current economic crisis triggered by the pandemic did not originate in the financial sector and ten years of structural transformation has put banks in a much stronger capital position and given them a much deeper understanding of the various risks and interdependencies. The average core tier 1 capital ratio in the European Union now stands at 18.3% of risk-weighted assets, 8 percentage points higher than in 2008 (Figure 21). Although the rise masks some major differences between countries, countries with a weaker capital position are still in a much stronger position than before the onset of the global financial crisis.

Non-performing loans (NPLs) might increase at a faster pace than during past crises, despite the payment deferrals put in place in most EU countries. Prior to the COVID-19 shock, NPL ratios were declining in most countries (3.2% of total loans in the euro area). However, they are now likely to increase, and will possibly do so faster than in the past two recessions as the fall in GDP is expected to be much steeper and more broad-based, with households, small businesses and companies in several economic sectors affected simultaneously. The allotment of credit lines to firms hit by the lockdown is likely to be accompanied by a rise in the risk for banks. However, the ECB has taken several measures to guarantee the liquidity of European banks, limit haircuts on debt and extend the pool of eligible collateral.

Figure 21
European banks' core tier 1 ratio (percentage of risk-weighted assets)



Source: *IMF and EIB calculations.*

Banks have significantly improved the quality of their assets in recent years, but the crisis could take a toll if it wears on. After peaking in the fourth quarter of 2014 (at 7.1%), the volume of non-performing loans dropped by more than half to 3.2% in the fourth quarter of 2019. These efforts enabled banks to enter the COVID-19 crisis in a stronger position than would have been the case some years ago. In addition to consistent policy support, two factors are likely to play a role in determining the rise in non-performing loans: the length of the crisis and banks' asset composition (Box D).

Are markets too benign in their assessment? A European Securities and Market Authorities' report analysed the impact of COVID-19 on financial markets during the first half of 2020 and highlighted the risk of a potential uncoupling of bond and stock markets from underlying economic activity, which calls the sustainability of the current market rebound into question. Since the end of the first lockdown, risky assets have attracted investors despite the subdued economic outlook. The ample liquidity provided by central banks could be fuelling the price rises and leading to an overall disconnection from economic prospects (Bank for International Settlements, 2020).

Box E
Bank exposure and COVID-19 policy responses

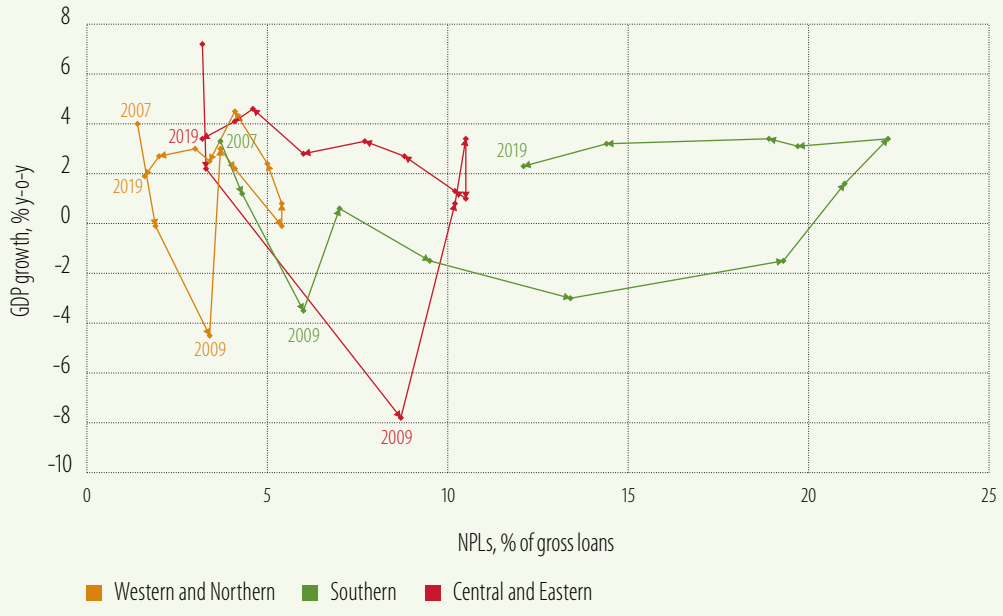
The ability and willingness of banks to lend will be critical to offsetting the current recession and supporting the recovery. Firms rely on external sources for one-third of their funding, to improve their cash flow and to fund their investments. Whereas larger firms can access the capital markets, bank loans play a significant role in funding small and medium-sized companies. During the pandemic, demand has increased for short-term loans to fund working capital in particular (ECB, 2020c).

A series of monetary, fiscal and prudential policy measures have supported the supply of bank credit. Central banks have lowered refinancing rates, in the ECB's case to as low -1% for banks that increase their lending to the real economy (ECB, 2020a). In addition, fiscal policy measures have reduced the credit risk associated with lending to businesses, for example by injecting equity, providing loan guarantees, and supplying liquidity to firms via tax deferrals and wage subsidies (see IMF, 2020a, for an overview). By June 2020, banks had granted COVID-19-related payment moratoriums amounting to 7.5% of their outstanding loans to households and companies in the European Union. Public guarantees covered new lending amounting to 1.6% of outstanding loans to households and companies (European Banking Authority, 2020).

Prudential policy measures were introduced to alleviate banks' concerns that risky lending to businesses would erode the buffers they hold over regulatory capital and liquidity requirements (for an overview of the measures, see for instance International Institute of Finance, 2020). Several supervisors have lowered requirements that were designed explicitly to be relaxed in downturns (Drehmann et al., 2020). For example, Sweden lowered the countercyclical capital buffer requirement by 2.5 percentage points of risk-weighted assets to zero. Many other countries had less scope for such large reductions as their countercyclical buffers were smaller at the outset of the crisis (ESRB, 2020). In addition, the implementation of some new requirements was delayed. For example, banks were effectively allowed to postpone holding capital against expected but not-yet-incurred credit losses (Ehrentraud and Zamil, 2020). Here, the concern was that banks with high, perhaps overly pessimistic, estimates of COVID-related credit losses would curtail their lending if they had to set aside more capital to cover expected losses. At the same time, supervisors have encouraged banks to build their capital buffers by retaining a greater share of their earnings (ECB, 2020b).

While these measures support the supply of bank credit and reduce defaults in the near term, loan losses are likely to mount in the medium term. First, loans typically take a couple of years to turn sour after the start of a recession. Second, most fiscal and prudential policy relief programmes are set to expire within the next few years. Third, the bulk of fiscal support has been granted in the form of debt, not equity. Loans provide liquidity but increase corporate leverage. Once loan guarantees expire, many firms will therefore pose a higher credit risk than before the crisis. Accordingly, recent surveys show that banks, on balance, are seeing loans to firms as more risky, and that banks are becoming more risk averse (ECB, 2020c).

Figure E.1
NPLs and GDP growth by region in the aftermath of the global financial crisis



Source: *World Bank and EIB staff calculations.*

Following the first lockdown, aggregate credit losses may ultimately amount to 5-10% of banks' exposures. One approach for estimating eventual credit losses relies on past correlations between GDP and non-performing loans, ignoring the support measures granted so far. This analysis suggests that non-performing loans to households and firms could have doubled from 2019 to about 7% of bank loans in 2020. This estimate is based on a panel regression of changes in euro area bank

non-performing loans on output gaps. According to the estimate, non-performing loans rise by 0.6 percentage points if the output gap increases by 1 percentage point. That said, non-performing loans may increase later, or remain below what past trends suggest because of the scale of fiscal and monetary policy measures. If the recovery resumes soon, viable firms might be able to restart their activity, while the weight of losses will not only be carried by banks but also by governments that provided guarantees. Another approach for estimating credit losses is to infer default likelihoods from the value and the volatility of listed firms' share prices. This estimate reflects the impact of support measures, but loss estimates depend heavily on the model used and its calibration. Using corporate equity prices as of April 2020, Reinders et al. (2020) estimate, for example, that corporate loan losses could equal 5% of banks' corporate exposure.

If the crisis lasts longer, however, the stimulating effect of support measures on bank credit may vanish and additional risks might arise. In these programmes, sovereign nations are effectively sharing their lower credit risk with the corporate and banking sectors. But sovereign risk itself is rising as governments' explicit and implicit liabilities are mounting. Sovereigns might themselves be dragged down by banking and corporate sector debt. This situation has proven explosive for highly indebted economies in the past, resulting in deep recessions and prolonged deteriorations in bank loan books. Figure D.1 shows that non-performing loans rose by significantly and for longer periods in places where sovereign-bank spirals developed.

If the pandemic lasts too long and triggers a major deterioration of bank asset quality, bad banks could be created to take over the non-performing loans, which could help the recovery.

Fortunately, banks are in a better position to absorb losses than at the outset of the 2007-2009 financial crisis. Bank capital levels have increased, and a great deal of effort has gone into reducing non-performing loans back to their 2007 level (European Commission, 2019).

Conclusion and policy implications

The government restrictions to contain the spread of the coronavirus pandemic are having a significant negative impact on the global economy. As the pandemic spread rapidly across the globe, many governments, especially in advanced economies, took drastic measures to contain the virus that severely constrained domestic economic activity and international trade. While most economies were bouncing back after the removal of the measures, concerns were rising of longer-term economic effects. Those concerns were intensified by the second wave of infections that washed over Europe in the fourth quarter of 2020.

The policy measures put in place have been expansive enough to contain the economic damage caused by severe government restrictions across the European Union. National governments, national central banks, the ECB and the European Union have rapidly mobilised resources to counteract the effect of restrictions on movement and social distancing. Fiscal and monetary policymakers, as well as financial supervisors, acted in coordination to mitigate the effects on firms, banks and employees. Most of these measures, however, were designed as an emergency response and were intended to be temporary. Removing them too soon might quickly prove devastating as a second wave of infections hit most EU members in the fourth quarter. At the same time, the policy measures' bluntness and expansive use of resources suggest that they may not be sustained in full for much longer.

The symmetry and intensity of the shock is pushing EU members to substantially strengthen common economic policy. The EU policy response to the pandemic is impressive both in its size and speed of delivery. Several indicators show that the policy response was well received by markets and strengthened confidence in the future of the European Union. Progressing swiftly and delivering on expectations remains key. The rapid economic rebound in the third quarter shows how successful the policy response to the first lockdown was. If anything, the second virus wave is a strong argument for maintaining the policy measures over a longer-term horizon, until a vaccine is widely distributed. When this happens, support may be recalibrated to reduce possible long-term side-effects, but the overriding concern should be to preserve the ecosystem as it was before the pandemic.

In addition to supporting the income of those unable to work and minimising negative effects on demand, the policy package could also be instrumental in shaping the future of Europe. The crisis provided an opportunity to address the major challenges facing the European economy, such as climate change and digitalisation. The crisis response is also historic as it led to the first joint European issuance of debt on a large scale. The joint debt issuance could turn out to be a cornerstone of the capital markets union. The crisis has affected European economies differently, and recovery needs to focus on stronger financial integration if cohesion is to be maintained within the European Union.

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Chapter 2

Gross fixed capital formation

Investment in the European Union fell precipitously at the onset of the coronavirus outbreak. This decline followed a slowdown in investment that had gradually set in during 2019 and was exacerbated by government restrictions on movement and business activity, especially in the second quarter of 2020.

Uncertainty and a sharply deteriorating economy, however, are the main reasons for the extraordinary decline in investment. While activity partially recovered in the third quarter, uncertainty is likely to continue to dampen investment in the near term, especially as new restrictions are introduced to contain the second coronavirus wave in the fourth quarter of 2020.

Elevated uncertainty, along with deteriorating firm finances, are likely to further impede corporate investment. The cash flows of non-financial corporates have retreated well into negative territory, causing these firms to draw down their cash balances, which might eventually eat into their net worth. This weakened position damages firms' ability to finance investment, internally and externally. Investment weakness is likely to persist even as economic conditions gradually improve.

The coronavirus outbreak is likely to prompt increased digitalisation and, in the medium term, to cause shifts in supply chains and product portfolios. Many of the companies bearing the brunt of the ongoing crisis see a permanent reduction in employment as another longer-term consequence. Policymakers should take action to ease the reallocation of labour to avoid large increases in structural unemployment.

Government investment in 2020 may be another victim of the pandemic. Even though policy support has been strong, there are signs that government investment levels might decrease across EU Member States. The decline in government investment must be halted and reversed from 2021 onwards. Redirecting investment from current to capital expenditure seems to be the sustainable option. It can be further supported by debt issuance for countries with sound fiscal positions.

Introduction

The initial impact of the coronavirus pandemic on investment in the European Union has surpassed the effects of the global financial crisis. In just two quarters, investment declined to the same extent as in the first year of the recession in 2008-2009. While there is no financial crisis to worry about yet, there are signs that investment may take a long time to recover. The purpose of this chapter is to trace the impact of the pandemic on investment and provide an analysis of the main drivers. The first section outlines the general investment trends in the European Union. Using the latest wave of the EIB Investment Survey (EIBIS), the second section explores the developments in corporate investment in 2019-2020 and expectations for 2021. The third section provides an overview of infrastructure investment through 2019 and information about infrastructure projects in the first half of 2020. The fourth section takes a closer look at government investment in the European Union in 2019, as well as the plans for 2020-2021. The last section draws conclusions about the implications for policy.

Aggregate investment dynamics

Investment growth continued until the end of 2019, but the pace slowed

Aggregate investment rates continued to rise throughout 2019 in most EU members as investment growth outpaced growth in real gross domestic product (GDP) (Figure 1).[1,2] The investment rate in the European Union rose above its long-term average at the end of 2019. This rise was also seen in Western and Northern Europe and in Central and Eastern Europe. The aggregate investment rate in Southern Europe, however, was 1.5 percentage points below the average of the past 25 years.

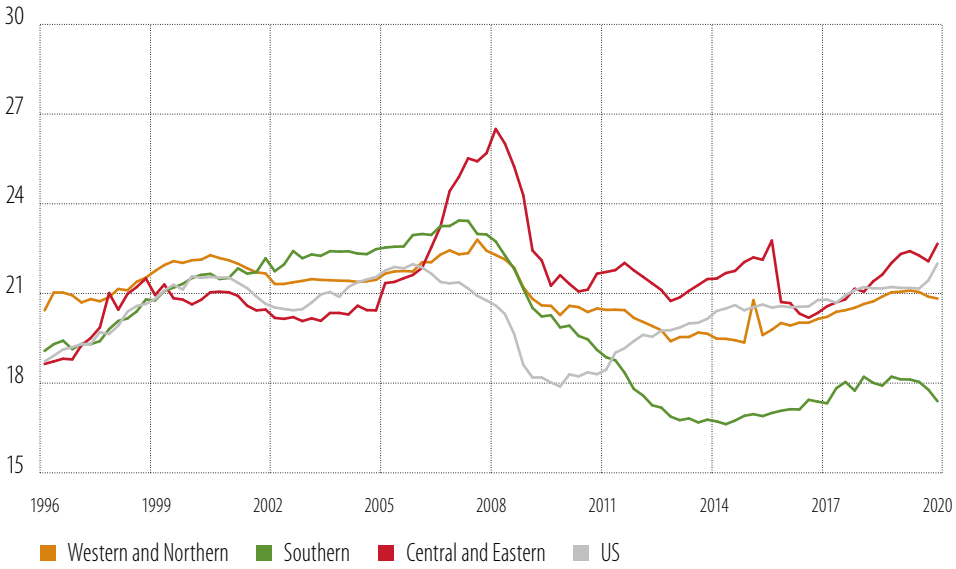
In 2019, aggregate investment in the European Union grew about 3% relative to 2018. Half of this pace of growth resulted from higher investment in buildings and structures, including dwellings (Figure 2a). Investment in other buildings and structures, which includes infrastructure investment (discussed separately in this chapter), expanded at faster rates in Central and Eastern Europe. The investment in buildings and structures was supported by higher government capital expenditure and investment grants from the European Structural and Investment Funds (Figure 3c). Austria, France, Germany and Portugal also saw significant investment increases in buildings and structures.

These positive developments notwithstanding, aggregate investment growth slowed down in the European Union in the second half of 2019 (Figure 2a). The slowdown was due to weakening international trade amid intensifying disputes between the United States and its main trading partners (EIB, 2019). In 2019 and early 2020, before the coronavirus pandemic drew all the attention of analysts and commentators, European economic discourse focused mostly on the weakening of the German economy as a result of falling exports.

1 Investment rate in this chapter stands for the share of investment to GDP in percent. Unless stated otherwise, both investment and GDP are measured in real, 2015 chain-linked volumes. In this chapter, investment and gross fixed capital formation have the same meaning and are used interchangeably.

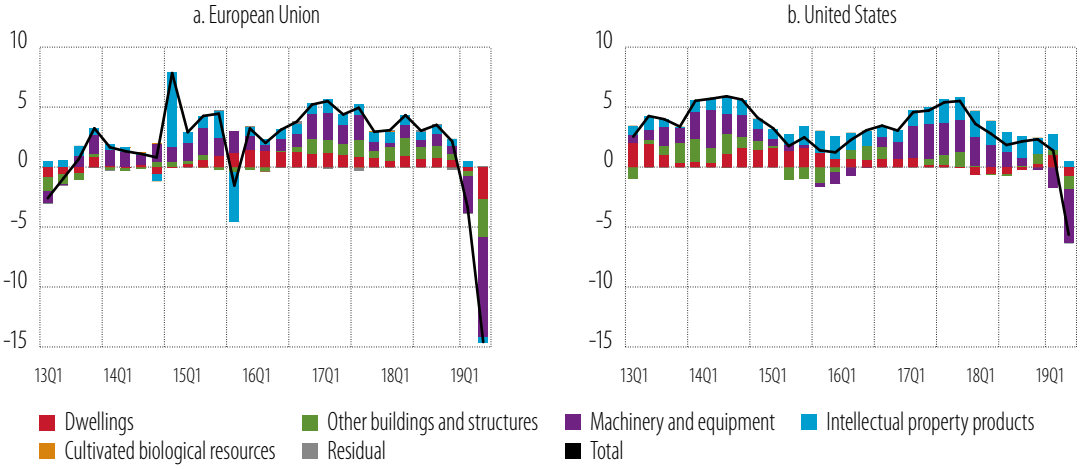
2 Belgium, Estonia, Finland, Hungary, Lithuania, Slovenia and Sweden saw a slight decline in 2019.

Figure 1
Gross fixed capital formation (GFCF) in the European Union and the United States
(% of real GDP)



Source: *Eurostat, Organisation for Economic Co-operation and Development (OECD) national accounts and EIB staff calculations.*
Note: *Real investment and GDP are in euro 2015 chain-linked volumes and US dollar 2014 chain-linked volumes for the European Union and the United States, respectively. The aggregate for Western and Northern Europe does not include Ireland, due to the high volatility of Irish data that obscures group-wide developments.*

Figure 2
Real GFCF and contribution by asset type (% change from a year earlier)

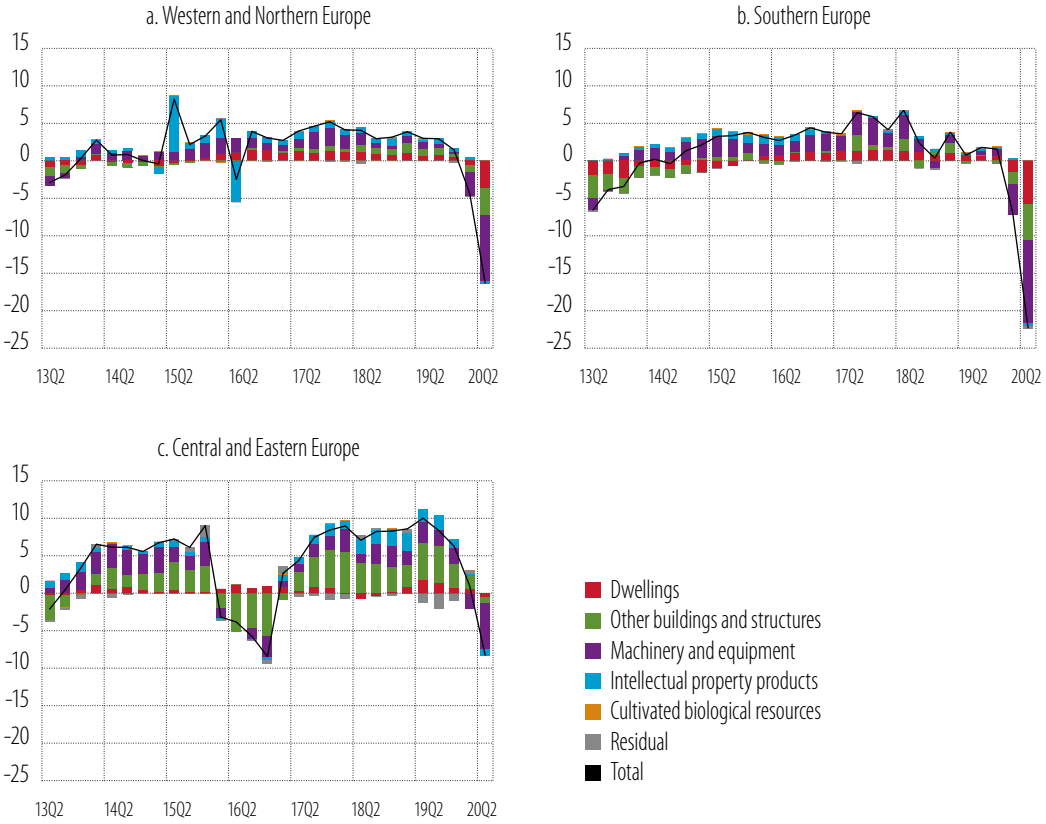


Source: *Eurostat and OECD national accounts; EIB staff calculations.*
Note: *Panel a shows data for the European Union without Ireland, due to high volatility of Irish investment data that obscures EU-wide developments.*

Part of the slowdown came from investment in machinery and equipment and in buildings and structures, including dwellings. Investment ran out of steam first in Southern Europe in early 2019 (Figure 3b), mostly due to a pronounced slowdown in Italy. By the third quarter of 2019, the phenomenon had spread to Western and Northern Europe, as investment growth waned in Austria, the Nordic countries and Germany (Figure 3a).

Unlike the European Union, investment in the United States was driven almost entirely by acquisitions of equipment and intellectual property and did not slow down in 2019 (Figure 2b). The United States has outperformed the European Union on investment in these two asset types throughout the past ten years, increasing the gap between the two economies. These types of investment are particularly important as they are likely to contribute to firm productivity and competitiveness and, as a consequence, aggregate economic productivity (EIB, 2018 and EIB, 2019).

Figure 3
Real GFCF and contribution by asset type, European Union (% change from a year earlier)



Source: Eurostat and EIB staff calculations.

Investment in the European Union fell precipitously with the arrival of the global pandemic

The large decline in investment in the first half of 2020 was commensurate with the contraction in GDP. Investment in the European Union dropped 19% relative to the second quarter of 2019, while GDP fell 14%.[3] This movement follows the usual business cycle pattern where investment declines more than overall GDP in recessions and bounces back more vigorously in expansions. By way of comparison, GDP in the first quarter of 2009 declined by 5.3% relative to the first quarter of 2008, whereas investment fell 11%. What was extraordinary about the decline in 2020 is that it all happened in just two quarters. This speed of events is a clear consequence of the government measures to tame the spread of the pandemic.

3 Excluding Ireland, whose large investment swings over the course of 2019 are not related to COVID-19, investment and GDP both declined by 14%.

Economic activity collapsed around mid-March, as most European governments began implementing drastic measures to curtail the pandemic. Investment might have already started to decline three weeks earlier, at the end of February when financial-market volatility jumped sharply in Europe. The decline in confidence indicators in February, reversing the gains of the previous three months, also supports this hypothesis. As a result, gross fixed capital formation (GFCF) in the European Union slid nearly 4% compared with the first quarter of 2019, with countries in Western and Northern Europe showing the same trend. As previously stated, the contraction was mostly due to falling investment in machinery and equipment (Figure 2a and Figure 3a). In Southern Europe, the downtrend in machinery and equipment investment was reinforced by a similar decline in investment in buildings and structures, including dwellings (Figure 3b). In Central and Eastern Europe, an increase in investment in other buildings and structures offset the decrease in equipment investment (Figure 3c).

Investment declined far less in the United States than in the European Union. This was despite a much smaller difference in the decline in GDP between the two economies. The US deterioration was consistently much smaller across asset types, but followed a very similar pattern to Europe. On both sides of the Atlantic, investment in machinery and equipment declined the most, followed by investment in other buildings and structures and investment in dwellings. Investment in intellectual property increased in the United States in the second quarter of 2020 compared with the same period a year earlier, while in the European Union it declined and helped push down total investment by an additional 0.5 percentage points.

Restrictions imposed across EU Member States acted as a major barrier to investment in the second quarter of 2020. A significant part of the precipitous decline is most likely due to these severe restrictions. The drop in investment in EU countries in the second quarter is clearly associated with the governmental or self-imposed curbs on movement (Figure 4). This kind of restriction explains, in particular, the varying declines in investment in buildings and structures across the different countries, as shown in Figure 3.[4,5] The restrictions on movement were lifted at the end of the second quarter and the beginning of third quarter. GDP showed a partial rebound in third quarter, so we can expect some of the decline in investment to be reversed in that quarter. That said, the recovery might prove to be unimpressive as two very important factors determining investment decisions gain prominence – uncertainty and the impact of corporate liquidity and net worth.

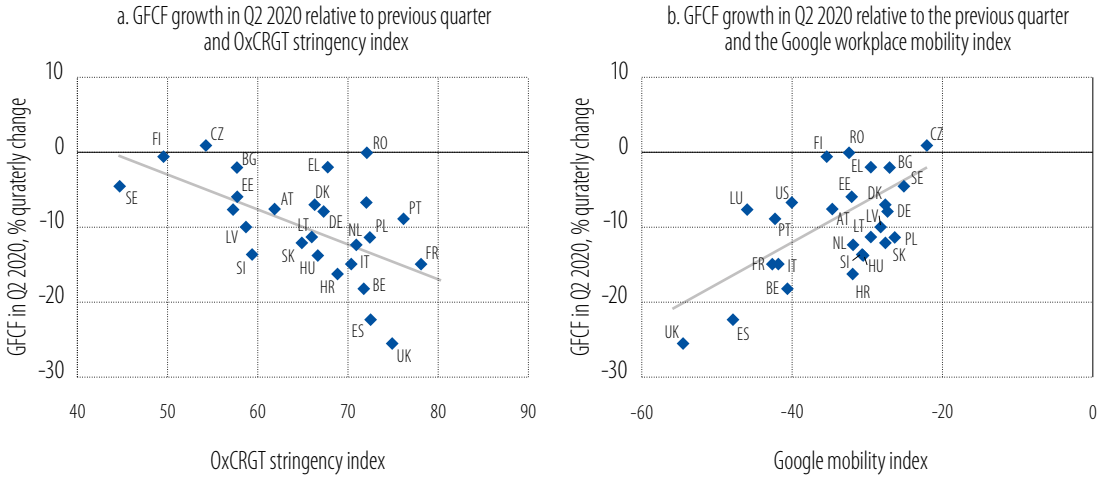
Elevated uncertainty has a powerful negative effect on investment that is widely documented in the academic literature (Leahy and Whited, 1996; Guiso and Parisi, 1999; Butzen, Fuss, and Vermeulen, 2003; Bloom, Bond, and van Reenen, 2007). As fixed assets are generally more difficult to liquidate, firms are reluctant to invest in this area during periods of elevated uncertainty because their sensitivity to demand shocks would increase as a result. The tendency to postpone this type of spending when uncertainty is high reduces the effectiveness of policies aimed at stimulating investment, and more aggressive policy actions are required. (Bloom, Bond, and van Reenen, 2007; Bloom, 2014).

While uncertainty seems to have partially subsided after the initial shock in March 2020, it is still elevated and is likely to remain so for some time (Figure 5). Early evidence suggests that higher uncertainty is taking a toll on business investment (Figure 6). The share of respondents in the EIBIS 2020 that say uncertainty is a major obstacle to investment explains about one-sixth of the decline in total investment in the first half of 2020. Similarly, differences in respondents' views about their business prospects, which is arguably another measure of uncertainty, explains around 13% of the variation in aggregate investment across countries.

4 For instance, not all countries interrupted construction works fully during the second quarter of 2020, which resulted in different investment outcomes in buildings and structures across EU countries. In addition, buying a new property requires a great deal of social interaction and the barriers to this varied in the different countries.

5 The Google mobility trends index explains around 60% of the variation of investment in buildings and structures across countries.

Figure 4
Real GFCF and COVID-19 containment measures



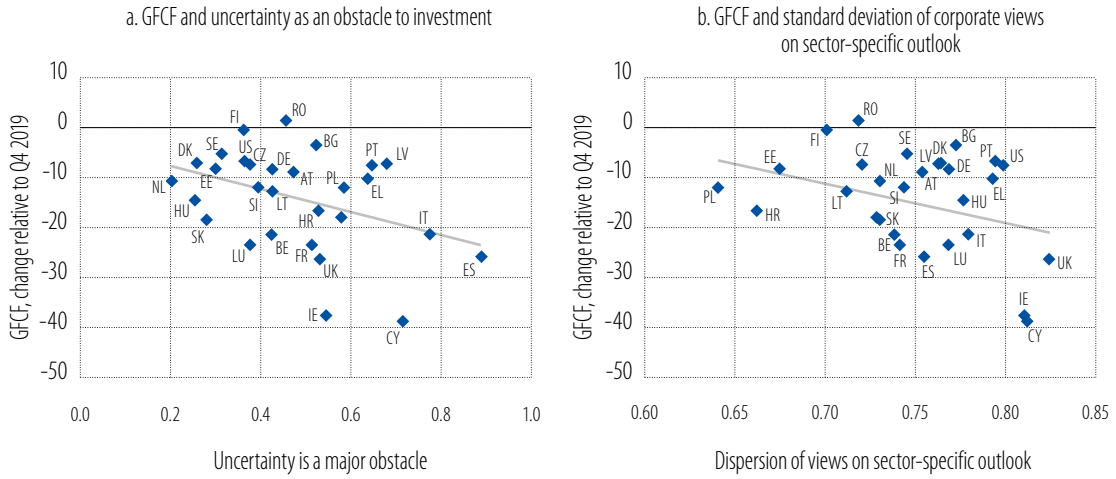
Source: *EIB staff calculations based on data from Eurostat, OECD national accounts, Oxford COVID-19 Government Response Tracker, Blavatnik School of Government and Google community mobility reports.*

Note: *The OxCRGT stringency index records the strictness of "lockdown style" policies that primarily restrict people's behaviour. Higher values indicate more restrictions. The Google index tracks visits to the workplace and shows the deviation in mobility on a given day from the median value, for the corresponding day of the week, during the five-week period 3 January to 6 February 2020. A higher, less negative number indicates mobility that is closer to usual. Both indices are daily and averaged over April, May and June.*

Figure 5
Euro STOXX 50 volatility index provides a forward-looking measure of uncertainty

Source: *Refinitiv Datastream and EIB staff calculations.*

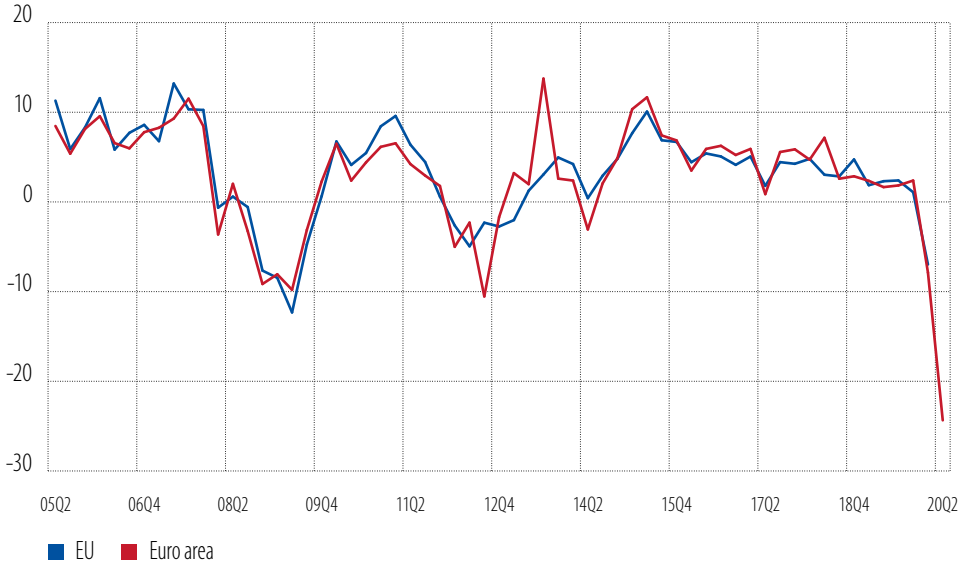
Figure 6
Investment growth in Q2 2020 and measures of uncertainty



Source: *EIBIS 2020, Eurostat, OECD national accounts and EIB staff calculations.*

Lockdowns and social distancing across the European Union have led to a large decline in corporate cash flows because firms are not able to reduce costs proportionally to the decrease in revenues (Chapter 3). Figure 7 shows the steep decline in the gross entrepreneurial income of non-financial corporations, which is the closest approximation in the European System of National Accounts to aggregated firm-level cash flow. The decline was more than twice the falloff seen in the past two recessions, one which was sparked by the global financial crisis and the other by Europe's sovereign debt crisis. Lower cash flows mean lower liquidity which will eventually undermine the net worth of firms, affecting their ability to borrow and invest. Expectations that firm's net worth will decline are already affecting investment decisions, but that negative sentiment will intensify in the coming year. A lack of investment could push down firms' net worth even further, creating a negative loop.

Figure 7
Gross entrepreneurial income of non-financial firms (% change vs. a year ago)



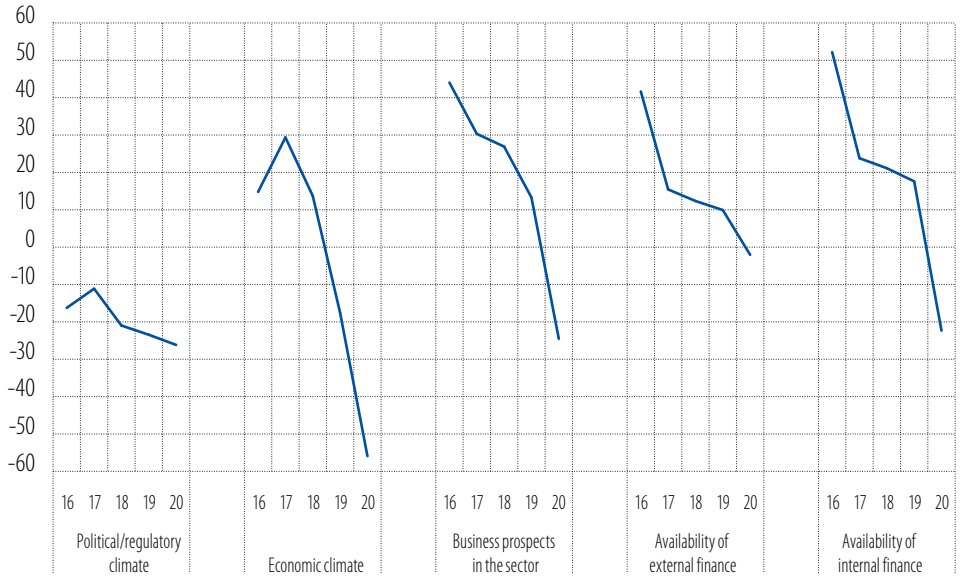
Source: *Eurostat.*

Corporate investment

Investment cycle and outlook

The near-term outlook for firms deteriorated significantly with the onset of the coronavirus pandemic. Expectations of non-financial corporations about the overall economic climate, as well as the business prospects in their own sectors and the availability of finance, had already deteriorated in 2019, as documented in last year's edition of the investment report (EIB, 2019). Still, the situation had worsened considerably by this summer with the EIBIS 2020 survey (Figure 8). A net balance of [6] 57% of firms in the European Union expect the economic climate to deteriorate in the next 12 months. About 25% (in net terms) expect business prospects to deteriorate in their sector or industry. The ability of firms to fund their own investments is expected to deteriorate. The percentage of firms that said they expected a net improvement in their ability internally finance their investments over the following 12 months was 18% in 2019. By 2020, however, 23% (in net terms) of firms said they expected the situation to deteriorate in the next 12 months. Expectations about the availability of external finance are broadly neutral following the massive interventions from the European Central Bank, national governments and the European Union (see Chapters 1 and 3).

Figure 8
Investment drivers in the European Union, firms expecting an improvement/deterioration
(net balance)



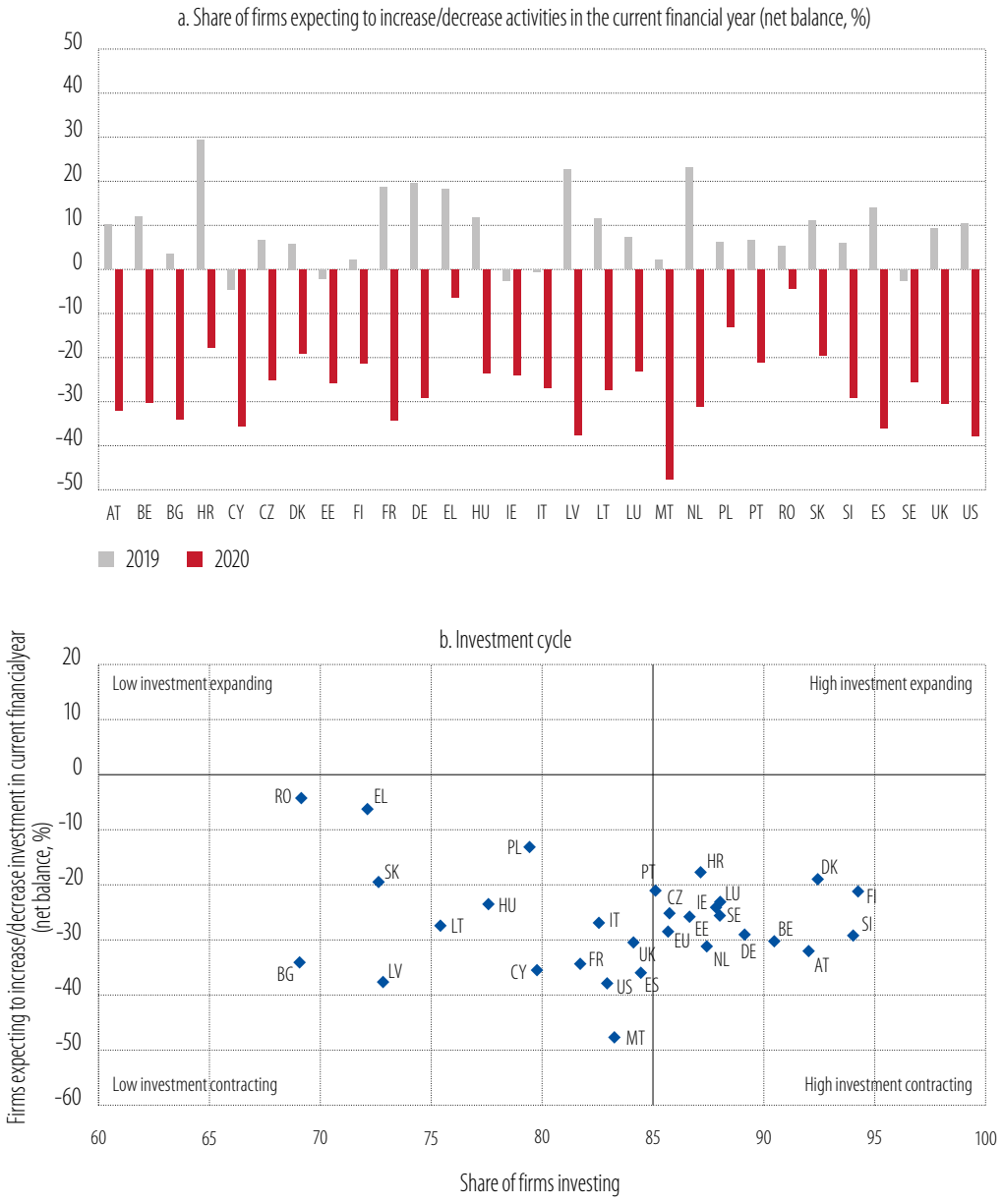
Source: *EIBIS 2016, EIBIS 2017, EIBIS 2018, EIBIS 2019 and EIBIS 2020.*
Base: *All firms (excluding don't knows/refusals to respond).*
Question: *Do you think that each of the following will improve, stay the same, or get worse over the next 12 months?*

Expected investment for the current year also plummeted, in line with the extraordinary deterioration in economic sentiment (Figure 9). Planned investment changed from an EU average of 13% (in net terms) of firms expecting an increase in 2019 compared to the prior year, to an EU average of 28% (in net terms) of firms expecting a decrease in investment in 2020 compared to the prior year. Country variations are significant (Figure 9a) – from a 60 percentage point deterioration in Latvia to a 9.6 percentage point

6 The net balance here means the difference between the firms that expect improvement and those that expect a deterioration as a share of total respondents.

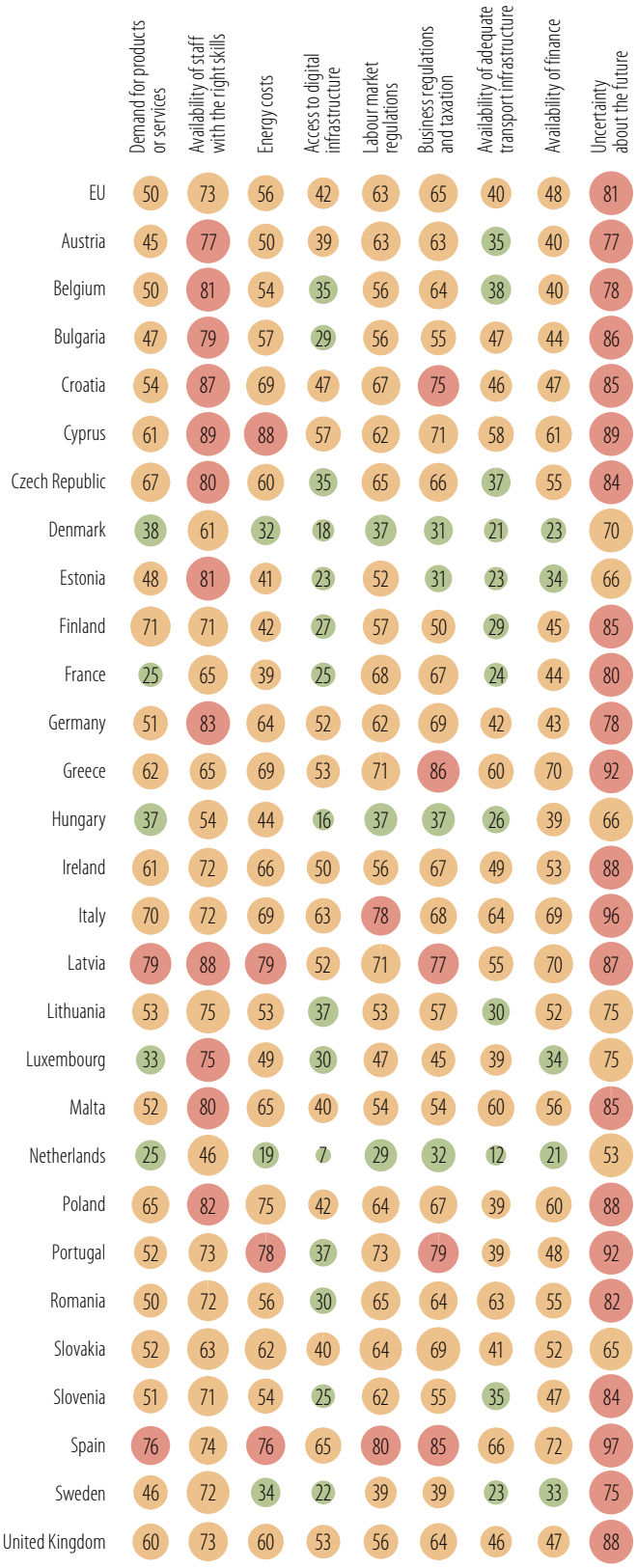
contraction in Romania. As discussed above, some of this decline can be explained by the pandemic. While it is still too early to assess the direct impact of government lockdowns and other restrictions on investment, those restrictions are expected to account for only part of the decline, given their relatively short duration. Deteriorating expectations about the economy and substantial uncertainty about the "new normal" will most likely explain a significant portion of the decline in investment in 2020.

Figure 9
Corporate investment dynamics



Source: *EIBIS 2019 and EIBIS 2020.*
Base: *All firms (excluding don't knows/refusals to respond). Share of firms investing shows the percentage of firms whose investment per employee is greater than EUR 500. The y-axis crosses the x-axis at the EU average in the previous four waves.*
Note: *Net balances show the differences between firms expecting to increase investment activities in the current financial year and firms expecting to decrease them.*

Figure 10
Barriers to investment by country



Source: *EIBIS 2019.*
Base: *All firms (excluding don't knows/ refusals to respond).*
Note: *A red circle means that the share of mentions of a particular obstacle is in the top quartile; a green circle means that it is in the bottom quartile; an orange circle that it is between the two. The size of the circle and the number inside indicate the share of firms mentioning an area (as either a minor or a major obstacle).*

Firms in almost all countries in the EIBIS see uncertainty about the future as the most significant impediment to investment in 2020 (Figure 10). Uncertainty has overtaken the availability of workers with the right skills as firms' major concern. Firm perceptions vary substantially depending on the country. In Spain, 97% of non-financial firms say uncertainty is an impediment to investing, whereas in the Netherlands, only 53% do. The second largest impediment in almost all countries is the availability of staff with the right skills. In Austria, Cyprus and Lithuania, lack of skills ties with uncertainty as the most reported impediment to investment. In Belgium, Croatia, Estonia, Germany, Latvia and Luxembourg, the availability of staff with the right skills is the top impediment to investment for non-financial firms, unchanged from the past two years.

Short-term impact of the pandemic

In the European Union, 45% of firms have decided to reduce their investments in 2020 because of the COVID-19 crisis. Nearly half of these firms say they will postpone their investments. Another 40% of these firms will change or rescale their pre-pandemic plans and only slightly less than 5% intend to abandon their investment plans altogether.[7] Six percent (net) of firms that did not change their investment because of the pandemic say they will increase investment in 2020, while more than 40% in this group have not changed their investments relative to 2019. Slightly more than half of the firms that have not changed their plans are large, profitable firms for which the availability of finance is not a great concern.

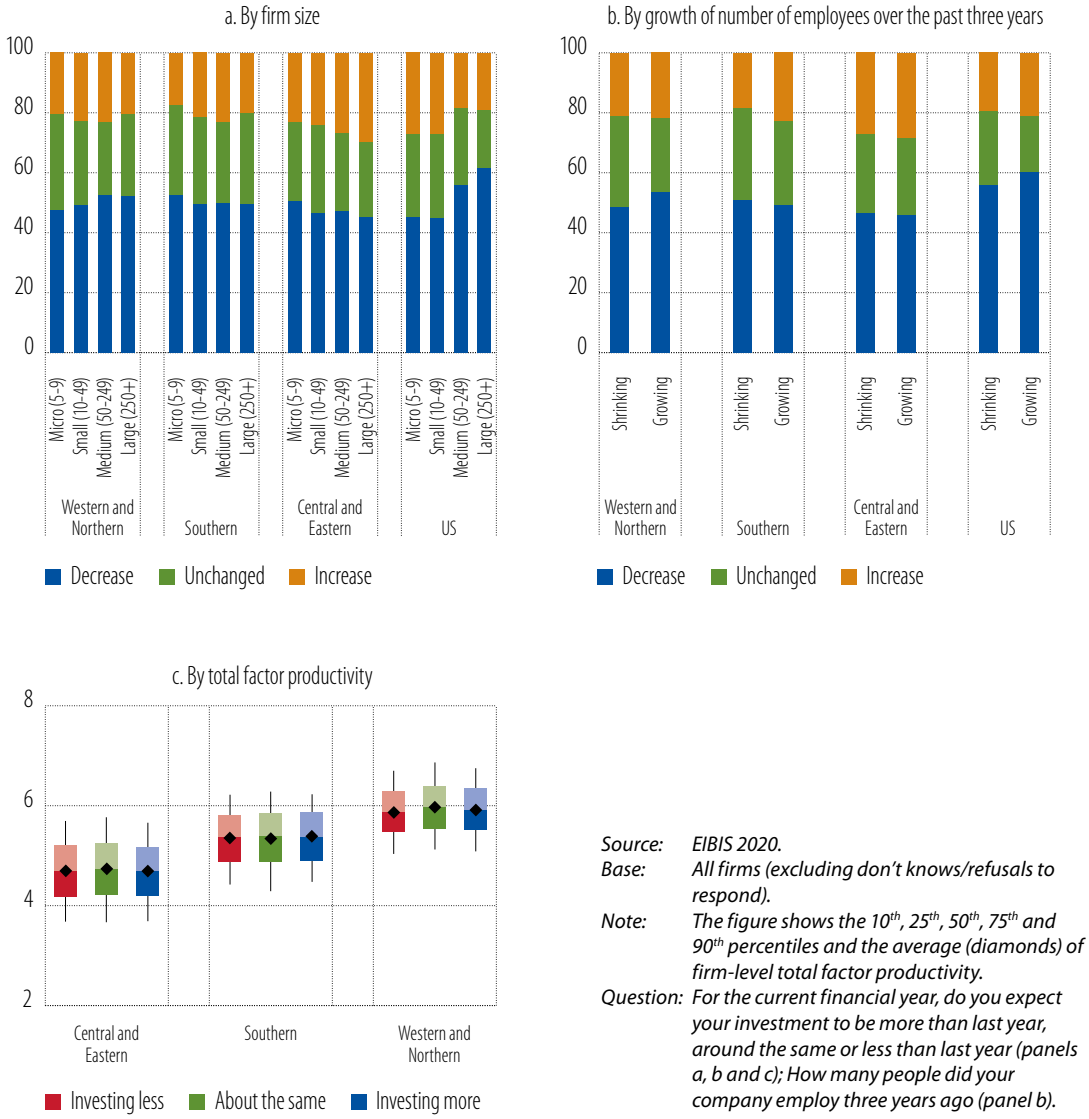
Plans to adjust investment in 2020 vary little across firm size or other characteristics. The share of firms reducing their investments in 2020 is remarkably similar across size classes (Figure 11a). In previous EIBIS waves, the share of medium and large firms increasing investment was, on average, 10 percentage points higher than for micro and small firms. In the United States and in Western and Northern Europe, a bigger share of medium and large firms are reducing their investments in 2020 compared to smaller firms. Differences in investment plans are likewise small or non-existent across firms with different growth dynamics over the past three years, or different average and median productivity profiles (Figure 11b and Figure 11c).

Firms cut employment radically following the coronavirus outbreak. In EIBIS 2020, the pandemic caused about 55% of firms to reduce to some extent their staff through layoffs, redundancies, unpaid temporary leave and cuts to working hours. The share varies significantly across regions – from 45% in Central and Eastern Europe to slightly more than 60% in Southern Europe. Medium and large firms tend to make smaller adjustments that affect up to a quarter of their employees, whereas smaller firms tend to make larger adjustments that involve half or more of their employees.

Regions where firms are more likely to reduce employment because of the pandemic are likely to see cuts in investment as well. Firms that reduced employment due to the COVID-19 crisis are twice as likely to have also revised downwards their investment plans due to the pandemic (Figure 12a). This is the case for all three regions within the European Union as well as for the United States.

7 The remaining firms answered yes to all available options, probably referring to a portfolio of investment projects.

Figure 11
Change in investment in 2020 (% of all firms)

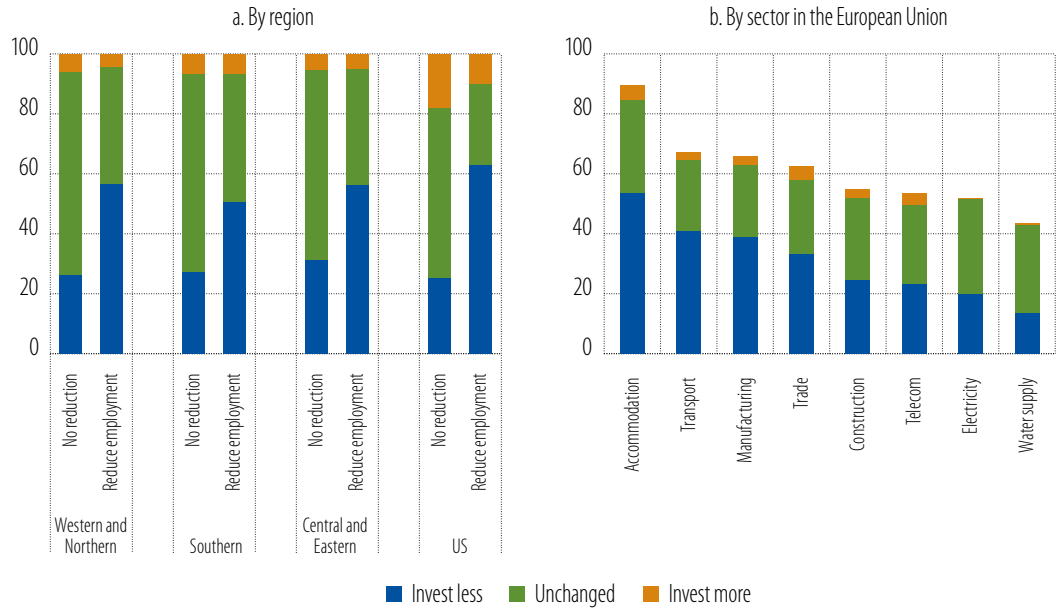


Source: *EIBIS 2020.*
Base: *All firms (excluding don't knows/refusals to respond).*
Note: *The figure shows the 10th, 25th, 50th, 75th and 90th percentiles and the average (diamonds) of firm-level total factor productivity.*
Question: *For the current financial year, do you expect your investment to be more than last year, around the same or less than last year (panels a, b and c); How many people did your company employ three years ago (panel b).*

The impact of COVID-19 on firms' investment plans varied by sector (Figure 12b). The bars on Figure 12b plot the share of firms in each sector that reduced employment due to the pandemic. Each bar is further split according to the pandemic's impact on investment plans. For the hospitality sector (accommodation), for instance, 89.6% of firms took measures to reduce their labour input, and 53% of these firms also reduced investment plans as a result of the coronavirus. In contrast, slightly more than 40% of firms in the water sector took steps to reduce their labour force, while only 14% of these firms reduced their investment plans because of the pandemic. The ranking in Figure 12b is not surprising, given that the operations of these businesses, especially in the first four sectors, were the most affected by government restrictions and social distancing measures. At the opposite end of the spectrum, utility companies were the least affected by the measures to contain the pandemic and, accordingly, their investment plans were less affected.

Uncertainty, deteriorating economic sentiment, and the uneven impact of social distancing measures are behind the sector divergence. Many businesses in the hospitality, transport, retail and manufacturing sectors were not able to carry out their investment activities, especially at the beginning of the second quarter of 2020, as they were constrained by social distancing measures. Despite easier conditions in the third quarter, however, it seems that most firms are unwilling to make up the lost ground. Firms are postponing their investment plans amid uncertainty and expectations of a further deterioration in business prospects and the general economic outlook (Figure 13a and Figure 13b).

Figure 12
COVID-19 impact on use of labour services and on investment plans



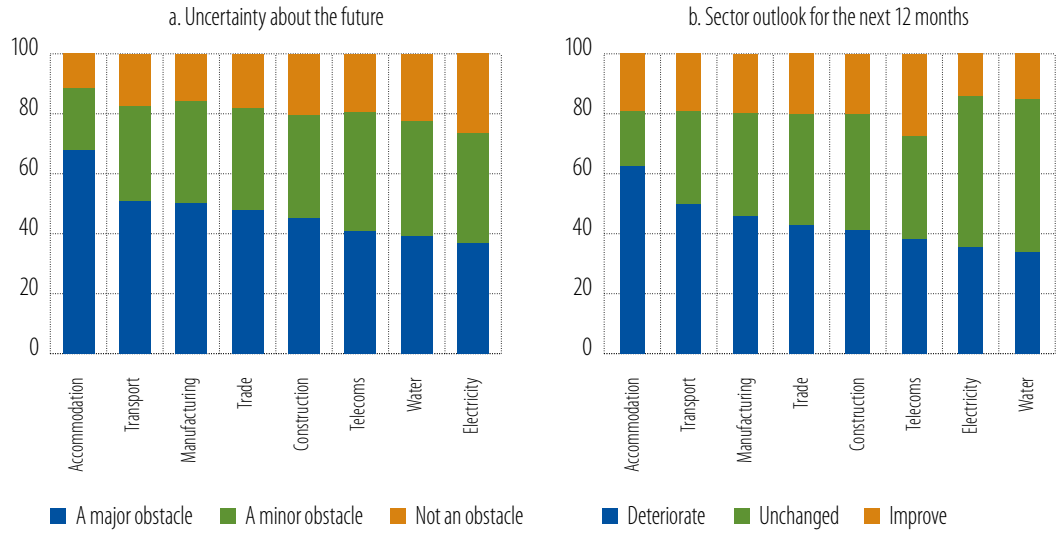
Source: *EIBIS 2020.*
Base: *All firms (excluding don't knows/refusals to respond).*
Note: *Sectors correspond to the NACE Rev. 2 classification of economic activities in the European Union as follows: manufacturing is section C; electricity is section D (electricity, gas, steam and air conditioning supply); water supply is section E (water supply; sewerage, waste management and remediation activities); construction is section F; trade is section G (wholesale and retail trade; repair of motor vehicles and motorcycles); transport is section H (transportation and storage); accommodation is section I (accommodation and food service activities); and telecoms is section J (information and communication).*
Question: *Thinking about the impact of coronavirus, have you had to put staff temporarily on leave, make staff redundant or unemployed or reduced the number of hours they work compared to before the coronavirus pandemic? Has your company's overall investment expectations for 2020 changed due to coronavirus? Will your company invest more, invest less or keep investment broadly the same?*

Optimism about a rebound in investment in 2021 may be premature, however. While increased uncertainty and the deterioration in the economy in the first half of 2020 had the strongest impact on investment, firms also said they expected difficulties with finance, especially internal finance. This should come as no surprise as cash flows have retreated well into negative territory, especially in some sectors (see also the analysis in Chapter 3).

Firms that are more affected by the pandemic are significantly more pessimistic about their ability to finance investment internally over the next 12 months (Figure 14). The decline in sales caused by the lockdown resulted in low or negative cash flows for many firms. Some of those firms were obliged to draw down their liquidity as a result, which will affect their overall capital and, ultimately, their net worth (Chapter 3). These firms have lower internal funds to finance investment and are more likely to

face worsening conditions for external finance because of their lower net worth.[8] Furthermore, the firms most affected by the crisis are often small and therefore even more exposed to finance difficulties. Unless these firms receive fresh capital, their investments are very likely to remain low beyond 2020, even in an economic recovery.

Figure 13
Change in investment in 2020 (by sector)



Source: *EIBIS 2020.*
Base: *All firms (excluding don't knows/refusals to respond).*
Note: *See explanations about sectors in the notes to Figure 12.*
Question: *Thinking about your investment activities, to what extent is uncertainty about the future an obstacle? Is it a major obstacle, a minor obstacle or not an obstacle at all? Do you think that business prospects specific to your sector or industry will improve, stay the same, or get worse over the next 12 months?*

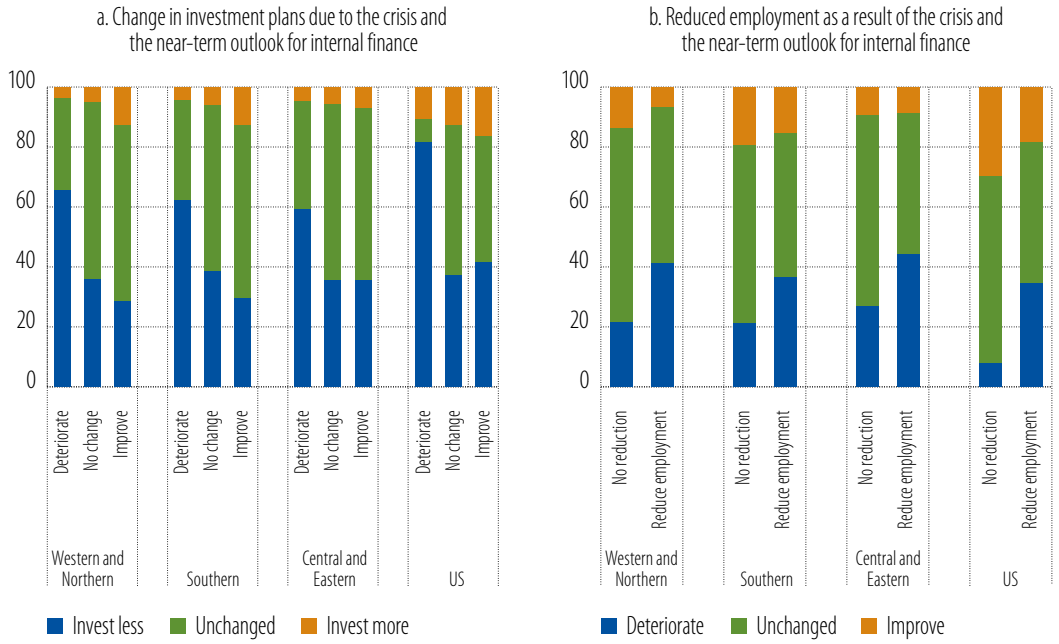
Less competitive firms with small cash holdings plan to invest less in 2020 (Maurin and Pal, 2020). Firms that were not profitable in 2018-2019 are much more likely to have pulled back their investment plans as a result of the pandemic, especially in Western and Northern Europe and in Southern Europe (Figure 15a). In previous EIBIS waves, these firms were typically less productive than profitable firms[9] and their liquidity was significantly lower. Figure 15b plots the cash-to-total assets ratio as a function of previous-year pre-tax profits, calculated using the matched EIBIS-Orbis database.[10] It shows that less profitable firms hold much less cash, as a share of total assets, than profitable ones. Firms with higher cash buffers can withstand a shock to cash flow much better, and they are better able to survive the shock and to continue to grow and invest (Joseph, Kneer, van Horen and Saleheen, 2020).

8 See Bernanke and Gertler (1989) on the importance of net worth for the cost of external finance over the business cycle.

9 Average productivity (log tfp) of profitable firms is 11% higher and median productivity is 8% higher. Similarly, average and median labour productivity of profitable firms is 6% and 4.6% higher than for unprofitable firms.

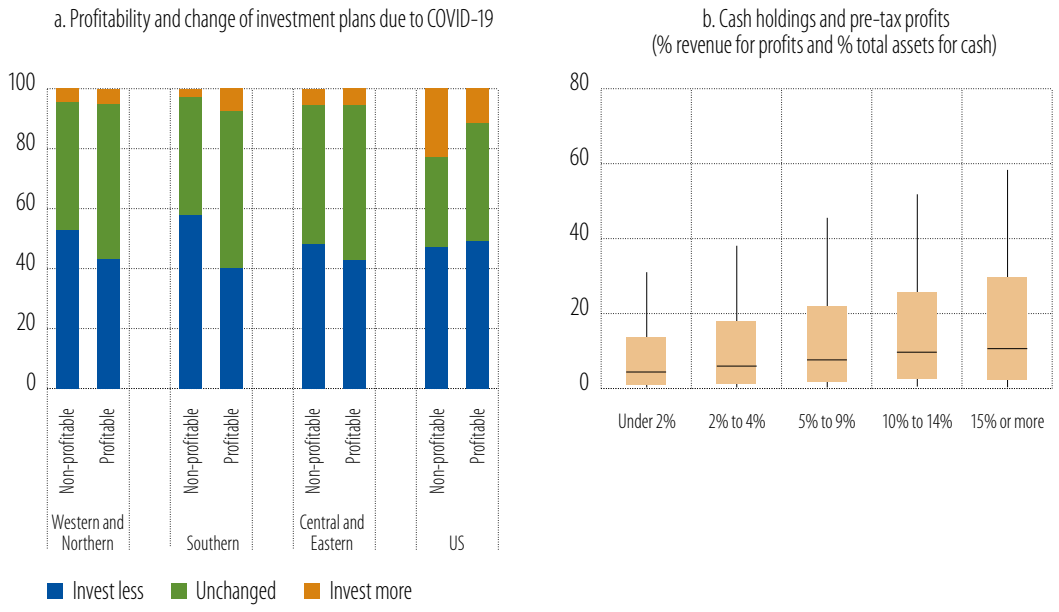
10 The Data annex of this report provides information about this dataset.

Figure 14
Impact of the COVID-19 crisis on internal finance



Source: *EIBIS 2020.*
Base: *All firms (excluding don't knows/refusals to respond).*
Question: *Do you think that availability of internal finance will improve, stay the same, or get worse over the next 12 months? Thinking about the impact of the coronavirus, have you had to put staff temporarily on leave, make staff redundant or unemployed or reduce the number of hours they work compared to before the coronavirus pandemic? Has your company's overall investment expectations for 2020 changed due to coronavirus? Will your company invest more, invest less or keep investment broadly the same?*

Figure 15
Profitability and cash holdings' effect on investment



Source: *EIBIS 2020 and EIBIS-Orbis matched database.*
Note: *The figure shows the 10th, 25th, 50th, 75th and 90th percentiles of firm-level cash to total assets.*

Longer-term impact of the pandemic

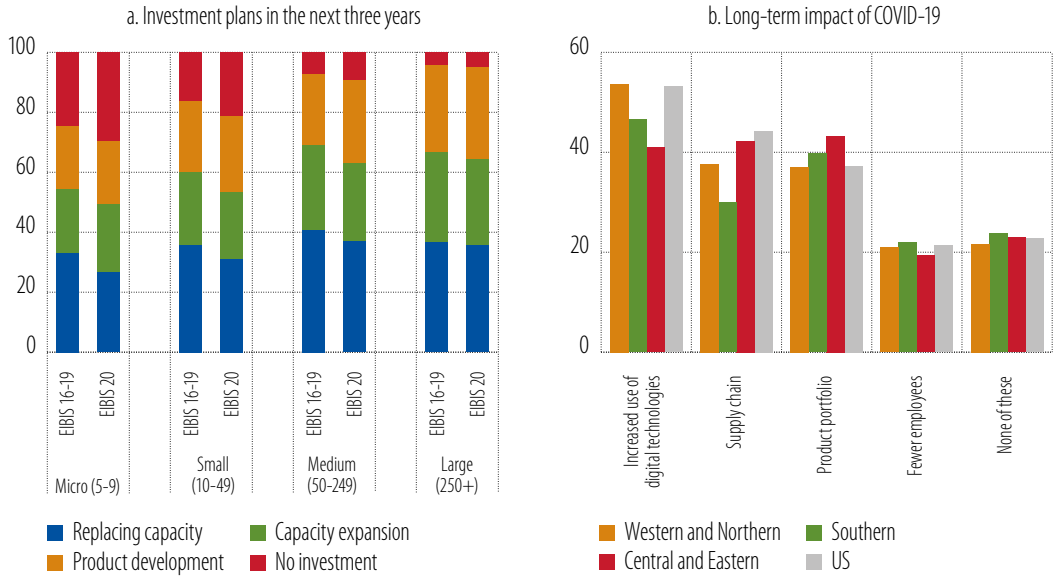
While the pandemic may be brought under control sometime in the near future, it may have a permanent effect on the economy. The size and nature of the shock caused by the pandemic are such that it will likely trigger sweeping, structural changes in the economy, altering how we work, commute, travel and spend our holidays for many years to come. The evolution will likely modify investment priorities and employment patterns. Firms that do not invest in adapting to these changes might be left unprepared for future challenges.

The share of firms that do not have any investment plans in the next three years has increased compared to the average from 2016 to 2019 (Figure 16a). The share of small firms that do not plan to invest in the next three years has risen even faster. Smaller firms face greater difficulties in coping with the economic shock caused by the pandemic. The evidence is corroborated in Figure 15. Smaller firms that do not plan to invest over the next three years have significantly lower median productivity than smaller firms that plan to invest. The difference in productivity is largely absent for medium and large firms. It is therefore very likely that the consequences of the coronavirus on investment and productivity will be felt acutely in the medium term.

Digital technology is likely to become more widely used. Half of the firms in the European Union expect the use of digital technologies to increase because of the COVID-19 crisis. The share of firms that expect digital technology to increase is higher in Western and Northern Europe (53%) and on par with firms in the United States (Figure 16b). In Southern and Central and Eastern Europe, the share is somewhat lower, but still above 40%. These high percentages underline the importance of investing in digital technologies if firms are to remain competitive (see Chapter 7).

Supply chains will change, along with product and service portfolios. More than a third of firms in the European Union expect long-term effects on their supply chains and product portfolios. These views were expressed in the wake of significant supply-chain disruptions in the first and second quarters of 2020. The results support expectations about structural changes in supply chains and in industries whose products and services are built around social interaction and face-to-face contact.

Figure 16
Firms' assessment of the longer-term consequences of the pandemic



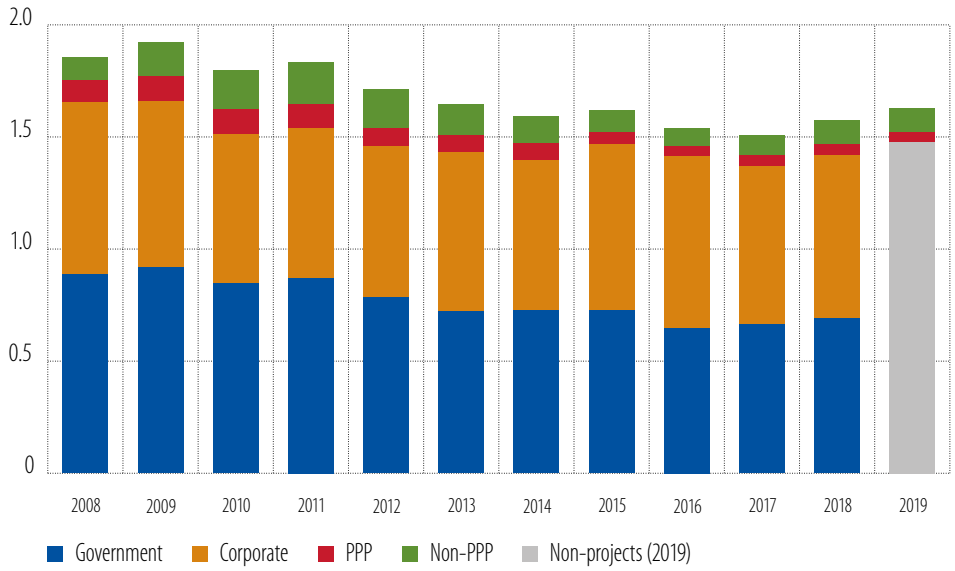
Source: *EIBIS 2020.*

About 20% of all firms estimate that the job cuts they made during the pandemic will be permanent. This share is constant across the European Union and in the United States. The aggregate effect of such a shock will be felt differently across the various countries, depending on their labour market institutions (Nickell, 1997). Economies whose labour markets are highly regulated may see a significant increase in structural unemployment, which could last for several years. While structural unemployment may not increase much in countries with more flexible regimes, a significant reduction of employment remains a challenge.

Infrastructure investment

Following a decade of contraction, the share of infrastructure investment in overall economic activity has been increasing since 2018 (Figure 17). The government and corporate sectors combined account for some 90% of EU infrastructure investment. While their shares are broadly equal, it was the corporate sector that provided the impetus for the recovery from the global financial crisis. The government sector's share of infrastructure investment, on the other hand, contracted severely in 2016 when it barely attained 42% of overall infrastructure investment activity. In 2017 and 2018, it contributed to the recovery of infrastructure investment, with its share rising to 44%.[11] The share of project-based infrastructure investment remains just shy of 10% after a rebound in 2017. Previously, its share had steadily contracted from a high of some 16% in 2011 to a low of 8% in 2016. About two-thirds of projects are not carried out as a public private partnership (PPP). Since 2011, the aggregate value of PPP investments has declined steadily, whereas the aggregate value of non-PPP projects declined more forcefully through 2016 and have steadily risen since.

Figure 17
EU infrastructure investment by sector (% GDP)

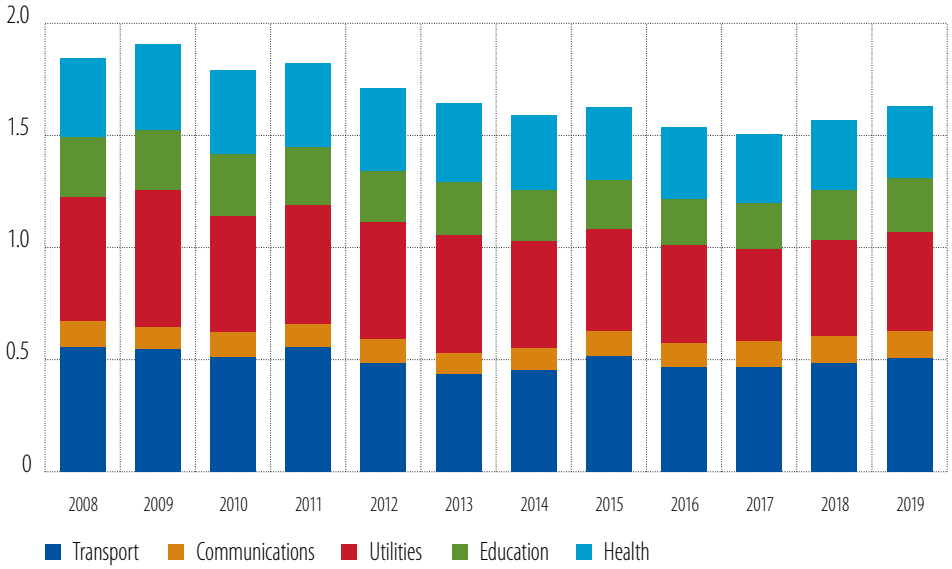


Source: *EIB calculations, European PPP Expertise Centre (EPEC), Eurostat, IJ Global.*
Note: *Annual infrastructure investment in EU27 by institutional sector as a share of GDP, expressed as a percentage. Infrastructure projects are either PPP or non-PPP. The remainder is split between government and corporate investment; for 2019, data to calculate the government component are not available at the time of publication. Relevant data series are not published for Belgium, Croatia, Lithuania, Poland or Romania. Slight deviations from the 2018 results are due to a refinement in the estimate of depreciation of infrastructure investment, as well as the Brexit-induced recomposition to EU27.*

11 The relative contribution of the corporate and government sectors to the 2019 increase remains to be seen, as EU data on government infrastructure investment had yet to be published at the time of writing.

In terms of asset type, investment in communications infrastructure has been the most dynamic component of the rebound. Education and transport infrastructure investment provided further support (Figure 18). Transportation and utilities constitute some 60% of infrastructure investment assets. Though broadly equal in parts, the share of utilities has been declining steadily since a high of 33% in 2013, reaching a low of 27% in 2019. The share of social infrastructure assets in health and education is fairly stable, constituting about one-third of investment; typically, health accounts for about 60% of this though education steadily increased its share from 39% in 2016 to 43% in 2019. The smallest and most volatile share of infrastructure investment is attributable to communications. In 2019, it accounted for just over 7% of infrastructure investments.

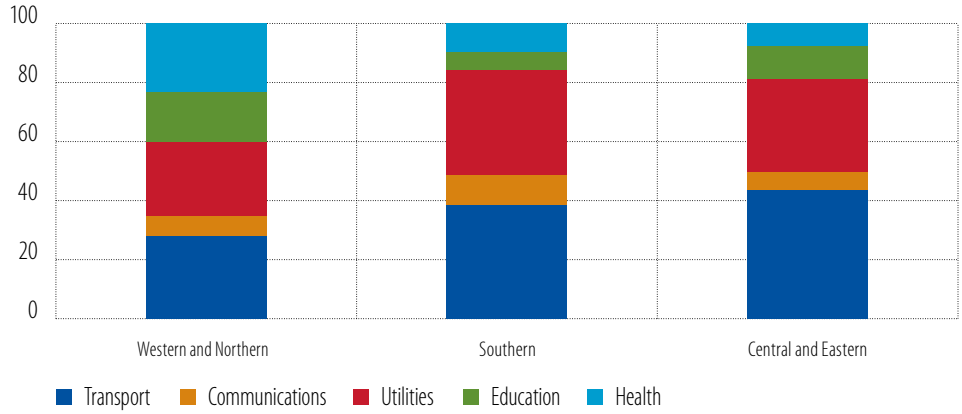
Figure 18
EU infrastructure investment by asset class (% GDP)



Source: *EIB calculations, EPEC, Eurostat, IJ Global.*
Note: *Annual infrastructure investment in EU27 by infrastructure asset as a share of GDP, expressed as a percentage. Data missing for Belgium, Croatia, Lithuania, Poland and Romania. Where data are not yet available, the sector share is assumed constant – this is generally the case for 2019 with Spain, Italy, Cyprus and Portugal, the areas of education, health and transport in the Netherlands, as well as with Denmark generally for 2018 and 2019. Slight deviations from the 2018 results are due to a refinement in the estimate of depreciation of infrastructure investment as well as the Brexit-induced recomposition to EU27.*

Following a decade of a highly uneven contraction, the recent EU rebound has seen Southern Europe falling further behind. Central and Eastern Europe as well as Southern Europe led a decade-long contraction in EU infrastructure investment's share of GDP, which bottomed out in 2017. Driving the revival is a rebound in Western and Northern European Member States, where the share of investment in GDP reached 1.8% in 2019, exceeding pre-crisis peak levels. Throughout 2018, the bulk of the increase was carried by the corporate sector, with support from government investment, while private sector projects provided some marginal dynamism. In 2019, Central and Eastern Europe provided further impetus to the revival, with the share of infrastructure investment in GDP reaching 1.9% in 2019, more than half of the pre-crisis highs. Here, government activities have become the mainstay of infrastructure investment, accounting for nearly two-thirds of 2018 volumes, whereas the corporate sector continues to wane, accounting for merely one-third. Projects have dwindled to barely 3% of infrastructure activity. It remains to be seen how the closing of the EU budget cycle will affect investment in the coming years and whether the predominant position of government investment will continue. In Southern Europe, government investment provided some tentative stabilisation in 2018 and the overall share in GDP increased to 1.12% in 2019, here again just over half of the pre-crisis level. Non-PPP projects have more than doubled since 2016 to 0.12% of 2019 GDP.

Figure 19
Regional shares of infrastructure investment by asset class



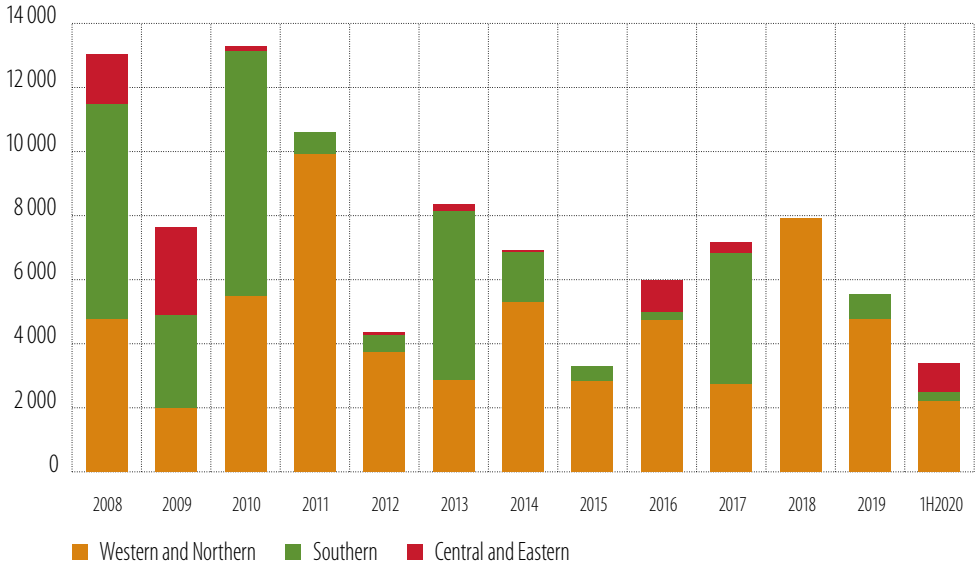
Source: *EIB calculations, EPEC, Eurostat, IJ Global*
Note: *Shares of infrastructure investment by infrastructure asset and by EU27 region in 2019 expressed as a percentage. Regions are Western and Northern, Southern, and Central and Eastern. Data missing for Belgium, Croatia, Lithuania, Poland and Romania. Where data are not yet available, the sector share is assumed constant – this is generally the case for 2019 with Spain, Italy, Cyprus and Portugal, the areas of education, health and transport in the Netherlands as well as with Denmark generally for 2018 and 2019. Slight deviations from the 2018 results are due to a refinement in the estimate of depreciation of infrastructure investment as well as Brexit-induced recomposition to EU27.*

Communications' share of infrastructure investment has remained elevated since 2015 (Figure 19). In Western and Northern Europe, three-quarters of infrastructure investment is accounted for in broadly equal measures by utilities, transport and health; the remaining quarter is dominated by education, with communications representing 7%. Transport and utilities constitute around three-quarters of investment for both Central and Eastern and Southern Europe. In Central and Eastern Europe, the bulk of the remainder is dedicated to education. In Southern Europe, communications remains the third-largest sector, with a share in excess of 10% of overall infrastructure investment, well ahead of the corresponding shares elsewhere, whereas the shares of education, health and utilities have dipped below their average in recent years. Considering their relatively small size, health and education represented a disproportionate share of the decade-long contraction in infrastructure investment in Southern Europe.

PPPs in the European Union remain concentrated in Western and Northern European Member States, with a continued decline in the number of projects reaching *financial close*[12] accompanied by an increase in average value (Figure 20). Compared to the period preceding the global financial crisis, annual volumes had declined to less than half in 2018. In the wake of the sovereign and banking crisis in the euro area, a saddle (high) point emerged in 2013 and 2014, following which volumes declined until 2019, when they constituted a mere third of the 2010 high. Activity in 2019 remained thin in Southern Europe and at best sporadic in Central and Eastern Member States. Over the first half of 2020, the number and total value of projects reaching financial close was broadly in line with the very low levels of 2019.

12 Volumes of euros associated with the financial close indicate the contracted value of the project and are therefore distinct from the actual levels of investment during any one year of the project's cycle.

Figure 20
Total annual values of PPPs reaching financial close by region (EUR billion)



Source: *EPEC.*
Note: *Total annual value in billion euro of PPPs brought to financial close in EU27. 2020 includes deals brought to financial close by 30 June 2020.*

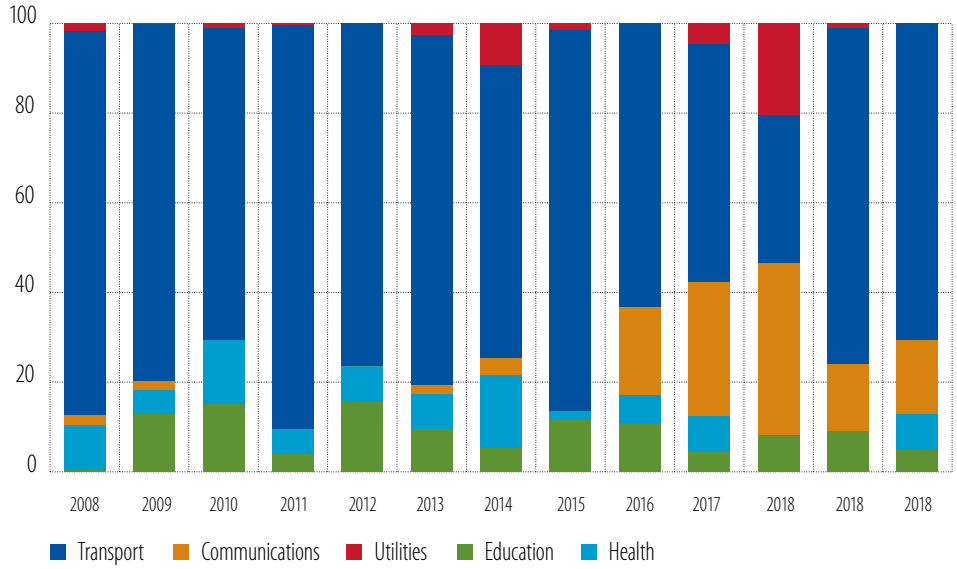
Communications projects have represented the second largest area of activity since 2016, with transport typically accounting for the bulk (Figure 21). Since 2016, transport projects have constituted some 56% of the total value of projects and nearly 40% of the number. Activity in 2017 was unusually low on both counts. Over the same period, communication projects have constituted an average of 20% of projects and one-quarter of their value. PPPs in communication essentially involve broadband roll-outs, notably in France but also in Austria, Poland and Greece. While education projects account for nearly one-quarter of the number, the value averaged around 8% of the total for the period.

The number and total value of infrastructure projects rebounded markedly in 2018 and remained at that level throughout the first half of 2020 (Figure 22). Activity from 2019 onwards was predominantly in Western and Northern Member States, after activity in Southern Member States briefly returned to pre-euro area crisis levels in 2018. Activity through the first six months of 2020 reached about half the full-year levels. Compared with the levels for the first six months of previous years, the total value of projects brought to financial close was high in 2020, even if the concentration in Western and Northern Europe rose significantly and the number of projects was lower.

Since 2016, non-PPP project financing has become more important for communications equipment (Figure 23). Utilities – notably energy – remain the principal asset class financed in non-PPP projects, typically accounting for three-quarters of the total value and more than four-fifths of the number of projects. There has been a notable increase in the share of transport and especially communications projects since 2016, with the latter also helping to prop up volumes in the first half of 2020.

Figure 21

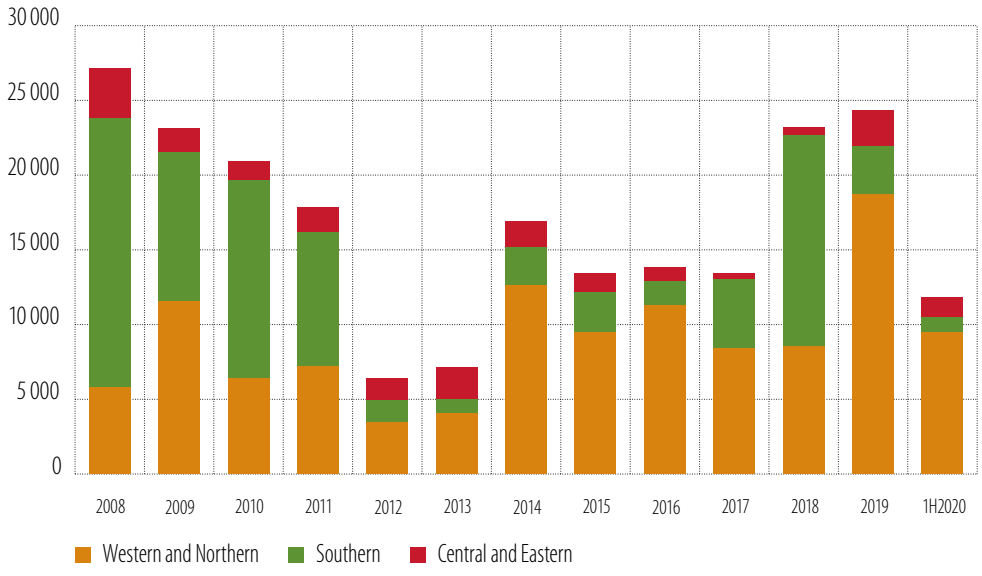
Annual distribution of PPP projects reaching financial close by asset class (in %)



Source: *EPEC.*
Note: *Distribution across asset class of the total annual value in euros of PPPs brought to financial close in EU27. 2020 includes deals brought to financial close by 30 June 2020.*

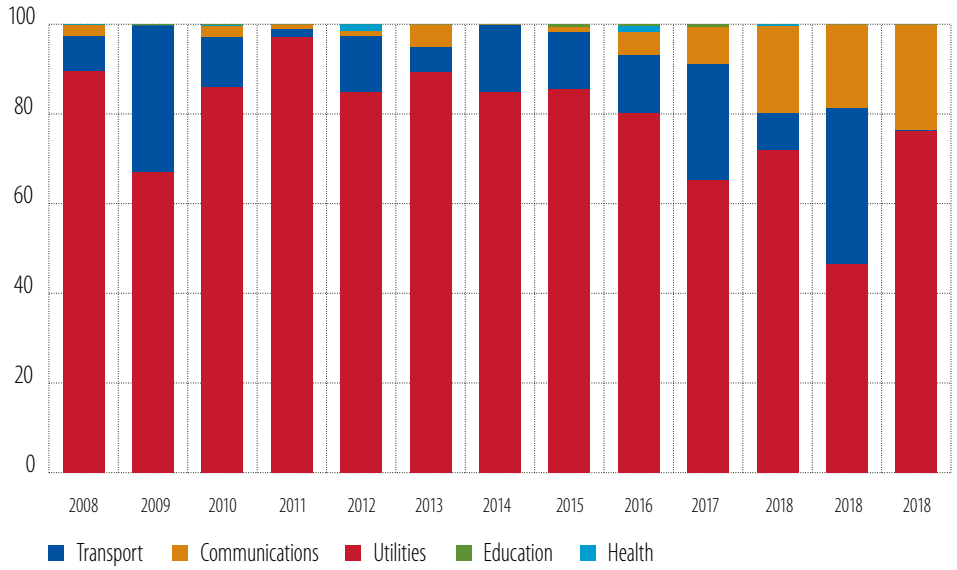
Figure 22

Annual value of non-PPP project by country group (EUR billion)



Source: *IJ Global.*
Note: *Total annual value in billion euros of non-PPP projects brought to financial close in EU27. 2020 includes deals brought to financial close by 30 June 2020.*

Figure 23
Annual non-PPP project activity by asset share



Source: *IJ Global.*
Note: *Distribution across asset class of the total annual value in euros of non-PPP projects brought to financial close in EU27. 2020 includes deals brought to financial close by 30 June 2020.*

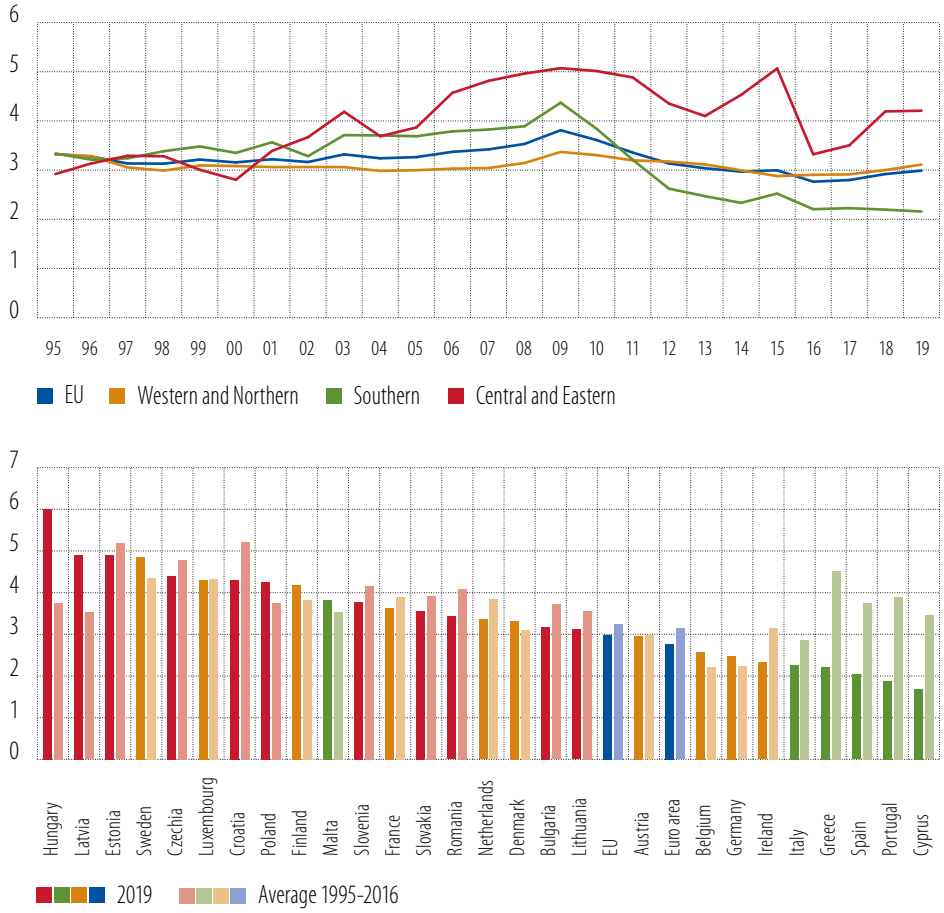
Government investment

Government investment showed a mild upward trend in the European Union before the coronavirus outbreak. As a share of GDP, government investment reached 3% in 2019 (from 2.8% in 2016, the lowest level in 25 years) compared with an average of 3.2% for 1995 to 2016. It increased in Western and Northern Europe and in Central and Eastern Europe, but continued to decline slightly in Southern Europe. In 2019, investment spending came to 4.2% of GDP in Central and Eastern Europe, 3.1% in Western and Northern Europe and 2.2% in Southern Europe. The low level of investment was fairly consistent across Southern Europe, without major differences between countries, except Malta, which had a much higher share at 3.8%.[13] The differences among countries in the other regions is much greater, ranging from 3.1% in Lithuania to 6% in Hungary in Central and Eastern Europe, and from 2.3% in Ireland to 4.9% in Sweden for Western and Northern Europe.

In the last three years, capital transfers and investment have fallen below the average witnessed in 1995-2016. Interest spending registered a larger drop, while primary current expenditure is higher than its historical average. This suggests that the wide reduction in the debt service burden has not translated into support for capital spending. The balance between current and capital expenditure, particularly in Southern Europe, has tilted in favour of current spending.

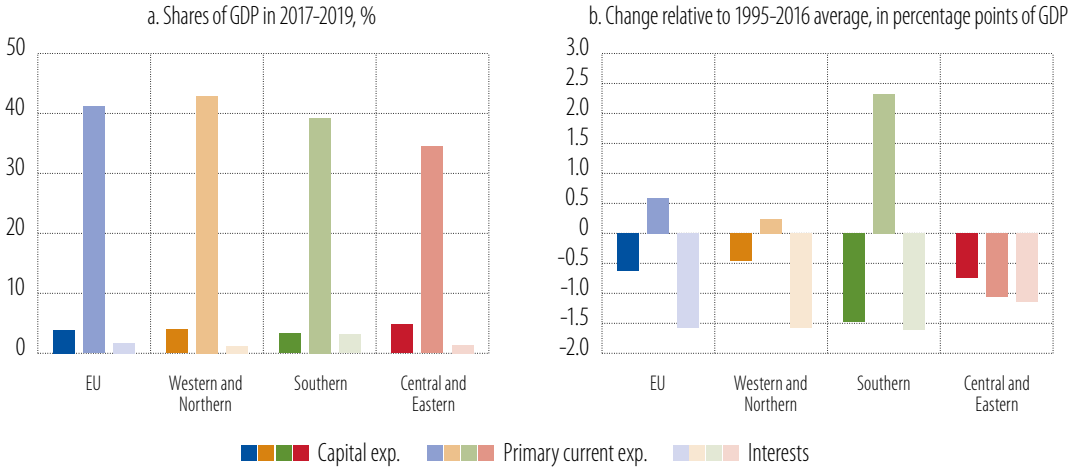
13 The level was 1.7% in Cyprus, 1.9% in Portugal, 2.0% in Spain, 2.2% in Greece and 2.3% in Italy.

Figure 24
Government investment as a share of GDP



Source: *European Commission's AMECO database, top panel country groups' time series, bottom panel 2019 vs. 1995-2016 average.*

Figure 25
Capital expenditure, primary current expenditure and interest



Source: *European Commission's AMECO database.*

The COVID-19 crisis caused current spending to rise notably, which was reflected in the budget plans of EU Member States. EU members first submitted (at the end of April 2020) streamlined versions of their Stability and Convergence Programmes, including a first assessment of the pandemic's impact on policies and public accounts. Then, around mid-October, members of the euro area submitted their draft budget plans for 2021. Combining these two sources with the European Commission's autumn economic forecast allows us to assess the pandemic's impact on fiscal policy.

Current expenditure increased substantially in 2020. Table 1a shows that revenues, as a share of GDP, are roughly constant, meaning that they are declining in line with the contraction in GDP. Total expenditure, on the contrary, is increasing as a share of GDP because of the emergency measures taken by Member States, the vast majority of which go under the heading of primary current expenditure.[14] This category of spending is growing significantly as a share of GDP (from 41.2% to 48.4%) and compared with the 2019 level (up 10.8%). The bulk of the spending is for unemployment benefits and subsidies to support incomes. The jump in current expenditure will be partially re-absorbed in 2021, when its share of GDP should decline to 45.9%. Current spending is also expected to dip in 2021, by 0.2%.

Table 1
Government budgets as a share of GDP, nominal growth rates year-on-year

a. Share of GDP, %

	Investment			Primary current spending			Total revenues		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
EU	3.0	3.4	3.4	41.2	48.4	45.9	46.1	46.2	45.7
Western and Northern	3.1	3.4	3.4	42.9	49.4	47.1	48.0	47.5	47.1
Central and Eastern	4.2	4.7	4.7	34.7	41.1	38.8	39.9	40.3	40.0
Southern	2.2	2.6	2.7	39.6	48.9	45.7	44.0	45.3	44.4

b. Annual growth, %

	Investment		Primary current spending		Total revenues		Nominal GDP	
	2020	2021	2020	2021	2020	2021	2020	2021
EU	5.2	5.9	10.8	-0.2	-5.8	5.2	-5.7	5.3
Western and Northern	4.5	5.9	10.3	0.3	-5.5	4.9	-4.3	5.3
Central and Eastern	5.6	4.5	12.7	-1.5	-6.5	5.2	-5.0	4.4
Southern	7.5	6.8	11.5	-1.3	-6.3	6.3	-9.8	5.7

Source: European Commission's AMECO database, European Commission's autumn forecasts.

The European Commission's autumn economic forecast suggests notable growth in public investment in the aftermath of the COVID-19 crisis. Investment's share of GDP is projected to increase to 3.4% in 2020, up from 3% in 2019. Compared to 2019, the amount spent on government investment will rise by 5.2% in nominal terms. The levels are not homogeneous across regions. In 2020, investment growth will be a little weaker in Western and Northern Europe (4.5% in 2020) and stronger in Southern Europe (7.5%) while in Central and Eastern Europe, public investment will grow by 5.6%. Government investment's share of GDP will increase in all three regions. In 2021, the share will continue to increase in Southern Europe (2.7%), with nominal growth of 6.8%. The share will stabilise at 3.4% in Western and Northern Europe and at 4.7% in Central and Eastern Europe.

14 Note, however, that part of the medical equipment purchased to tackle the epidemic is classified as investment.

Governments are planning more investment to support the recovery, particularly in 2021. The expenditure targets included in the draft budget plans for 2021 submitted by euro area members suggest a more expansionary path, with a more prominent role for government investment. The largest differences between these plans and the European Commission's forecasts of the target share of GDP for government investment are for Greece (6.6% vs. 4.1%), Estonia (6.7% vs. 5.9%), Italy (3.4% vs. 2.7%), Slovenia (6.24% vs. 5.8%), Spain (2.8% vs. 2.4%) and France (4.2% vs. 3.9%). If achieved, these targets will imply notably stronger investment growth, particularly in Southern Europe. For example, the Greek draft budget plan foresees an increase in the share of investment in GDP from 2.2% in 2019 to 3.6% in 2020 and 6.6% in 2021. Those increases will bring the share of investment in GDP in Southern Europe almost in line with the EU average (3.3% vs. 3.6%) in 2021.

Table 2
Government investment: Draft budget plans and European Commission's autumn economic forecast

	Draft budget plans					European Commission autumn economic forecast				
	Share of GDP, %			Change YoY, %		Share of GDP, %			Change YoY, %	
	2019	2020	2021	2020	2021	2019	2020	2021	2020	2021
EU	3.0	3.4	3.6	5.2	12.9	3.0	3.4	3.4	5.2	5.9
Western and Northern	3.1	3.4	3.5	4.5	8.9	3.1	3.4	3.4	4.5	5.9
Central and Eastern	2.2	2.6	3.3	7.5	32.8	2.2	2.6	2.7	7.5	6.8
Southern	4.2	4.7	4.8	5.6	5.4	4.2	4.7	4.7	5.6	4.5

Source: European Commission's autumn economic forecast and euro area members' draft budget plans.

The prospect of activating the Recovery and Resilience Facility and the Multiannual Financial Framework (MFF) for the 2021-2027 budget period is enabling Member States to focus on capital expenditure in their 2021 budgets. The European Union's recovery programme allows for a longer-term perspective. Without it, the marked increase in public deficits may have reduced governments' ability to support the recovery by spending on investment. This is particularly evident when comparing the draft budget plan submitted in October with the European Commission's spring forecasts. Aggregating the numbers shows that the planned increase in investment in 2021 is EUR 40 billion higher, with a share of GDP that is around 0.3% higher than in the forecast.[15] Many draft budget plans include references to the RRF, a central pillar of the NextGenerationEU recovery programme, as a key factor in the medium term.

Some Member States have discussed or already approved plans that aim to support the economy amid the COVID-19 crisis. Early June, Germany approved a large package worth EUR 52.8 billion for 2020-2021 that mainly consists of government investment. Part of the package includes EUR 15 billion supporting e-mobility, EUR 11 billion for artificial intelligence, communication technologies and networks, and EUR 15.3 billion for the digitalisation of public administration and local authorities. Investment in hydrogen technology (EUR 9 billion) and R&D (EUR 2.3 billion) is also planned. France has designed a support package that includes EUR 4.6 billion for the aerospace industry, including military and civil security purchases, along with EUR 8 billion for the automotive sector and its supply chain. The Spanish government set EUR 1 billion aside for strengthening science, technology and innovation and established a regional fund for investments in education (EUR 2 billion) in addition to EUR 9 billion for healthcare spending. As part of their extraordinary measures, many countries allocated funds to shoring up the automotive industry, which remains the easiest way to stimulate demand and activate a large and mainly local production chain. This effort involves incentives for renewing vehicle fleets, favouring low-emission vehicles. The automotive initiative includes the European Union's largest Member States, namely France, Spain, Germany and Italy.

15 Draft budget plans also suggest higher investment spending for 2020 but to a smaller extent (around 0.1% of GDP).

In 2020-2021, a substantial increase in capital transfers will appear on many public sector balance sheets. Capital spending, which includes investment and capital transfers, is projected to show a massive increase in 2020. Many governments have allocated considerable resources to shore up firms. Examples include the hardest-hit sectors, such as air transport, along with innovative firms or start-ups, firms in the utilities sector or, in general, "strategic" companies as shown in Table 3. Not all of these funds will necessarily be used and, even if they are, the equity injections by governments will likely be only temporary as the shareholdings will be sold to private investors at a later date.

Table 3

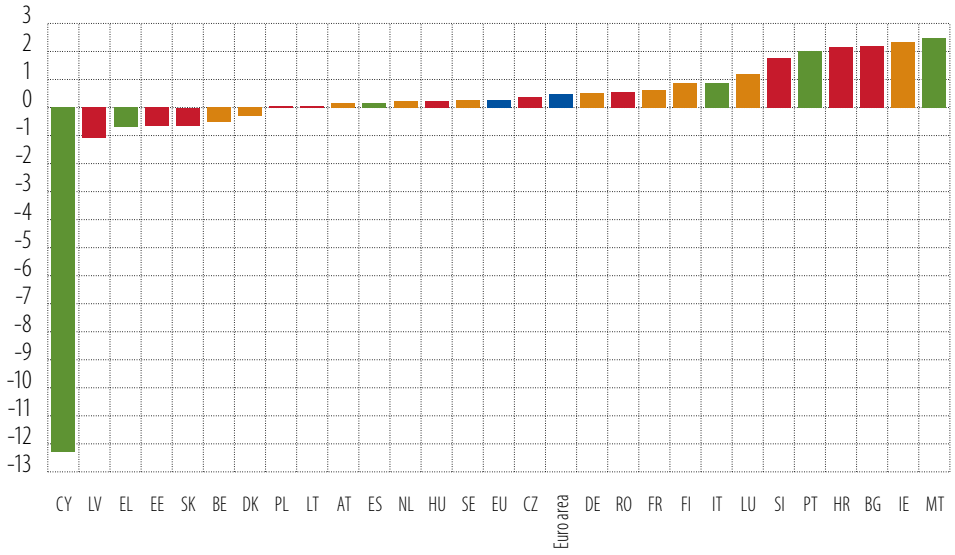
Programmes providing equity support for large, strategic firms or small businesses/startups

	Large or strategic firms	Small businesses
Germany	100	2
France	20	3.9
Spain	10	
Denmark	1.3	
Ireland	2	
Italy	45	2

Source: Bruegel, Bank of Spain, IMF Policy Tracker[16].

Figure 26

Capital expenditure as a share of primary current expenditure, 2020-2021 change relative to 2017-2019 (percentage points)



Source: European Commission's AMECO database and EIB staff calculations.

Policymakers should keep in mind that historically, government investment has tended to decline substantially following a surprise contraction in GDP (Box A). We argue that this time, the outcome should be different. As a share of GDP, government investment has approached a 25-year low following several years of fiscal consolidation in the wake of the global financial crisis. Infrastructure needs in many

16 Bruegel, The fiscal response to the economic fallout from the Coronavirus (Aug.2020); Bank of Spain DO 2019 Fiscal policy measures in response to the health crisis in the main euro area economies, the United States and the United Kingdom. IMF https://www.imf.org/en/Topics/imf-and-covid19/Policy-Responses-to-COVID-19.

European regions have been increasing after years of underinvestment (EIB, 2017; EIB, 2018). Furthermore, the biggest challenges for the future of the European Union – climate change and digitalisation – require even more government investment. At the same time, current ultra-low interest rates are allowing many governments to borrow very cheaply, easing fiscal constraints. Recent high estimates of the impact of government investment on GDP lend further support for an increase (International Monetary Fund (IMF), 2020).

Fiscal sustainability issues, however, require a careful balance between taking on new debt and re-orienting government spending from current to capital expenditure. Low borrowing costs could quickly increase and force fiscal consolidation (Lian, Presbitero and Wiriadinata, 2020). That said, sovereign borrowing costs are historically very low as a result of central-bank purchases of sovereign debt in most EU countries. Theoretically, governments could lock in low interest rates for their bonds if they extended the maturity of their borrowing. However, investor demand for very long-term securities may be low.[17] In addition, debt management offices tend to caution against varying long-established issuance patterns.[18]

17 For this reason, the United States shelved plans in February to issue 50-year Treasury bonds in February.

18 "Modern monetary theory" questions whether concerns about fiscal sustainability are overdone. The idea is that governments would not have to repay their debt at all as long as central banks monetise it. Inflation could be kept in check with countercyclical fiscal policy. Historical experience, however, shows that debt monetisation is accompanied by large fiscal deficits and high inflation.

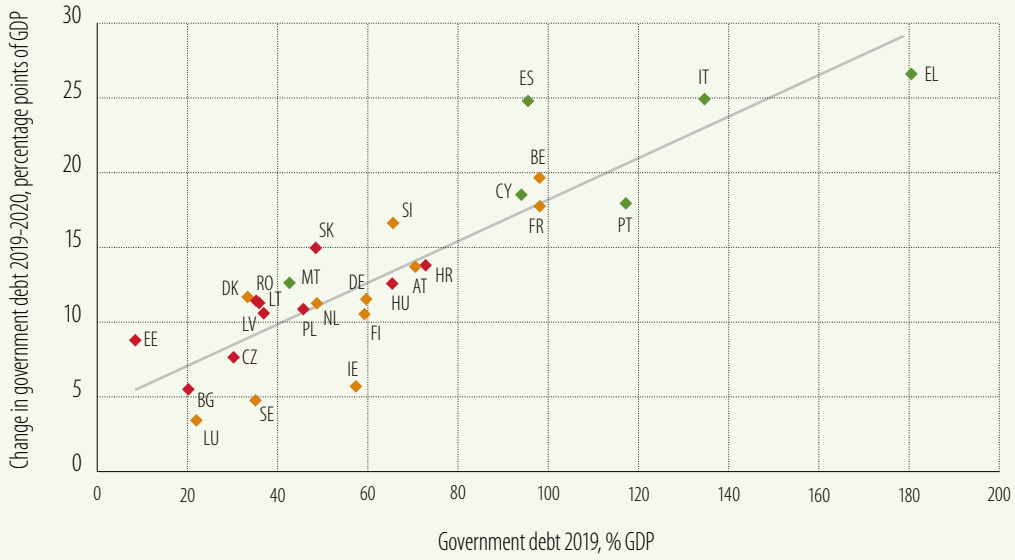
Box A

Government investment following recessions and fiscal consolidation

Contingent liabilities and fiscal deficits have climbed rapidly in most EU countries as economic activity collapsed and government support programmes were rolled out. In its 2020 spring forecast, the European Commission estimated that government debt to GDP in the European Union will likely increase by 15 percentage points to 94%. The increase varies substantially across Member States, from 3.4 percentage points in Luxembourg, the country with the third-lowest government debt, to 26.6 percentage points in Greece, the country with the highest (Figure A.1).

Figure A.1

Increase in government debt, European Union in 2020



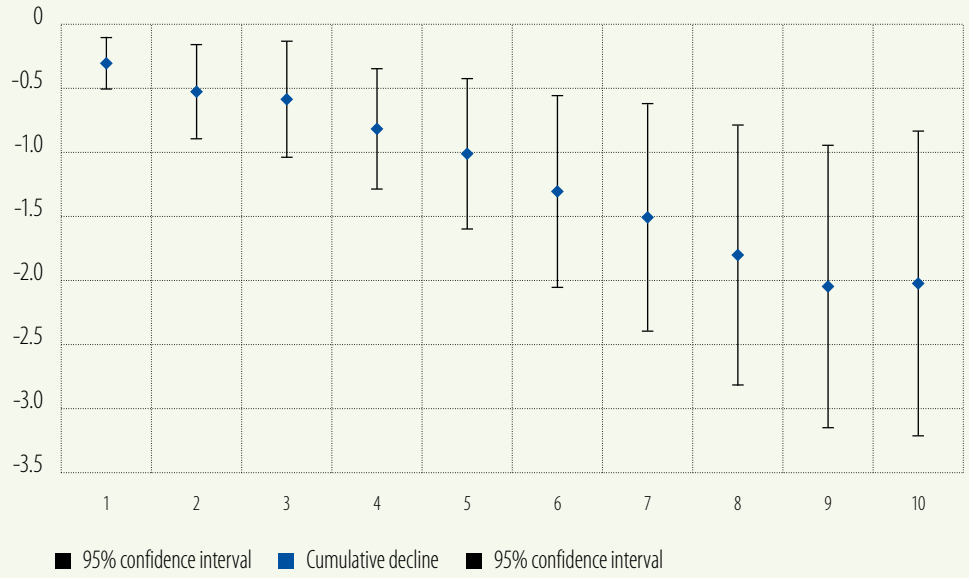
Source: *AMECO database.*

Once the health and economic crises subside, countries will need to rebuild fiscal reserves to deal with future challenges, in particular ageing, structural change, and, in the longer term, climate change (see for instance European Commission, 2020).

Cuts to government investment played an outsized role in previous rounds of fiscal consolidation. Fiscal efforts often entailed a mix in spending cuts and increases in revenues, with increases in revenues playing a bigger part in large-scale consolidations (OECD, 2011). In many countries, belt-tightening involved significant cuts to the largest expenditure items, such as public sector wages and social security spending. However, some expenditures suffered disproportionately. Government investment was sometimes cut vigorously, even though it generally comprises only about 5% of spending. For example, Blöchliger, Song and Sutherland (2012) find that government investment spending as a share of GDP was cut in half, on average, during 13 major rounds of consolidation over 1981-2000. The pressure on investment could be because those cuts encountered less political resistance than reductions in entitlements (for instance, Blöchliger et al., 2012).

In recent work, we find that the decline in investment following fiscal consolidation was not only large, but also long-lasting. We identify fiscal consolidation, following Alesina and Ardagna (2013), by sustained improvements of the cyclically adjusted primary balance. The estimation strategy is similar to Rioja, Rios-Avila and Valev (2014): the deviation from the trend in the government investment rate is regressed on indicator variables, one for each year since the start of the fiscal consolidation, and a number of relevant controls. The cumulative sum of the coefficients on these indicator variables form the impulse response of government investment to the fiscal consolidation (Figure A.2). Results illustrate the substantial and persistent effects of fiscal consolidation on government investment. After ten years, the cumulative decline in government investment is about 2 percentage points of GDP. Put differently, ten years after the start of a round of fiscal consolidation, government investment remains, on average, 0.2 percentage points of GDP below the historic trend.

Figure A.2
Deviation of government investment from trend (cumulative percentage points of GDP)

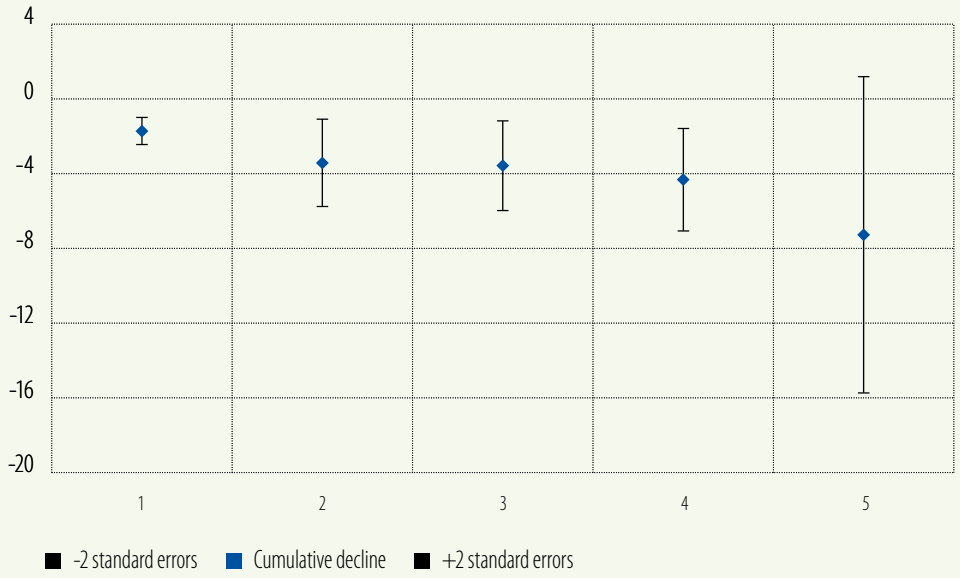


Source: EIB staff calculations.

Government investment also fluctuates significantly more than current expenditure over the business cycle, independently of fiscal consolidation. This suggests that governments find it easier to adjust

public investment than current expenditure. To explore the effects of these changes, we have regressed changes in government investment on surprise declines in GDP, using local projections (Jordà, 2005) to estimate the impulse response. The results suggest that a 1% surprise drop in GDP reduces government investment cumulatively by about 3-4% over the following few years (Figure A.3).

Figure A.3
Cumulative response of government investment after a 1% surprise decline in GDP



Source: EIB staff calculations.

Given the current economic environment, our results suggest that government investment could drop substantially if past fiscal consolidation patterns prevail. For the euro area, for example, the surprise decline in GDP is about 8 percentage points this year, suggesting that government investment could fall by more than a quarter over the next couple of years. Admittedly, the contraction may be smaller. We measure growth surprise as the two-year ahead forecast error in the IMF's World Economic Outlook. Relative to forecasts made in 2019, GDP growth is likely to be surprisingly large in 2021. However, according to our analysis, the response of public investment to surprise increases in GDP is smaller, and statistically far less significant, compared to the response following a surprise drop in GDP.

Current forecasts predict that government investment will increase in most regions, at least in nominal terms, despite the pandemic shock (Table 3, main text). This would mark a welcome break with the past. Cutting government investment is not an option. Government investment as a share of GDP approached a 25-year low in most EU countries (EIB, 2019). Public infrastructure needs modernising in many countries (EIB, 2017 and EIB, 2018). Digitalisation and dealing with climate change also require large public investments over the coming decades.

Conclusion and policy implications

The pandemic may continue to weigh on investment well after governments lift restrictive measures. With the partial economic rally of the third quarter of 2020 curtailed by a second wave of infections across the European Union, uncertainty about the pandemic and the economic recovery is running high. Even if governments refrain from imposing too many restrictions, investment is unlikely to pick up.

The corporate sector needs creative measures. Whole industries are affected by the declining cash flows resulting from collapsed demand. Lower sales are depleting firms' cash reserves and, ultimately, their capital and net worth. Some companies can endure a long period of subdued cash flows, because they have large cash buffers and good business prospects that allow them to borrow. The majority, however, will struggle to keep afloat and to invest to maintain competitiveness (see Chapter 3). Standard guarantee programmes and subsidised loans are only part of the solution for these companies, as they cannot take on more debt. Firms need fresh capital, but it will take time to be generated from retained earnings, if at all. Capital may also not be readily available from private investors either, given the size of the European private equity market. Government intervention, which includes providing equity or quasi-equity investments along with debt restructuring, would help significantly. A multitude of proposals are circulating about the right course to take, while maintaining appropriate incentives and reducing moral hazard (Blanchard, Philippon and Pisani-Ferry, 2020; Boot, et al., 2020).

The lift-off of infrastructure investment is at stake. It took five years of economic expansion for the growth rate in infrastructure investment to turn positive. Investment in 2019 was still well below the level seen in many countries before the global financial crisis.[19] The resurgence was due to increased investment from both the private sector and the government. Sustained high levels of uncertainty, along with mounting government deficits, could derail infrastructure investment, however. Policymakers need to focus on reassuring the private sector so that it will continue investing and implementing the current pipeline of planned infrastructure investment.

While government investment plans remain ambitious, past experience sounds a note of caution. The aggregate EU government deficit in the second quarter of 2020 was -11.4% of GDP. At the same time, government debt increased by 8.4 percentage points of GDP to 87.8% of GDP. The European Commission expects the ratio of government debt to GDP in the European Union to increase by a further 7.3 percentage points in 2020, before shedding 2 percentage points in 2021. While current market conditions, along with large-scale support from the European Central Bank, are conducive to increasing debt, history shows that markets can swing suddenly and may force through a round of fiscal consolidation. In the past, episodes of fiscal consolidation have been very detrimental to government investment. That said, the latest budgetary plans submitted by Member States to the European Commission provide some reassurance that governments are trying to avoid reducing their investments, at least for the time being.

19 Infrastructure investment rate here is the share of infrastructure investment in GDP.

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Chapter 3

Financing corporate investment

Firms entered the COVID-19 crisis on a stronger footing. During the previous economic upturn, firms strengthened their balance sheets and reduced liquidity risk and debt, while increasing capital and building up cash buffers. Increased profits, along with a rise in demand and a very accommodative monetary policy environment, facilitated this favourable evolution. While financial constraints tightened compared to 2019, those constraints remained below their historical peak.

The policy response to the crisis has been strong and managed to maintain the flow of credit to the economy. During the first lockdown in March-May 2020, firms faced a slump in revenues. Because it takes time to reduce costs following a decline in demand, firms' cash positions declined as well as their ability to finance their capital expenditure. National policies helped limit this decline by alleviating labour and tax obligations and supporting credit to businesses through guarantee programmes. At the EU level, central banks and the European Commission also launched programmes to restore confidence. These policies successfully "froze" the economy during the first lockdown. They must be maintained – and possibly recalibrated – through waves of infection and resulting lockdowns.

In addition to the short-term effects of the crisis, investment capacity will be damaged. According to the EIB Investment Survey (EIBIS), some 45% of EU firms are investing less because of the pandemic. Reduced cash positions and lower net revenues have put the trade-off between debt and investment into sharper focus. Our analysis of different scenarios points to the time to return to normal conditions to operate economic activity as being key. It suggests that in the first year of the crisis, corporate investment is likely to fall by 25% to 50% compared to pre-pandemic levels. Subsequently, uncertainty is also likely to further weigh on investment.

Investment was already relatively muted during the upturn, and Europe has not strengthened its competitive position in promising sectors. Firms should invest more to adequately address their environmental and digital needs and prepare for future shocks. The decline in investment is likely to take the biggest toll on R&D and intangible investments, which are not easy to collateralise and must be financed internally.

Future policy measures should be rolled out over time, particularly as an intense second coronavirus wave increased the risk of a long period of uncertainty, before the return to normal. At the onset of the crisis, government policies focused on providing liquidity and maintaining the flow of credit from banks by backing up loans with guarantees. Looking forward, policies should focus on enhancing the financing options available to firms and supporting financial products that use equity instead of debt. This change in focus will help to offset the rising risks and support Europe's goals of improving resilience, greening and digitalising.

Introduction

The chapter reviews the major developments in EU corporate investment and financing since the second half of 2019. Special attention is paid to the impact of the COVID-19 crisis on the European corporate ecosystem and the resulting outlook for investment and investment finance in a more challenging post-coronavirus environment. The source of corporate resilience, the economic implications of the crisis and the likely consequences for firms' decisions are analysed in detail. The rest of the chapter consists of four sections described below and ends with concluding remarks and policy implications.

The first section elaborates on firms' strong position before the crisis. After years of adjustment and deleveraging, and under very accommodative financing conditions, EU corporates by and large entered the crisis on a stronger footing. However, fragile pockets of a more structural nature remained, with underinvestment in some specific assets such as R&D, intangibles and digitalisation equipment as well as some characteristics of the financial system that hampered investment. In this section, a box considers the three main corporate surveys now available – the EIBIS, produced by the European Investment Bank (EIB), the survey on the access to finance of enterprises (SAFE) by the European Central Bank (ECB) and the European Commission, and the Enterprise Survey by the European Bank for Reconstruction and Development (EBRD), the EIB and World Bank – and shows that the data related to finance for EU corporates are very consistent.

The second section shows that a swift policy response helped maintain the flow of credit in the early stages of the pandemic. However, firms' ability to finance their activities internally will decline substantially, for at least the first year of the crisis. The decline in internal finance will likely affect overall corporate investment – unless firms increase their debt levels further than they already have to cover liquidity needs.

The third section shows that young and small and medium-sized enterprises (SMEs) face an even more adverse environment. The slump in demand is more pronounced in sectors where smaller firms tend to be overrepresented, their cost structure is less flexible and their access to finance tighter. Survey indicators suggest that various sources of finance specific to young enterprises and SMEs – such as private equity, venture capital and business angels – may well dry up. This should cause concern as these sources of finance were already not sufficiently developed in Europe prior to the crisis.

The fourth section warns of larger risk to specific assets and elaborates on the nature of the policy measures aimed at limiting the drop in corporate spending. In the future, policy measures should tilt towards supporting much needed green, digital, intangible and R&D investment. Prior to the crisis, Europe had recorded a relatively muted cyclical rebound in investment, and some much-needed investments, in digital, R&D and intangibles in general, had lagged behind. It is important to seize the opportunities presented by the COVID-19 crisis to reshape the European economy. The European Union needs to avoid following the same path as it did during the financial and debt crises more than a decade ago.

Corporates entered the crisis on a stronger footing

Mostly net savers since the global financial crisis, European firms bolstered their financial position and entered the COVID-19 crisis on a stronger footing. Firms improved their balance sheets by reducing indebtedness and accumulating liquid financial assets. Firms also recorded higher profits and improved their financial coverage ratio, a measure of a company's ability to service its debt and meet its financial obligations. These favourable developments were accompanied by a softening of financing conditions and a decline in the proportion of finance-constrained firms.

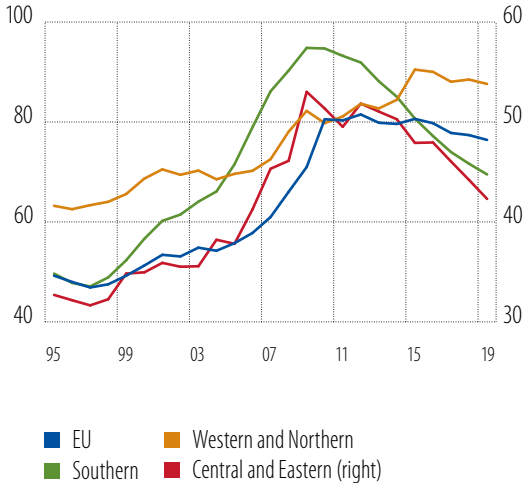
Stronger balance sheets

The indebtedness of European firms continued to decline in 2019. As shown in Figure 1, since peaking at 82% of gross domestic product (GDP) in 2012, the decline in corporate indebtedness has been relatively

modest overall at about 7 percentage points. However, the evolution in Europe has been very diverse. Corporate debt ratios continued to increase in Northern and Western Europe, by 5 percentage points, while they declined by 26 percentage points in Southern Europe and 13 percentage points in Central and Eastern Europe. In these two regions, the indebtedness ratio in 2019 was lower than in 2007. Moreover, empirical evidence suggests that most indebted firms deleveraged more (EIB, 2019).

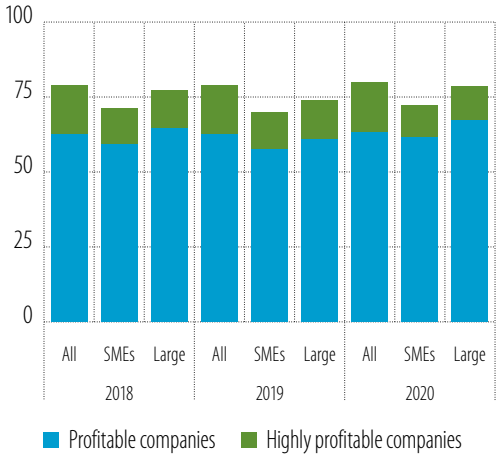
In the EIBIS 2020, 80% of EU firms surveyed reported profits, 17% of which said profits were high.[1] Figure 2 reports the share of firms having recorded profits over the last three years. It defines highly profitable companies as those whose profits were more than 10% of revenue. During the economic upturn, the acceleration in corporate sales remained moderate. The shares of profitable and highly profitable firms have remained relatively stable since the first EIBIS survey in 2016, at around 63% for profitable firms and 16% for highly profitable firms. The indicators remained almost unchanged in 2020, despite the slowdown in the EU economy that started in 2019. However, from 2016 to 2020, the share of SMEs reporting profits is about 6 percentage points lower than that of large enterprises.

Figure 1
Corporate indebtedness (% GDP)



Source: *Eurostat and EIB Economics Department calculations.*
Note: *Latest observation 2019. Indebtedness includes loans and debt securities.*

Figure 2
Share of profitable companies
(% of respondents)



Source: *EIB Investment Survey (EIBIS) 2018, 2019 and 2020.*
Note: *Highly profitable companies report a profit margin above 10%.*

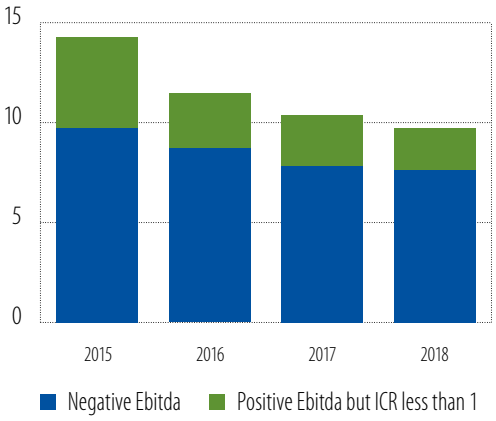
Reduced indebtedness together with a lower cost of finance have helped to increase firms' ability to resist shocks by raising interest coverage ratios. Figure 3 shows that the share of net revenues[2] dedicated to the payment of interest expenses has fallen continuously since at least 2015, reaching historically low levels in 2018. This drop reflects the increase in net revenues and the declines in debt and interest rates. Particularly low interest rates also support corporate income. As shown in Figure 9, borrowing costs on corporate loans have declined by more than 210 basis points since the beginning of 2012.[3] Monetary policy has remained very accommodative in most EU economies since the sovereign debt crisis.[4]

1 This question from the EIBIS 2020 refers to fiscal year 2019.
2 Net revenues are similar to gross profit. They are a measure of sales revenues from which the main cost components are deducted except amortisation and taxes.
3 In the European Union, the share of gross interest payments over GDP has been decreasing since the middle of 2012. At the beginning of 2019, firms' debt payments were well below their average since the beginning of 2003, especially in the South and Centre and East.
4 See Chapter 1 for more details.

Financing conditions were already tightening before the COVID-19 crisis

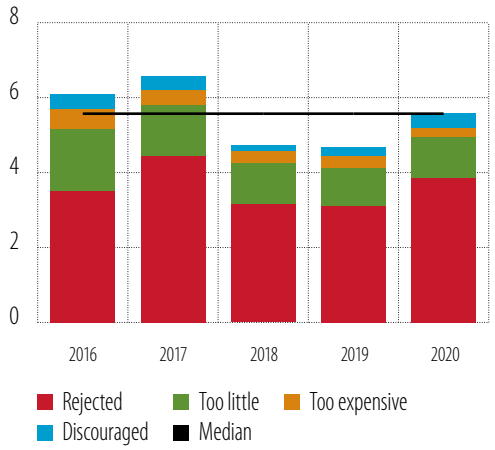
In the EIBIS 2020 that preceded the pandemic, 5.6% of firms said they were finance constrained, almost 1 percentage point above the level in 2019. Figure 4 shows the proportion of firms that report finance constraints.[5] After declining in 2018 to 4.7% from 6.6%, and after no change in 2019, the percentage rose to 5.6% in 2020. The tightening of finance came as economic activity slowed and uncertainty over trade tensions and Brexit rose. The rise in firms reporting finance constraints was contained, however, remaining below the peak of 6.6% recorded in 2017. The pandemic is likely to substantially push up the percentage of firms that report finance constraints.

Figure 3
Interest rate coverage ratio (% Ebitda)



Source: ORBIS and EIB Economics Department calculations. Ebitda stands for earnings before interest, taxes, depreciation and amortisation.

Figure 4
Finance-constrained firms
(% of respondents)



Source: EIBIS 2016-2020.
Note: See footnote 5.

Finance-constrained firms are twice as likely to report an investment gap. Figure 5 plots the investment gap for finance-constrained and those that are not finance constrained. It clearly shows that the gap is higher for finance-constrained firms – 12 percentage points in 2020 compared to non-finance-constrained firms. In the EIBIS 2020, 15% of firms without financial constraints report an investment gap. The number rises to 27% for finance-constrained firms. The difference between firms facing constraints and those that are not is relatively stable over time and across EU regions, ranging from 12 to 14 percentage points.

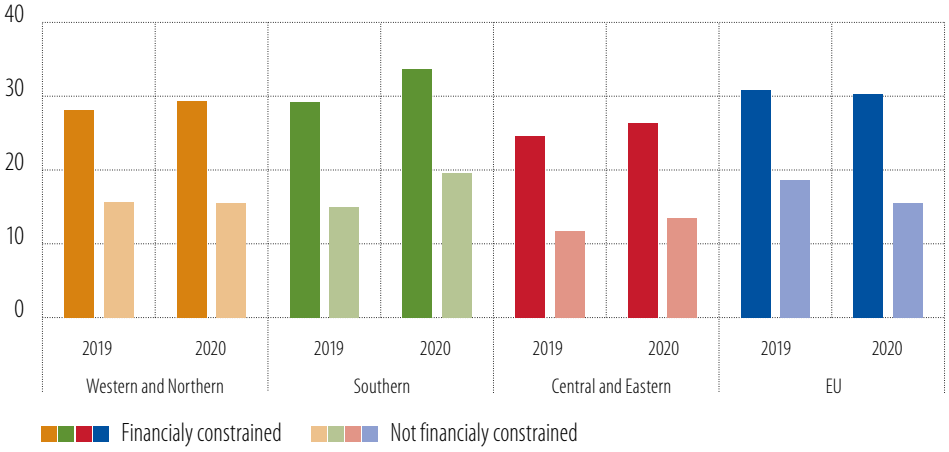
Investment gaps are distributed unevenly across regions. Investment gaps materialise when companies perceive that their investment is lower than optimal levels. In 2020, the investment gap is higher in Northern and Western Europe. In Northern Europe it is 7 percentage points above levels in Southern Europe, while in Central and Eastern Europe it is 4 percentage points higher. In 2020, the share of firms reporting investment gaps increased in Northern and Western Europe while it declined on the rest of the continent.

A lack of finance is not the main impediment to investment. Lack of finance comes well after uncertainty, lack of skilled staff, and regulation (see Chapter 2). Firms throughout the European Union cite uncertainty as an obstacle, a situation that was exacerbated by the COVID-19 crisis. Firms reporting labour market regulation as a major impediment to investment also tend to see business regulation as a problem. Across economies, there is a clear correlation between a lack of investment and labour market and business regulations. In addition, regulation is clearly more of a concern in Southern Europe than in Northern

5 Financial constraint indicator includes: firms dissatisfied with the amount of finance obtained (too little), firms that sought external finance but did not receive it (rejected), and those that did not seek external finance because they thought borrowing costs would be too high (too expensive) or they would be turned down (discouraged).

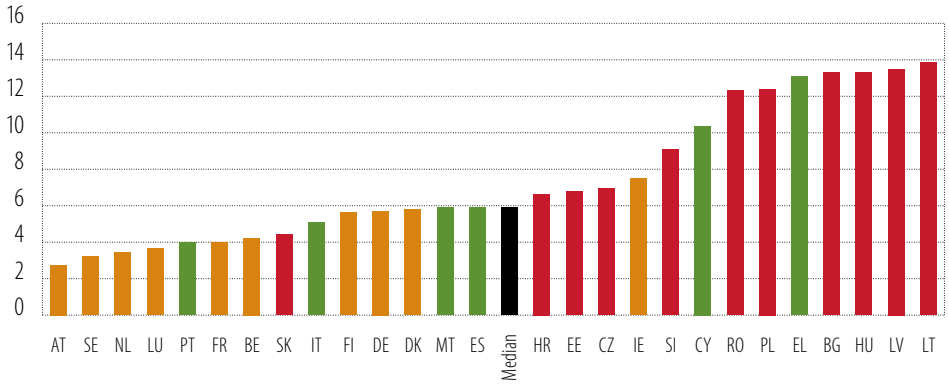
and Western or in Central and Eastern Europe. In some parts of Europe, administrative burdens and an antiquated regulatory environment may prevent a strong post COVID-19 economic rebound.

Figure 5
Finance constraints and investment gaps (%)



Source: *EIBIS 2019 and 2020.*

Figure 6
Share of finance-constrained firms by country (%)



Source: *EIBIS 2020.*

Finance constraints remain asymmetric across countries and type of investment

The overall improvement in the finance conditions masks wide disparities across EU regions and economies. Figure 6 plots the proportion of finance-constrained firms across countries. The figure ranges from below 3% in Austria to 13% in Lithuania, Latvia, Hungary, Bulgaria and Greece. Firms in Northern and Western Europe tend to be less financially constrained, with the exception of Ireland, where the share of finance-constrained firms is above the EU median. Apart from firms in Greece and Cyprus, firms in Southern Europe now tend to be less finance-constrained than the EU median. The countries in Central and Eastern Europe, except in Slovakia, report a percentage of finance-constrained firms above the EU median.

Other surveys confirm the finance constraints signalled by the EIBIS. Box A presents two other major corporate surveys: the ECB's SAFE survey of European corporates and the Enterprise Survey conducted

by the EIB, World Bank and the EBRD in 43 countries, including some European economies. Comparing the survey results across firms in the same countries, the box shows that the EIBIS data are relatively robust. Across surveys, the share of firms reporting finance as a major impediment to investment shows a 55% to 80% correlation, while the share of finance-constrained firms shows a 42% to 56% correlation.

Box A

Measuring access to finance with European firm surveys

The EIB is currently engaged in two major efforts to collect firm-level data in Europe and beyond. In addition to the EIBIS, which it has conducted every year since 2016, the EIB has joined forces with the World Bank and EBRD to carry out Enterprise Surveys in 43 countries across Asia, North Africa and Europe, including 13 Central and Eastern European countries plus Greece, Italy, Spain and Portugal. With support from the European Commission, the coverage of the Enterprise Survey will be extended to all 27 EU Member States by 2021. Together with the Survey on the Access to Finance of Enterprises (SAFE) implemented by the European Central Bank and the European Commission, three sources of internationally comparable firm-level survey data are now available for Europe. This box introduces the surveys and illustrates some results on firms' access to finance.

Description of the surveys

The EIBIS is an annual EU-wide survey that gathers qualitative and quantitative information on firms' investment activities, their financing requirements and the difficulties they face. The survey was conducted for the first time in 2016 and covers approximately 12 500 firms across the EU27 and the United Kingdom, and slightly more than 800 firms in the United States. The survey is administered by phone. The EIBIS collects panel data; some of the firms that have responded to one survey wave are contacted again the following year.

The Enterprise Survey covers a broad range of business environment topics including access to finance, corruption, infrastructure, crime, competition, and firm performance. The World Bank has been implementing the survey based on a globally comparable methodology since 2005. The survey provides a representative sample of the formal private sector. The EIB participated in the survey for the first time in 2014. So far, more than 164 000 interviews have taken place in 144 countries. The Enterprise Survey is based on face-to-face interviews and has a panel component. In most countries, repeat surveys take place at four to seven-year intervals.

The SAFE provides information on the latest developments in the financial situation of enterprises, and documents trends in the need for and availability of external financing. The survey is conducted twice a year: once by the ECB covering euro area countries and once in cooperation with the European Commission covering all EU countries plus some neighbouring countries. The SAFE is a telephone survey and has a panel component. The typical euro area sample has some 11 000 observations, the extended sample approximately 18 000.

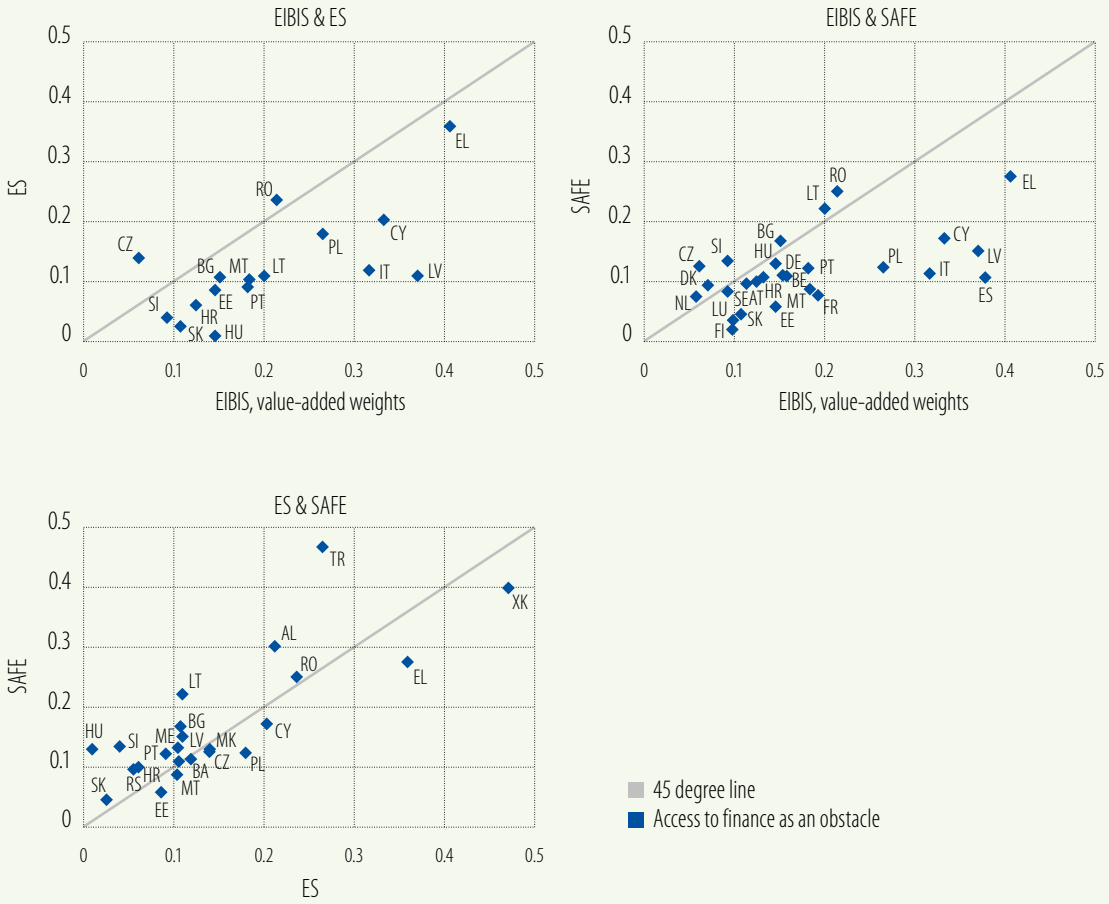
Despite the overlap in geographic coverage, there are important differences between the surveys. The SAFE, run by the ECB, is geared towards representing cyclical developments. Moreover, the survey focuses clearly on the liability side of firms' balance sheets. The EIBIS, on the other hand, focuses on investment and deals with firms' liabilities only to the extent that it helps with understanding investment. The EIBIS covers both cyclical and structural aspects of the business environment. The Enterprise Survey is the most wide-ranging of the three surveys with the topics it covers. In line with the low frequency of waves, the surveys focus on slow-moving, structural aspects of the business environment.

Access to finance

The surveys measure access to finance in different ways. These include financial access as an obstacle to the firm, measures of supply of and demand for finance, the purpose of external financing, and the properties of loans that firms have obtained. This box focuses on two concepts that are present in the three surveys: firstly, the extent to which respondents consider access to finance as an obstacle to the firm; secondly, the extent to which firms that need a loan are able to obtain one. The latter indicates the prevalence of credit constraints.

Figure A.1

Firm perceptions of access to finance as an obstacle



Source: EIBIS, SAFE, Enterprise Surveys (ES), EIB calculations.

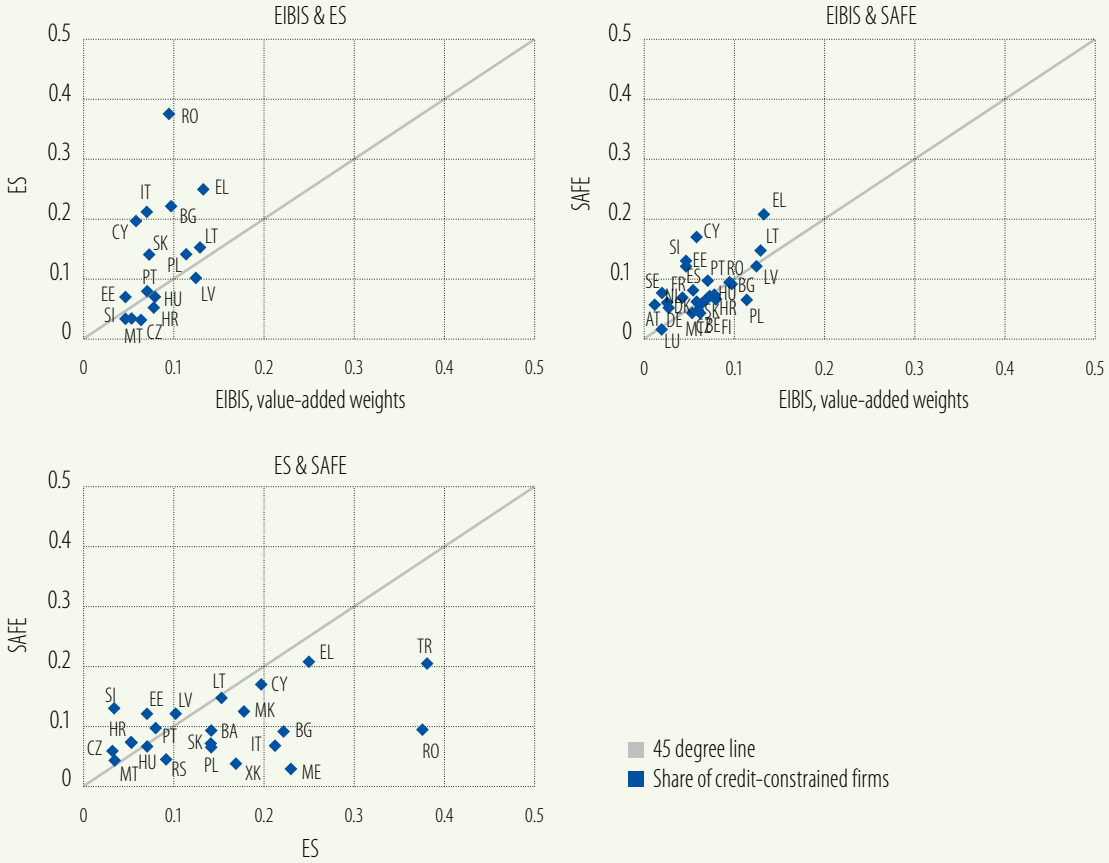
The surveys adopt a similar wording to elicit perceptions of access to finance as an obstacle. The question in the EIBIS (Q38) reads: "Thinking about your investment activities in [ADD COUNTRY OF INTERVIEW], to what extent is each of the following an obstacle? Is it a major obstacle, a minor obstacle or not an obstacle at all?" The question covers several potential obstacles, including "Availability of Finance" (Q38_H).[6] The main difference between surveys is the response scale. Enterprise Survey respondents answer on a five point scale, ranging from "no obstacle" to "very severe obstacle"; SAFE respondents on

6 The wording in the Enterprise Surveys (question K30) reads, "To what degree is Access to Finance an obstacle to the current operations of this establishment?" The SAFE question Q0B reads "How important have the following problems been for your enterprise in the past six months? Please answer on a scale of 1-10, where 1 means it is not at all important and 10 means it is extremely important." Item Q03b_3 deals with "Access to finance."

a scale from 1 to 10. For the purposes of this box, responses are converted into a binary variable equal to one for EIBIS respondents who consider access to finance a major obstacle, for Enterprise Survey respondents who consider access to finance a major or very severe obstacle, and for SAFE respondents that rate access to finance 9 or higher.

The three surveys yield similar results on access to finance as an obstacle. Figure 1 provides pairwise scatterplots of country averages. The plots include all countries for which at least two surveys are available, which explains why the number of countries differs across plots. Correlation coefficients are high, ranging from 0.55 for EIBIS and SAFE and over 0.68 for EIBIS to 0.8 for the Enterprise Survey and SAFE.[7] The level of country averages differs across surveys, but this is likely to reflect the different response scales. Perhaps the correlation coefficient between the Enterprise Survey and SAFE is higher than that between EIBIS and the Enterprise Survey because it is easier to map a five point scale into a ten point scale than it is to map a three point scale into a either a five or ten point scale.

Figure A.2
Share of credit-constrained firms



Source: EIBIS, SAFE, Enterprise Surveys, EIB calculations.

The approach to measuring credit constraints differs to a certain degree across the surveys. Measuring credit constraints is complex, and the three surveys employ a sequence of questions to determine whether a company is credit-constrained. Detailing the sequence and the wording of these questions

7 SAFE and the Enterprise Survey both cover the following non-EU countries: Albania, Bosnia and Herzegovina, Kosovo, Montenegro, North Macedonia, Serbia, Turkey

exceeds the scope of this box. It is important to note, however, that the measurement approaches differ to a certain extent across the surveys. For instance, unlike EIBIS and the Enterprise Survey, the SAFE first asks respondents whether bank loans are a relevant source of finance. Only if the firm answers positively does the survey follow up with the sequence of credit constraint questions. The Enterprise Survey includes items that are more attuned to a developing country or emerging market context, such as discouragement due to strict collateral requirements or procedural hurdles.

The average share of credit-constrained firms is correlated across countries but to a lesser extent than the perception-based measure. As Figure 2 shows, correlation coefficients range from 0.42 for SAFE and the Enterprise Survey and over 0.46 for EIBIS and the Enterprise Survey, to 0.56 for EIBIS and SAFE. That said, the Enterprise Survey yields on average a higher share of credit-constrained firms than either the EIBIS or the SAFE.[8] For example, for the 16 countries covered by both the EIBIS and Enterprise Survey, the country average is 14% in the Enterprise Survey compared to 8% for EIBIS. For some countries, such as Romania, the difference is substantial.

The differences in survey results reflect several factors. First, the wording and sequencing of questions differs, with the Enterprise Survey taking a wider view of credit constraints. Second, the weighting philosophy differs. The published EIBIS results are based on value-added weights, which assign a higher weight to large firms. Large firms, in turn, tend to have easier access to finance. The Enterprise Survey, on the other hand, employs inverse probability weights. The weighting philosophy of the EIBIS is useful for tracking macroeconomic aggregates whereas that of the Enterprise Survey represents the experience of the "typical" firm. Third, the sectoral composition differs across surveys. The EIBIS, for instance, includes utility companies, which are excluded from the Enterprise Survey.

8 To facilitate the comparison across surveys, this box presents the share of credit-constrained firms in the Enterprise Surveys relative to the population. Alternatively, one may show the prevalence of credit-constrained firms among firms needing a loan.

The COVID-19 crisis

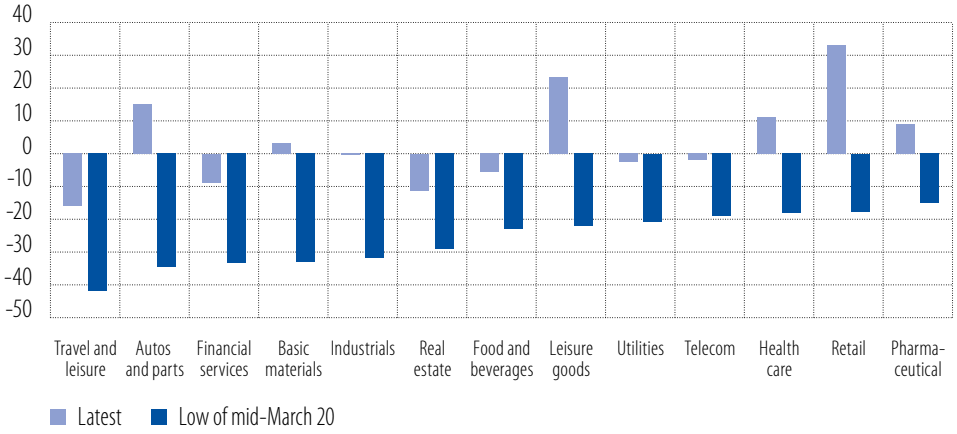
The COVID-19 crisis was so incomparable to a standard cyclical downturn that even EU firms' stronger resilience didn't meet the challenge. In the first half of 2020, the slump in GDP was more pronounced than that of the global financial crisis, which at that time was already thought to be exceptional. The second infection wave and the renewed need to implement lockdown policies mean that the crisis will last until a vaccine is widely distributed. Beyond the cyclical impact following each wave, the crisis will have structural implications as firms need to accelerate their digitalisation efforts and increase their resilience. The acceleration of those efforts will increase investment needs for years to come.

The crisis affected firms unevenly

European stock markets have rallied after a 40% collapse at the beginning of the COVID-19 crisis in March. Worldwide stock prices plunged as countries across the globe began locking down. In the European Union, stock prices hit bottom mid-March – falling 30% from the beginning of 2020, according to Refinitiv. From then, the stock prices of non-financial firms rose almost continuously until September, recovering much of the losses incurred during the crisis. This evolution contrasts with banks' stock prices. Bank stocks are still around 30% to 40% lower than they were before the crisis. Many analysts consider valuations to be on the high side given weak earnings expectations, which is a possible side effect of the ample liquidity provided by central banks.

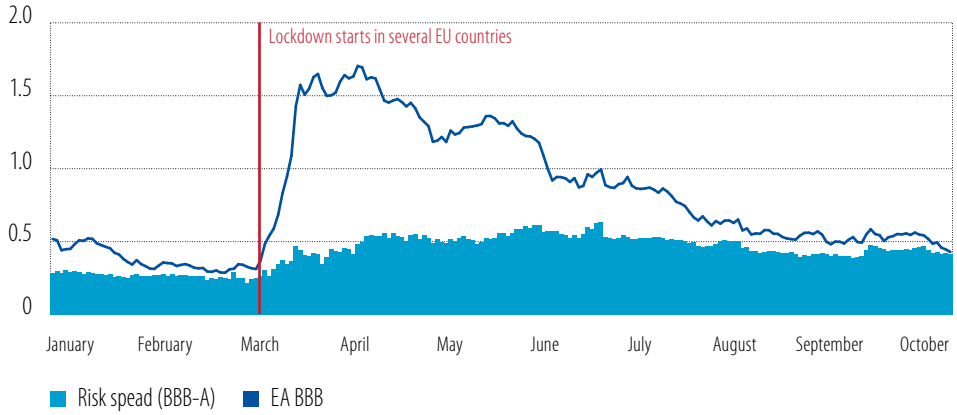
Economic sectors have been affected unevenly by the crisis. While equity valuations are relatively high, differences between sectors are also historically high. Stock markets have priced in a larger decline (since the beginning of 2020) for industrial goods, automobiles, and travel and leisure than for any other sectors. By comparison, pharmaceuticals, retail, telecom and healthcare services have not only rebounded from the lows in mid-March but are close to or above December 2019 levels (Figure 7). The crisis has hit some sectors harder than others. Transport or recreational activities have suffered, while IT or health firms have fared well (Ebeke, 2020). Preliminary evidence suggests that investors require significantly lower returns from more pandemic-resilient firms (Pagano et al., 2020).

Figure 7
Changes in stock prices, by sector (%)



Source: *Refinitiv and EIB Economics Department calculations.*
Note: *Latest observation 10 October 2020, world indices.*

Figure 8
Corporate bond yields and risk spread (% per year, euro area, five-year bonds)



Source: *Refinitiv and EIB Economics Department calculations.*
Note: *Latest observation 12 October 2020.*

Corporations have learned lessons from the COVID-19 crisis. While investment plans are mostly frozen in the short term, owing to extreme uncertainty, investment needs are greater than ever before. According to the EIBIS 2020, 40% of firms believe that the coronavirus pandemic will require them to adapt their product and services portfolio, 40% expect it to affect their supply chain and more than 50% said more digitalisation will be necessary. The crisis has accelerated the adoption of digital technologies, as the lockdown moved activities like events, learning, and, in some cases, even doctor's appointments online.

The lockdown has affected companies unable to make teleworking available to their staff. In some cases, the nature of the activity requires a physical presence. In other cases, such as in business-to-business services, teleworking can be an option but requires substantial spending on equipment. As the crisis continues, the need to improve teleworking infrastructure will become more pressing.

Access to funding has been maintained, and firms have frontloaded liquidity needs

After peaking in late March, corporate bond yields have trended downward and were back to pre-crisis levels in October 2020 – despite the second wave of the virus. Figure 8 plots the corporate bond yield for five-year BBB euro area issuances for non-financial firms, together with an indication of the risk spread, the difference between BBB and A-rated bonds with five-year maturities. At the beginning of the crisis, corporate bond yields increased substantially – from 40 to 160 basis points in late March for BBB-rated bonds. The rise was shared across rating categories and therefore not associated with a large widening of risk spreads.[9] The bond yields of non-financial firms gradually fell back after the initial peak, and by September had settled back to levels before the crisis. Since then, those bond yields have moved in a narrow range. While the risk pricing returned to pre-crisis levels, many corporations are facing ratings downgrades (see Figure 35).

The cost of bank borrowing has remained broadly unchanged since the start of the COVID-19 crisis. Figure 9 shows the evolution of the composite nominal cost of bank financing for firms in the European Union and the four larger economies. Given the prominent role of bank finance, this cost has a profound impact on the price of external finance. The cost of bank borrowing – which declined by about 200 basis points since peaking during the sovereign debt crisis –has remained almost unchanged since the start of the COVID-19 crisis.

The ECB's intervention protected firms at the very start of the coronavirus crisis. The ECB reacted quickly and boldly to the crisis, effectively maintaining the flow of credit (Altavilla et al., 2020). Firstly, risk premiums did not substantially increase, primarily because the bold policy intervention maintained confidence. Secondly, the spread between the cost of finance for firms in the more vulnerable economies, those with higher levels of public indebtedness, and firms in other economies has not increased during the COVID-19 crisis. The developments contrast with the sovereign debt crisis and show how successful policy intervention has been this time.[10]

Since the beginning of the coronavirus crisis, firms have tapped low-cost liquidity. Bank loans have picked up strongly, partly backed by guarantee programmes. Euro area firms took on a record EUR 189 billion of bank loans in February and March. Lending to firms was 6.6% higher year-on-year in April, up from 5.5% in March (Figure 10). According to the latest euro area bank lending survey, the main reasons firms took on loans in the first quarter of 2020 were to pay for inventories and working capital. Loans for fixed investment declined in net terms. Because the financing was mostly related to liquidity needs, the rise in lending was noticeably stronger for short-term loans than for long-term loans.

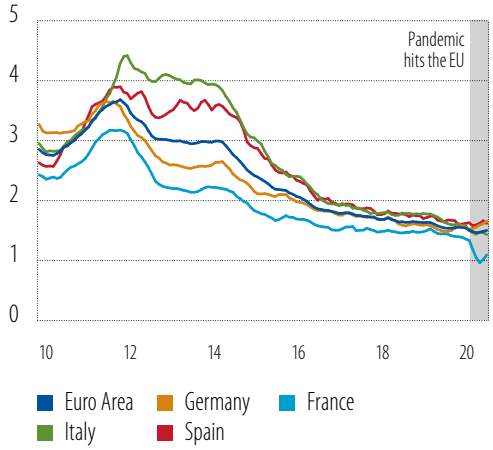
From the start of the crisis, corporate borrowing differed greatly across countries. Loan issuance in Slovenia and France doubled in the second quarter of 2020, whereas in Belgium, banks actually issued fewer new loans compared to the same quarter one year earlier.[11] The already high levels of corporate borrowing in the second quarter of 2019 could possibly explain this evolution. In addition, Spain (+45%), Italy (+28%), Slovakia (+43%) and Portugal (+48%) recorded increases in corporate lending activity well above the euro area average (+19%). Germany, on the other hand, registered no significant increase.

9 The spread between five-year BBB-rated and A-rated bonds increased from 30 basis points in late February to 60 basis points in June and stood at around 45 basis points at the beginning of October 2020. Collateralised loan obligation structures are more affected, however (Aramonte et al., 2020).

10 At the peak of the sovereign debt crisis, the interquartile range of 10-year sovereign bond yields in the euro area reached 400 basis points.

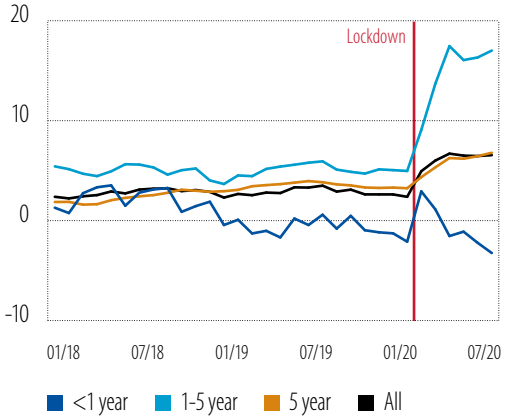
11 The numbers reflect the evolution of new business volumes of loans other than revolving loans and overdrafts, convenience and extended credit card debt, summed over all maturities, to non-financial firms.

Figure 9
Cost of bank borrowing
(%, three-month moving average)



Source: *Refinitiv and EIB Economics Department calculations.*
Note: *Euro area, five-year bonds, % per year. Latest observation August 2020.*

Figure 10
Annual change in corporate bank loans (%)



Source: *ECB and EIB Economics Department calculations.*
Note: *Latest observation August 2020.*

Since the start of the crisis, corporate debt issuance has been buoyant, supported by the ECB programmes: the Asset Purchase Programme (APP) and the Pandemic Emergency Purchase Programme (PEPP). From Figure 11, it is clear that since the start of the COVID-19 crisis, issuance activity has risen substantially compared to the past. Issuance activity has been far above previous levels in 2019 or 2018 and the deviation was well beyond the bounds of historical volatility. In August 2020, cumulated net issuance was double that of recent activity. To some extent, this strong activity partly reflects the impact of the Corporate Bond Purchase Programmes and the Short Term European Paper Programme (STEP)[12] conducted by the ECB.[13]

The strong recent activity comes on top of an increase in corporate bond issuance triggered by the sovereign debt crisis. Andersson et al. (2020) show that during the sovereign debt crisis, financial conditions weighed on investment. However, the resulting constraints on bank lending – illustrated by lower loans and higher spreads – were to some extent alleviated by strengthened corporate debt issuance. Part of the protracted increase in debt-to-loan ratios since the crisis reflects bottlenecks in bank credit supply. However, tightened bank lending has hurt small firms without market access more. While firms are diversifying their sources of funding, policy actions are needed to improve small firms' ability to access public markets for funds.

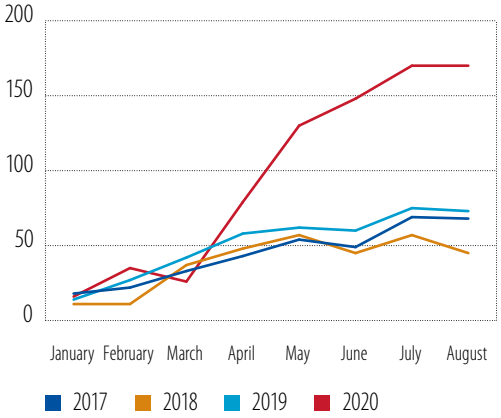
Prior to the crisis, low rates and an uncertain environment led companies to accumulate liquid financial assets, mostly cash and deposits. Figure 12 clearly shows the upward trend in cash and deposits as a percentage of GDP in the European Union, a rise that was shared across the three regions. The ratio increased from 14% in 2005 to 23% in 2019, while GDP increased by 9%. Despite evolving constantly over the long term, the ratio shifted by about 2% of GDP during the global financial crisis. The coronavirus pandemic is likely to spur another downward shift. Companies are unlikely to recover their pre-crisis liquidity buffer for some time.

Prior to the crisis, firms' cash positions cushioned them from adverse shocks. Prior to the COVID-19 crisis, analysts debated the effect the larger cash positions were having on investment. Garrido and Maurin (2020) use a granular dataset of European non-financial firms to show that uncertainty pushes

12 See ECB (2020).
13 See EIB (2018), Box C, "Corporate bond market stimulus and access to finance for bank-dependent firms."

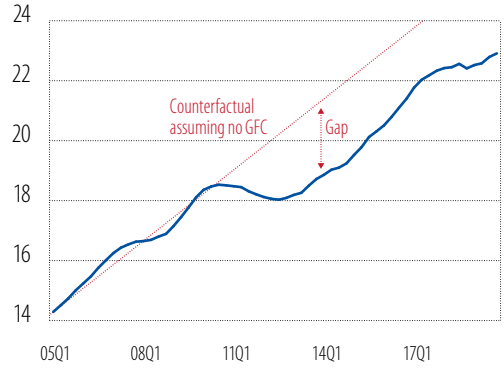
investment down while hoarding cash pushes it up. However, investment becomes more sensitive to cash, demand or income indicators as uncertainty rises. For a given level of cash, an increase in uncertainty therefore pushes down investment – a decline that is stronger for less cash-rich firms. As a result, the higher the uncertainty, the stronger the cash increase required to maintain investment, all other things being equal. In the EIBIS 2020, uncertainty is reported as a major impediment to investment with cash buffers dwindling because of the crisis. This combination does not bode well for investment, and indeed around 45% of firms expect to scale back their investment plans.

Figure 11
Cumulated net issuance of corporate debt
(Year-to-date, EUR billion)



Source: *ECB and EIB Economics Department calculations.*
Note: *Latest observation August 2020.*

Figure 12
Cash and liquid assets of corporates
(% GDP)



Source: *Eurostat and EIB Economics Department calculations.*
Note: *Four-quarter moving average.*

The public policies implemented have maintained confidence and averted a liquidity crisis, but at the cost of higher debt levels. Despite waves of corporate downgrades, firms have benefitted from their ability to issue debt to cover their higher liquidity needs. Credit has flowed to the corporate sector and liquidity issues have been mostly circumvented. However, this has come with a rise in corporate debt. As the second infection wave hits the economy, the recovery will be slower and accompanied by further rises in indebtedness.

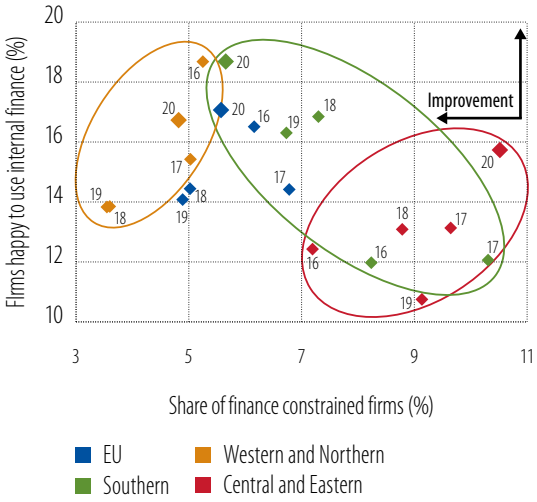
A liquidity freeze would have had a devastating effect on trade credit, resulting in a cascade of defaults. When the crisis hit, the vulnerabilities of longer and more geographically extended trade credit came to the fore, especially those related to international trade. While these risks can be mitigated by financial intermediaries, the bulk of the exposures associated with supply chains is borne by the participating firms themselves, through inter-firm credit. Given the prevalence of the US dollar in trade financing, measures such as central bank swap lines – which ease the conditions of dollar-based credit – cushioned the pandemic's impact on global value chains (Boissay et al., 2020).

The crisis will drastically reduce firms' net revenues

Overall, the coronavirus crisis unfolded very differently from the global financial crisis and the sovereign debt crisis. During the sovereign debt crisis, the flow of credit dried up as banks' funding tightened along with the European sovereign bond market. As the cost of external finance increased and access to finance was tightened, companies were forced to deleverage under harsh conditions. Many firms were forced to reduce their capital expenditure. During the COVID-19 crisis, firms first shored up their liquidity and stockpiled cash, at the cost of higher indebtedness. The low cost of debt made this stockpiling sustainable in the short term. However, the lockdown drastically reduced profits and therefore the capacity to pay back debt or to invest.

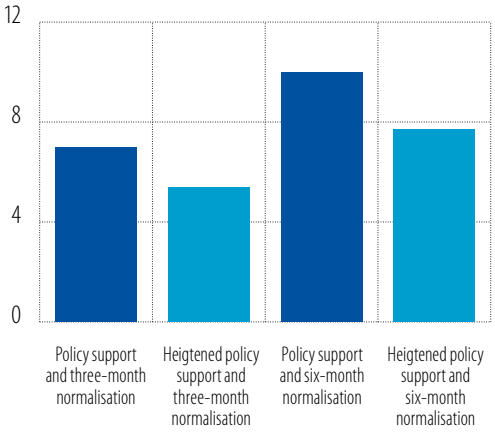
The very large decline in demand will hurt revenues and the damage is likely to be greater for firms that rely more on internal finance and face tighter conditions for external finance. In Figure 13, we correlate two results from the EIBIS: one indicator measuring finance constraints and another that looks at the willingness to rely on internal finance. Financial constraints hamper investment less when the desire to access external funds is weaker. On the figure, investment financing conditions improve as we move upwards or to the left. Two features emerge: Central and Eastern Europe are in the weakest position and, conversely, Northern and Western Europe are in the most favourable position. Southern Europe, however, has moved from an adverse environment, similar to that of Central and Eastern Europe, to a more benign one, closer to that of Northern and Western Europe. This swing took place from 2017 to 2018, and little change was recorded in 2019.

Figure 13
Finance constraints vs. willingness to use internal finance



Source: *EIBIS 2016-2020.*
Note: *See footnote 5. The dark blue, orange, green and red dots respectively refer to the European Union, Northern and Western, Southern, Central and Eastern Europe. The numbers indicate the year.*

Figure 14
Net revenue reduction according to various scenarios (mean, % of total assets)



Source: *ORBIS and EIB Calculations.*
Note: *See Maurin and Pal (2020). Net revenues correspond to profits before amortisation and taxes.*

Firm revenues fell drastically during the lockdown, and are still being affected. For firms, the COVID-19 crisis materialised in several steps. Firstly, liquidity buffers were depleted when closures stopped or radically reduced business activity. This period was followed by a fairly long period of normalisation with reduced internal funding capacity. To illustrate the magnitude of the net revenue loss, we analyse a scenario based on 1.4 million firms, stressing revenues and costs. The sales contraction during the lockdown is commensurate with the decline in turnover and economic confidence indicators recorded during the worst of the crisis in April 2020, or 35%.

Costs adjust asymmetrically and imperfectly to sales in the short-to-medium run, but some components have been financed by public policies. Some of the costs remain fixed, while some can be adjusted or benefit from policy intervention. Sales and costs are not independent of each other, however. When firms face a change in activity, they adjust their production. When activity goes down, firms reduce their expenditure mainly by reducing their consumption of intermediate products. They also lay off some of their employees. Finally, they can reduce other charges such as rent (by reducing the physical space they occupy) energy consumption or insurance contracts. The various policy interventions such as forbearance[14], tax exemptions or temporary unemployment schemes have helped to alleviate some of the additional costs compared to a non-crisis period.

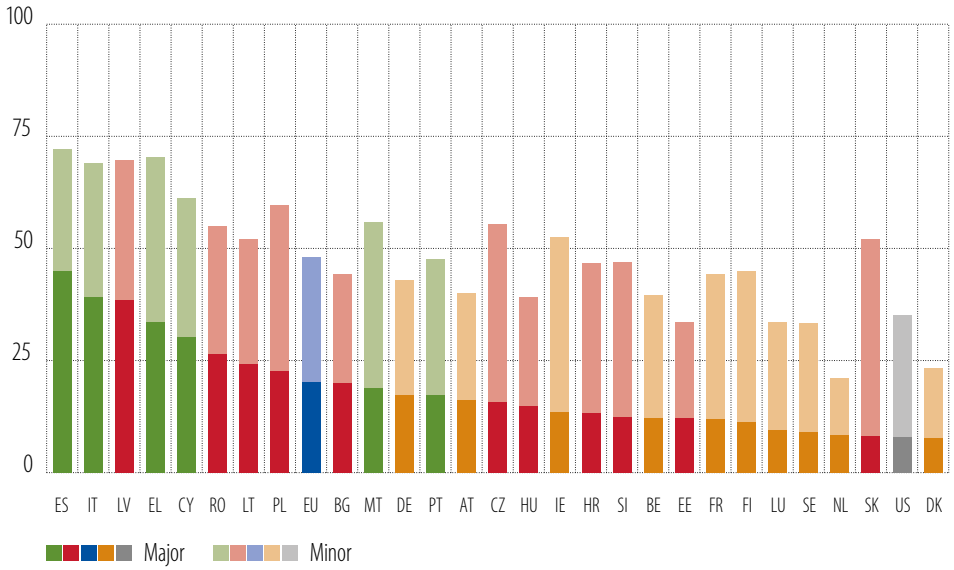
14 A special agreement between the lender and the borrower to delay the payments of debt obligations.

We estimate the loss in net revenues resulting from the lockdown and the normalisation period using a simplified accounting identity of net revenues. Using a dataset comprising 1.4 million firms, we estimate the cost elasticity to sales and calibrate the policy support.[15] We then develop four scenarios to account for the possible impact of the crisis. The scenarios are based on views on (1) the strength of the policy support, for which we consider two cases; and (2) the length of the normalisation period, which can either be three or six months. As infection waves are likely to continue until a vaccine is widely distributed, the analysis emphasises the key role of the length of the normalisation process.

Estimates suggest that firms could face declines in net revenues of 5.4% to 10% of total assets as a result of the crisis. As shown in Figure 14, the unweighted mean reduction in net revenues could range from 5.4% to 10% of total assets across the four scenarios combining the length of the normalisation period, from three to six months, and the size of the policy support. A longer normalisation process would be more adverse, adding a further decline of around 1.5% of total assets when the period is extended by three months. Compared to the normal policy support, heightened policy support would further limit the reduction in net revenues by 3 percentage points for a long normalisation period and 1.7 percentage points for a shorter period.

Access to finance remains a major long-term impediment to investment in several EU economies. Internal finance is deteriorating quickly, more than external finance, which has been supported by policy intervention. However, for structural reasons, a lack of access to finance remains a long-term barrier to investment in several European economies, mostly located in Central, Eastern and Southern Europe. Figure 15 shows that the proportion of firms that consider a lack of access to finance to be a major impediment to investment ranges from 45% in Spain to 8% in Denmark. Denmark is the only European economy where the percentage of firms considering a lack of access to finance to be a major issue is lower than in the United States.

Figure 15
Post-pandemic – lack of finance a major impediment



Source: *EIBIS 2020.*
Note: *Orange bars represent Northern and Western Europe, while green stands for Southern Europe and red represents Central and Eastern Europe. Grey represents the United States.*

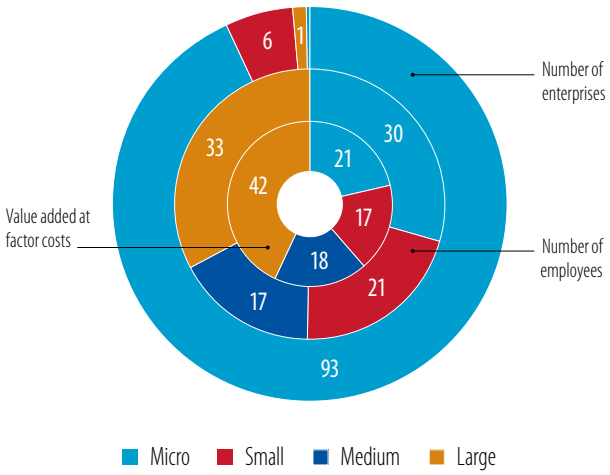
15 A simple relation relates the change in net revenues to the change in sales minus the change in costs: ΔNet revenues = ΔSales – ΔCosts. We then break down costs into the four main items: employee costs (compensation and social contributions), material costs (intermediate consumption of material assembled or used in the production process), financial costs and other costs (such as rent, administrative costs, insurance, energy consumption – these do not include depreciation): ΔCosts = – ΔEmployee Costs + ΔFin. Costs + ΔAdm. Costs + ΔMaterial Costs. Sales and costs are not independent of each other, however. However, for various reasons, costs do not fully react to sales in the short-to-medium term – their elasticity is below one and varies across cost components: ΔCosts = α . ΔSales, with $0 < \alpha < 1$. As a result, profits are pro-cyclical. The policy support is a subsidy illustrated by an increase in cost elasticity. See Maurin and Pal (2020) for technical details.

Government loan guarantees helped to keep credit accessible for firms, but looming rises in non-performing loans may lead to tightened credit. According to the ECB July 2020 Bank Lending Survey (BLS), so far, credit conditions have remained favourable for corporate loans, which are supported by guarantee programmes. However, banks expect a considerable tightening of credit conditions for corporate lending. The expected end of state guarantee programmes in some large euro area countries will have an impact, as will continued high levels of uncertainty caused by the pandemic. Banks also reported that since the start of the coronavirus crisis, non-performing loans had been causing credit tightening and had affected the terms and conditions for all loan categories in the first half of 2020. Prior to the COVID-19 shock, non-performing loan ratios were trending downward in most countries, and had reached 3.4% of total loans in the euro area at the end of 2019.

The specific environment of small businesses[16]

Small businesses contribute significantly to European job creation and economic growth (Figure 16). In 2018, 25 million SMEs in the European Union made up 99.8% of all non-financial enterprises, employed around 95 million people (66.6% of total employment) and generated over EUR 4.35 trillion, or 56.4% of European added value.

Figure 16
Employment and value added by SMEs in the European Union, 2018



Source: ESBFO (Kraemer-Eis et al., 2020), based on European Commission (2019).

While SMEs are relevant across the EU corporate ecosystem, their importance differs across regions. In the case of employment, SMEs in Greece and Cyprus accounted for more than 80% of total employment, while in France, Germany, Denmark and the Netherlands the SME employment share was less than 65%, and in the United Kingdom the share came in just shy of 55% (European Commission, 2019).

The economic outlook is particularly bleak for SMEs. European SMEs' confidence is at the lowest level ever documented, decreasing 25% from the end of 2019 (SME United, 2020). This strongly negative result, clearly due to the effects of the COVID-19 crisis on the European economy, is even well below the historic low of the financial crisis in 2009. Nearly all European SMEs (90%) reported having lost revenue as a result

16 Large parts of this section are based on Kraemer-Eis et al. (2020), and the latest issue of European Investment Fund's European Small Business Finance Outlook (ESBFO). The ESBFO is published annually (typically in September) by the Research and Market Analysis division of the European Investment Fund (EIF) and provides an overview of SME financing in Europe.

of the lockdown, with about two in ten SMEs having lost 100% of their revenue for several consecutive weeks (SME United, 2020). With most liquidity support measures being debt-focused, SME insolvency risks could increase dramatically.

Several factors explain why SMEs are relatively more affected by the current crisis. On the supply side, their small-scale business models and limited workforce make dealing with absenteeism more challenging, for example, if their workers are subjected to obligatory quarantine measures. They typically also have less diversified supply channels, increasing their vulnerability to supply chain disruptions. SMEs are also ill-equipped to deal with social distancing regulations. A recent survey on teleworking practices, for example, brought to light a significant gap in the prevalence of teleworking between SMEs (10% to 20%) and large firms (48%), with the most important reason cited being a lack of appropriate digital infrastructure (Organisation for Economic Co-operation and Development (OECD), 2020). On the demand side, SMEs represent a disproportionate share of companies in sectors hit most severely by the crisis, such as the recreational, hospitality and construction sectors.

Firm estimates suggest that the net revenue decline resulting from the crisis is more pronounced for SMEs (Gourinchas et al., 2020). We reproduce the estimate conducted in Figure 14 and find that the computations based on the unweighted mean of the whole sample mask important differences across firms' sizes. By grouping the four scenarios considered earlier, SMEs (companies with less than 250 employees) would suffer a reduction in net revenues of 5.7% to 10.6% of assets (Figure 17).[17] Larger firms (with more than 250 employees) would only lose about 1.6% to 3.3%.

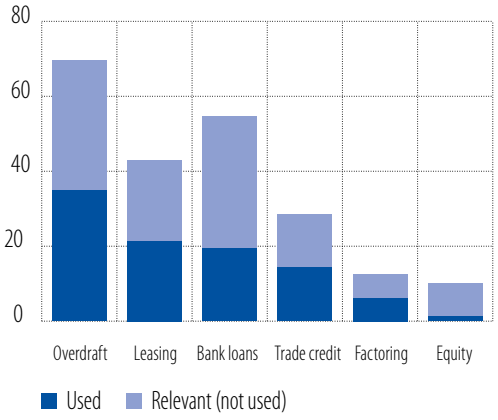
Figure 17

Interval of net revenue reduction by firm size (mean, % of total assets)

Source: *ORBIS and EIB calculations.*
Note: *See Maurin et Pal (2020).*

Figure 18

Preferred sources of external financing for euro area SMEs (second half of 2019)



Source: *European Investment Fund's European Small Business Finance Outlook - ESBFO (Kraemer-Eis et al., 2020), based on ECB SAFE (ECB, 2020).*

Small businesses' access to finance

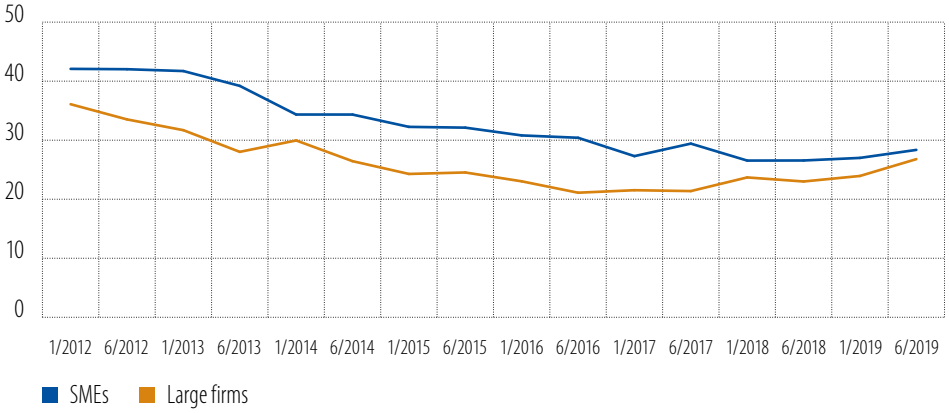
Bank products (loans and overdrafts) are by far the most popular financing instruments, followed by leasing and hire-purchase (instalment plans). Equity and factoring make up just a small fraction of overall SMEs' external financing needs (Figure 18). In general, the composition of SME financing does not vary widely over time, although we did observe a decrease in the use of overdrafts, together with a minor decrease in the use of bank loans and trade credit during the second half of 2018. Unfortunately, the SAFE survey (the basis for Figure 18) does not report alternative financing instruments such as crowdfunding, even though they have gained popularity in SMEs' financing mix in recent years.

17 Within the SME group, the differences between micro (fewer than ten employees), small (between 10 and 49 employees) and medium enterprises (between 50 and 250 employees) are much more contained, with impacts ranging between a low of 5.4% to 6.3% and a high of 10.2% to 11.7%.

Compared to large firms, SMEs are perceived as riskier investments. Several factors are behind this. Firstly, they are young, small, less transparent and, in many cases, family-run and owned by a single individual. Secondly, their financial structure is more rigid than that of large companies as they are more dependent on banks, and their capacity to substitute external financing sources is more limited. They have a higher exposure to idiosyncratic shocks and tend to have less collateral. Moreover, estimating their creditworthiness is more challenging, as they are younger and subject to fewer reporting obligations.

Figure 19

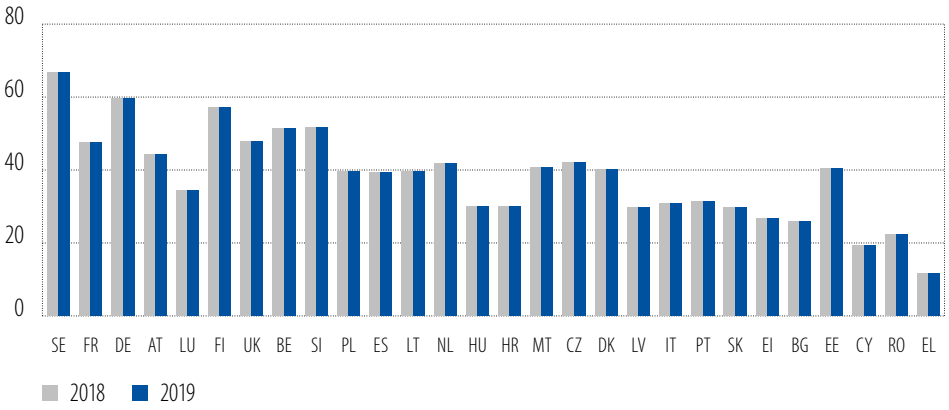
Euro area firms ranking access to finance as a highly important issue (% of respondents)[18]



Source: ESBFO (Kraemer-Eis et al., 2020), based on the ECB.

Figure 20

The EIF SME Access to Finance Index



Source: Torfs (2020).

The lockdown measures introduced in the wake of the initial coronavirus outbreak had a severe impact on European SMEs' liquidity needs. As revenues dried up, about four in ten SMEs reported experiencing liquidity issues as a direct consequence of the economic lockdown. This increases to five in ten for the most affected parts of the economy, such as hospitality and the retail and construction sectors (SME United, 2020). Even with extensive policy support measures, it is estimated that over half of EU firms faced urgent liquidity needs after a three month lockdown period, adding up to a total minimum liquidity shortfall of close to EUR 100 billion, which affected SMEs more significantly (Maurin et al., 2020). The dramatic rise in liquidity needs occurred in the context of worsening finance conditions in 2019 (Figure 19), as the

18 The SAFE wave, referred to as HY2/2020, was in part run in early 2020 and asked respondents about their experiences in the previous six months. It therefore does not include the impact of the COVID-19 crisis.

share of euro area SMEs that consider a lack of finance to be a critical problem[19] increased slightly during the second half of 2019, to 27%. This aggregate percentage hides vast country-level differences within Europe, which range from as low as 13% for Finland, to as much as 43% for Greece.

The external financing market for EU small businesses is characterised by strong disparities among countries. To synthesise the various sources of information related to SME access to finance, we use the EIF SME Access to Finance (ESAF) Index.[20] The ESAF Index is a composite indicator that summarises SME access to finance for all 27 EU Member States and the United Kingdom. It provides a convenient benchmark for the overall SME financing market in the EU Member States, as well as instrument-specific sub-segments. The index contains four sub-indices, three of which are related to different financing instruments (loans, equity, credit and leasing), while the fourth covers the general macroeconomic environment. The 2019 ESAF ranking is headed by Sweden, with France and Germany completing the top three. Compared to 2018, Sweden retains the top spot in the ranking. Greece is last on the ESAF ranking for the seventh consecutive year in a row, and its gap with the next to last country, Romania, is growing.

Bank loans for small businesses, volumes and pricing conditions

In the six months leading up to June 2020, borrowing costs for small borrowers declined to record lows (Figure 21). The magnitude of this decline depends on the loan maturity. Borrowing costs for small loans, a good proxy for SME lending, have continued to fall in recent months, in particular for short and medium-term maturities. Long-term borrowing costs for small loans have stagnated. These evolutions contrast with the large loans segment, where short and medium-term borrowing has become slightly more expensive since the start of the pandemic, but long-term borrowing costs have declined.

Over the 12 months leading up to June 2020, the interest rate on small loans[21] decreased in all but four countries[22] (Figure 22). In Ireland and the Baltic countries, borrowing costs for small borrowers increased, going against the general trend of declining rates. In Estonia and Ireland, borrowing rates increased more strongly for small loans (increasing size spread), thereby increasing the competitive disadvantage of SMEs vis-à-vis larger firms. Borrowing costs decreased most strongly for Greek, Portuguese and especially Finnish SMEs. In Greece, the drop in borrowing rates was common across all size segments of the lending market, whereas in Finland and Portugal, the decline was driven by a drop in the cost of SME lending, as evidenced by the drop in the size spread.[23]

Issuance of small loans[24] to non-financial firms in the euro area increased drastically during the second quarter of 2020, exceeding EUR 50 billion in April (Figure 23). This increase contrasts with the plateauing trend that emerged in early 2019. Over the entire second quarter, small business lending increased by 27% compared with the same quarter a year ago.

19 The rating corresponds to the intensity of the problem perceived by the respondent. A rating above seven on a scale of ten for the SAFE survey reveals a serious problem.

20 The index was developed by the EIF's Research & Market Analysis division. See Torfs (2020) for the most recent update of the ESAF Index.

21 As measured by a 12-month backward looking moving average, to eliminate the influence of erratic monthly fluctuations.

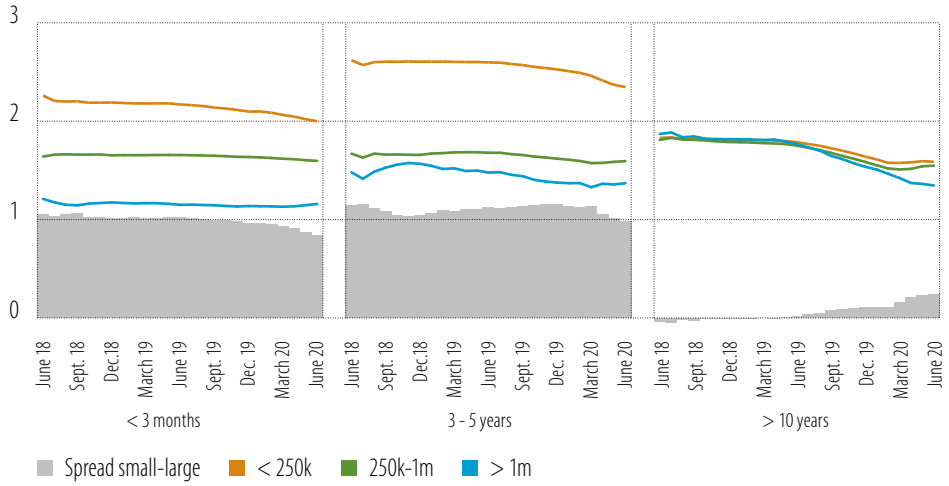
22 For which data were available.

23 This is the difference between the cost of borrowing on small loans and on large loans.

24 As shown by Huerga et al. (2012), small loans, loans of less than EUR 250 000, are a good proxy for SME loans. To better reflect lending conditions to SMEs specifically, rather than small loans in general, the data exclude interest rates on revolving loans and overdrafts, since these instruments are used independently of firm size.

Figure 21

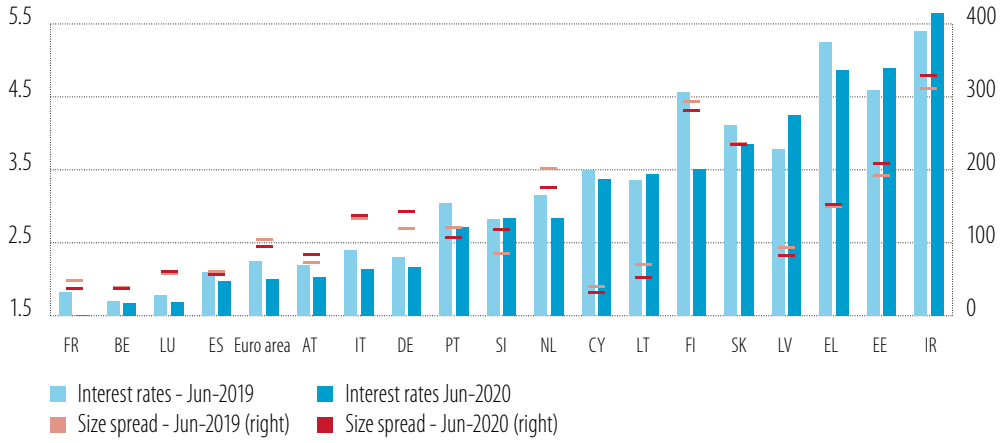
Interest rates by loan size and maturity, and size spread (%, 12-month moving average)



Source: *ESBFO (Kraemer-Eis et al., 2020), based on ECB.*

Figure 22

Interest rates on small loans and size spread in euro area countries (left axis: % and basis points; right axis: 12-month moving average)



Source: *ESBFO (Kraemer-Eis et al., 2020), based on ECB.*
Note: *Small loans are less than EUR 250 000. The spread is calculated as the difference in the bank lending rates on small and large loans (exceeding EUR 1 million). Countries or data points for which no sufficient data were available are omitted.*

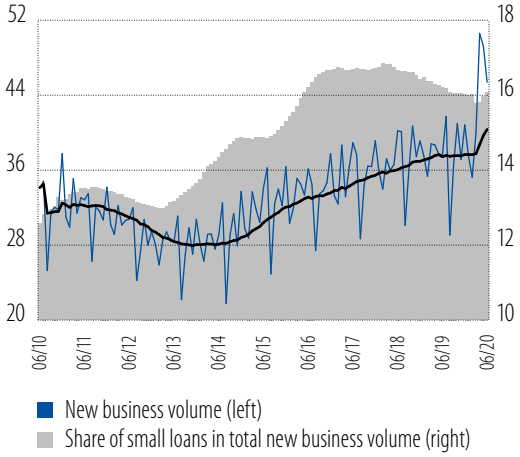
The rise in corporate borrowing is a direct consequence of the policy measures implemented to limit the fallout of the COVID-19 crisis. The financing support measures, which mostly targeted SMEs, led to a minor increase in the relative importance of small lending in the corporate debt market, as the 12-month moving average of the share of small lending to total lending increased slightly, to just over 16%, by June 2020.

Securitisation

A well-functioning securitisation market can support new loans to SMEs. SME securitisation – which includes transactions backed by SME loans, leases and other products[25] – can provide indirect access to capital markets for SMEs by transforming illiquid loans into an asset class with adequate market liquidity. When analysing these securities, it is important to look not only at bank lending, but also at leasing companies, which form part of the securitisation market. Given that bank financing has been less available for leasing companies since the crisis began, it could be expected that SME securitisation is more relevant for leasing.

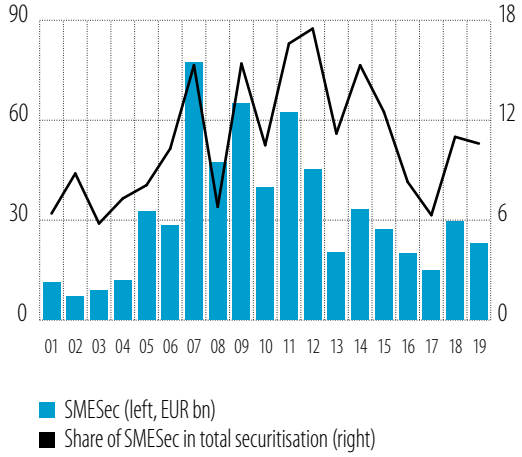
Before the coronavirus outbreak, SME securitisation issuance was still suffering from the after-effects of the financial crisis. The coronavirus crisis hasn't helped. The overall issued (and visible) volume of SME deals in 2019 was only EUR 23 billion (Figure 24). The market share of SME securitisation in overall securitisation issuance rose (with some volatility) from 6% in 2001 to 18% (of total yearly issuance) in 2012, the highest value ever registered in the European Union. This, however, was due to overall activity declining (while SME securitisation decreased slightly less). From 2014 to 2017, the share of SME issuance in overall activity slipped from 15% to 6.3%, based on shrinking SME securitisation volumes. In 2019 the share was 10.6%.[26] In the first quarter of 2020 there was no visible SME securitisation activity.

Figure 23
Small corporate bank loans in the euro area
(EUR billion)



Source: ESBFO (Kraemer-Eis et al., 2020), based on ECB data, loans to non-financial corporations (<EUR 0.25 million), new business volumes in the euro area (12-month backward moving averages).

Figure 24
Issuance activity of SME ABS in Europe
(left axis: EUR billion; right axis: %)



Source: ESBFO (Kraemer-Eis et al., 2020), based on the Association for Financial Markets in Europe (AFME).
Note: SMESec: securitisation of transactions for small and medium-sized enterprises, equivalent to SME ABS.

The base of investors in SME securitisation has not yet recovered, and a very small fraction of issuances are placed with investors. The nature of the SME securitisation market changed from a developing market (pre-crisis, with most transactions placed in the primary market) to a purely retained/ECB repo-driven market during the financial crisis (with almost no placement on the primary market). The retention rate[27] increased from a pre-crisis level of below 50% in 2007 to values of 85% to 100% since 2009. This shift led to liquidity drying up and originators accepting higher costs as the repurchase agreements envisaged considerable haircuts on the face value of the notes. For individual countries, placed issuances of SME

25 For more information on the importance of leasing for SME finance, see Kraemer-Eis and Lang (2012).

26 Driven by negative market sentiment, but also by shrinking SME stocks in financial intermediaries' loan books. Moreover, during the crisis, the large volumes of synthetic SME securitisation transactions that were evidenced on SME portfolios pre-2007 (dominated primarily by German SMEs on the back of KfW's PROMISE programme) virtually disappeared.

27 This is the share of ABS remaining on the balance sheet of the issuer.

securitisation occurred only in Italy and the United Kingdom (EUR 0.7 billion each), as well as in Germany (EUR 0.5 billion) and Spain (EUR 0.3 billion), in 2019.

Like other financial markets, the SME securitisation market is now suffering from the COVID-19 crisis. At the start of the new crisis, transaction parties focused more on amending deal documentation than on deal origination (Moody's, 2020). Therefore, new issuance stalled. It remains to be seen if the second half of the year – which is traditionally stronger than the first half – will show a recovery. The impact of the crisis on SME securitisation asset quality and deal performance remains to be seen. At the beginning of the 2008 financial crisis, there was also a fear that the SME securitisation market would suffer from defaults, but the defaults didn't materialise. The recovery of the securitisation market is essentially tied to the economic recovery, which is in turn tied to the evolution of the pandemic. Any predictions about the future are therefore highly uncertain.

Outlook for private equity and venture capital[28]

Private equity is a form of equity investment in private companies that are not listed on the stock exchange.[29] It is a medium to long-term investment, characterised by active ownership, for example by strengthening management expertise, delivering operational improvements and helping companies access new markets. Venture capital is a type of private equity focused on startups with high growth potential, supporting entrepreneurs with innovative ideas for a product or service that need investment and expert help in growing their companies.

Venture-backed startups are historically vulnerable to recessions and economic slowdowns. The dotcom crisis in the early 2000s and the global financial crisis in 2007-2008 led to significant reductions in fundraising and investment. In particular, the financial crisis led to a near collapse of the European private equity market, as fundraising and investment volumes declined by 75% from their pre-crisis levels (Figure 25). Similar events occurred on the venture capital markets.

In 2019, European venture capital and private equity markets rose to new heights after a decade-long recovery (Figure 25). Compared to 2018, private equity investment volumes rose by 12% to EUR 95 billion. Growth on the venture capital investment market was even stronger, with 2019 volumes just shy of EUR 11 billion. Fundraising also grew significantly on both markets. By the end of the year – right before the coronavirus pandemic would ravage the European economy – it appeared that the European private equity and venture capital markets had finally erased the losses inflicted by the global financial crisis, and had recovered beyond pre-crisis levels.

While it remains unclear whether the coronavirus pandemic will have an equally devastating impact on the European private equity and venture capital markets as the 2008 financial crisis, the general consensus is that investment activity has stalled. The pandemic tore through the EU economy, inflicting a series of complex supply and demand shocks, meaning that the impact on the private equity and venture capital markets is different from 2008. A complicating factor is the well-known opaqueness of the private equity and venture capital markets, resulting in the high degree of uncertainty about the initial reaction on these markets in Europe. Figure 27 and Figure 28 plot the indexed growth of private equity and venture capital investments in Europe until the first quarter of 2020, according to various leading data providers.[30] It reveals a substantial lack of consensus with regard to the short-term developments of the European private equity and venture capital ecosystem in the first half of 2020.

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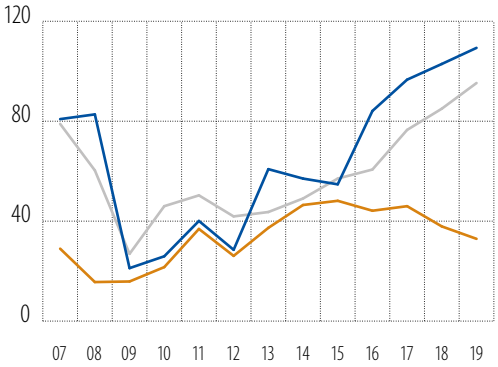
28 Large parts of this section are based on Kraemer-Eis et al. (2020a) and Kraemer-Eis et al. (2020b), a recent EIF working paper that analyses the sentiment on European private equity and venture capital markets.

29 See Invest Europe at https://www.investeurope.eu/about-private-equity/private-equity-explained/.

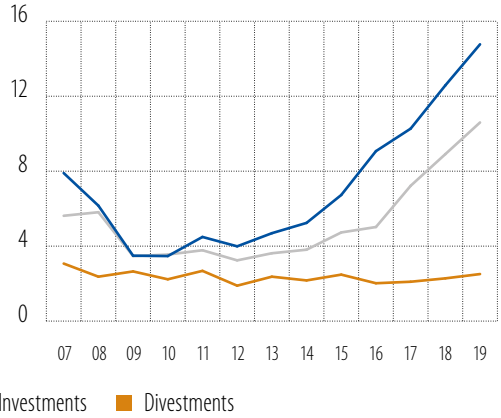
30 Invest Europe: "Quarterly Activity Indicator Q1 2007 - Q3 2015"; PitchBook: PitchBook database [Accessed: 2 July 2020]; Preqin: Preqin database [Accessed: 3 July 2020]; Dealroom and Sifted, 2020; Unquote (and Aberdeen Standard Investments): "Private Equity Barometer", Q1 2020 edition; CB Insights (and PwC): "MoneyTree Report Q1 2020".

Figure 25
Fundraising, investment and divestment amounts by private equity firms in Europe (EUR billion)



Source: Kraemer-Eis et al. (2020b), based on data from Invest Europe.

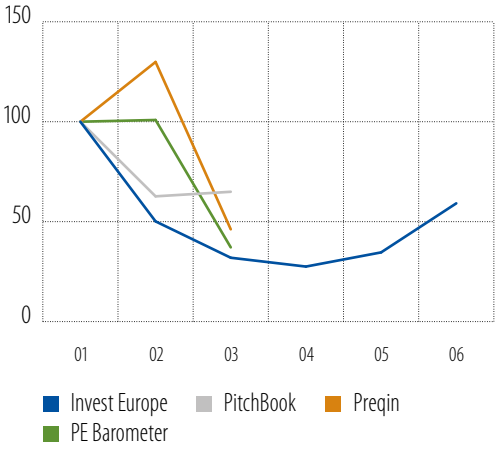
Figure 26
Fundraising, investment and divestment amounts by venture capital firms in Europe (EUR billion)



Source: Kraemer-Eis et al. (2020b), based on data from Invest Europe.

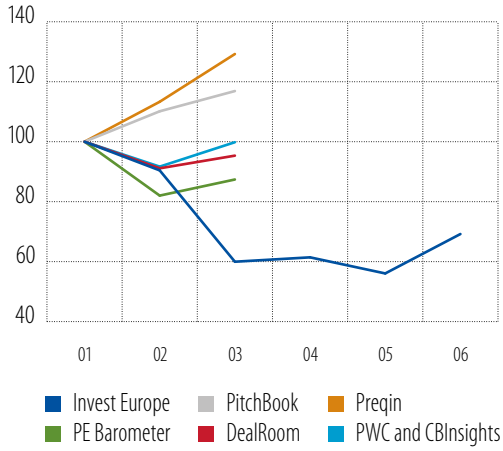
Analysts point to the increased availability of capital that has been raised but not used as a factor that could potentially shield the private equity and venture capital industry from the worst of the COVID-19 crisis. In Europe, unallocated capital (dry powder) almost doubled in 2019 compared with 2007. However, the share of dry powder in total assets under management actually decreased. One reason for this could be the quicker deployment of private equity and venture capital funds. Anecdotal evidence suggests that deployment dropped to three to four years vs. five years in the past.

Figure 27
Outlook for private equity investments in Europe



Source: Kraemer-Eis et al. (2020b), based on data from Invest Europe, PitchBook, Preqin, Dealroom, Unquote, CB Insights.
Note: 2019:Q4=100. The plain line "Invest Europe" refers to the episode of the great financial crisis.

Figure 28
Outlook for venture capital investments in Europe



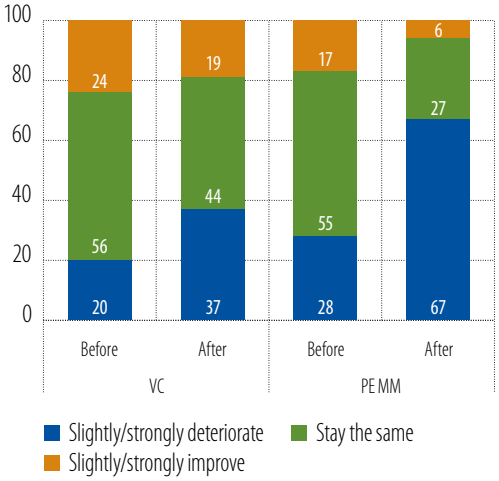
Source: Kraemer-Eis et al. (2020b), based on data from Invest Europe, PitchBook, Preqin, Dealroom, Unquote, CB Insights.
Note: 2019:Q4=100. The plain line "Invest Europe" refers to the episode of the great financial crisis.

The recent wave of the EIF's signature business angel, venture capital and private equity survey can be used to gauge how the pandemic changed the sentiment of European fund managers. The survey was launched just prior to the COVID-19 outbreak in Europe. To measure the initial impact of the crisis

on European private equity and venture capital activities, we analyse discrepancies in responses received before and after a certain cut-off date, which we set at 1 March 2020. All surveys were closed mid-March.[31]

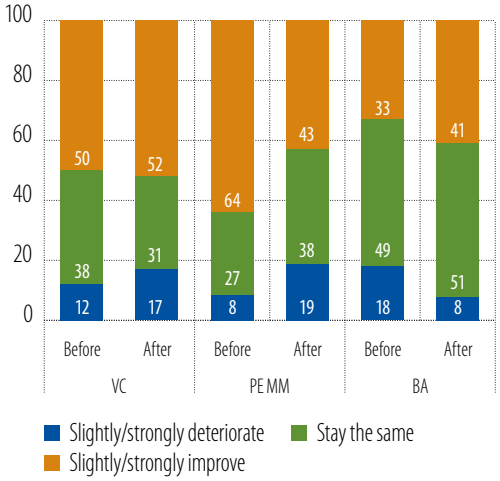
The pandemic caused a significant deterioration in fund managers' optimism regarding fundraising (Figure 29). Following the onset of the pandemic, almost four in ten venture capital fund managers expected the fundraising environment to deteriorate, more than twice the number before the pandemic hit. Private equity middle market fund managers became even more pessimistic, as nearly seven in ten of them predict fundraising will become more challenging in the year to come.[32]

Figure 29
Fundraising environment, next 12 months
(Percentage of respondents)



Source: *Kraemer-Eis et al. (2020b).*
Question: *Over the next 12 months, how do you expect the fundraising environment to develop?*

Figure 30
New investments, next 12 months
(Percentage of respondents)



Source: *Kraemer-Eis et al. (2020b).*
Question: *To venture capital/private equity managers: How do you expect the number of your new venture capital/private equity mid-market investments to develop over the next 12 months? Question to Business angels: How do you expect the number of your new investments to develop over the next 12 months?*

The COVID-19 crisis does not seem to influence the outlook of future investment opportunities to the same extent as the global financial crisis (Figure 30). All three investor groups expect a net increase[33] in new investments in the year to come. The sentiment could reflect investors' expectation that firms battered by the pandemic will need to raise more funding, or alternatively that declining valuations could create new opportunities.

A strong policy response in support of the private equity and venture capital markets is imperative to maintaining long-term growth (Samila and Sorenson, 2011). A strong response is also a desirable strategy given the significant public policy efforts to build a thriving risk-capital ecosystem for SME financing in Europe over the past decade (as well as in the context of creating a Capital Markets Union). For this reason, the EIF – as a leading provider of SME finance in the European Union and the largest

31 Please note that, in our terminology in this chapter, "after 1 March" means after and including 1 March. The cut-off date was chosen to ensure that the number of responses in both categories (such as received before and after that date) is sufficiently high to avoid random differences in market sentiment between the two respondent groups. Moreover, we identified several changes in the political reaction to the crisis that support our choice of this particular date. See Kraemer-Eis et al. (2020b) for details.

32 Leaving aside differences in the underlying business lines, another plausible explanation for the particularly acute difference between the before/after 1 March results for private equity middle market fund managers could be that the EIF Private Equity Mid-Market Survey ran for a longer period (compared to the other two surveys) in the course of March, and therefore it might have captured the aftermath of the crisis to a greater extent.

33 Net increase means the share of respondents expecting an increase minus the share of respondents expecting a decrease.

public investor in the venture capital ecosystem in Europe – is considerably stepping up its efforts, both in the equity and debt markets.[34] The EIF's efforts are in conjunction with the EIB Group's response to the pandemic and in close cooperation with the European Commission.

Policy support can contain the damage to investment

Lower net revenues resulting from the lockdown and reduced activity will be passed on to corporate balance sheets. In a simplified balance sheet approach, net revenues are retained and converted to capital to finance cash and liquid assets, real investment and debt reduction. A loss in net revenues will therefore result in a reduced cash balance, increased indebtedness and/or lower investment. In this section, we show how the deployment of policy support must rely on a proper sequencing of initiatives over time.

Less ability to self-finance, and a trade-off between debt and investment

History suggests that following downturns, firms' cash buffers absorb a part of the reduction in net revenues. This is likely to happen in the European Union, especially as EU firms entered the crisis with sizeable cash positions (Figure 12). During the lockdown period, these positions decreased, but post-crisis, firms will likely not fully restore their cash positions. We estimate that over the global financial crisis and sovereign debt crisis, cash positions were reduced by 2% of GDP. According to current forecasts, during the coronavirus crisis output will be reduced by up to twice as much as during the financial and sovereign debt crises. Moreover, given the current very low interest rate environment, returns on cash and liquid assets are almost nil. Following the coronavirus crisis, cash positions will therefore likely be drawn down more than during the Lehman Brothers crisis. The loss in net revenues is likely to be about 3% of GDP.

According to the EIBIS, internal resources are used to finance 60% of investment (EIB, 2019). This ratio is an average across firms. However, half of firms do not tap external finance. When firms do use external finance, their funding mix consists of 60% external finance and 40% internal finance (median values). These two extreme cases are considered below.

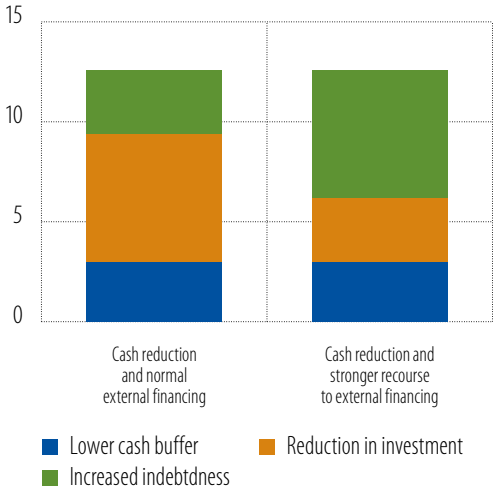
In the "as usual" case, firms do not alter their financing pattern and continue financing two-thirds of their investment internally. In this case, in the less adverse scenario presented in Figure 14, after drawing on cash positions, two-thirds of the remaining decline in net revenue would be absorbed by lower investment (a reduction of 6.4% of GDP). EU corporate investment would shrink by 48.5%. Debt would also help to fill the gap, and rise by 3.2% of GDP (Figure 31, left-hand bar).

Alternatively, if corporations were to increase their use of external finance, the decline in investment would be more contained. We use the EIBIS to calibrate this change and assume that the whole sample of firms uses external finance, even those that do not do so in a normal period. In this example, corporations that normally finance investment only through internal resources (around 50% of firms according to the EIBIS) use external finance. The share of external finance to investment would then rise from one-third to two-thirds. Following the decline in net revenues, investment would be reduced, but by only 3.2% of GDP (a fall of 24.3% compared with 2019 levels of investment). The cost, however, would be a higher level of indebtedness – to 6.4% of GDP (Figure 31, right-hand bar).

Estimates suggest that the pandemic's impact on investment could be well above that of the global financial crisis. During the global financial crisis, corporate investment fell by 19% (Figure 32). The larger decline in corporate investment following the coronavirus crisis is in line with forecasts that depict a much higher impact on GDP and European Commission findings of a cumulative drop in private investment of EUR 831 billion in 2020 and 2021 taken together (European Commission, 2020).

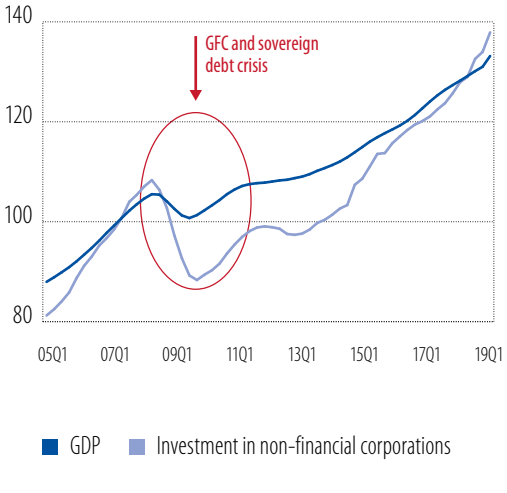
34 The EIF's debt products fall outside the scope of this working paper. For a brief overview, see Brault and Signore (2020).

Figure 31
Filling the gap: impact on investment and indebtedness (% of GDP, EU economy)



Source: *Eurostat, ORBIS and EIB Economics Department calculations.*
Note: *Results under the benign scenario: heightened policy support and three-month normalisation period. See Maurin and Pal (2020).*

Figure 32
Historical perspective on GDP and non-financial corporate investment (index, 100=2007)



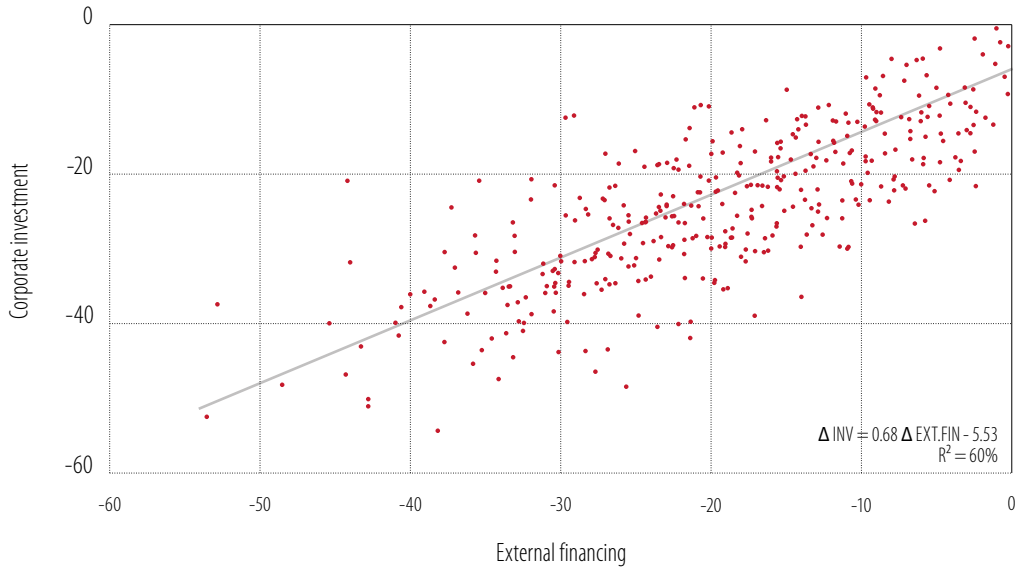
Source: *Eurostat and EIB Economics Department computations.*
Note: *Nominal values, fourth-quarter moving average to seasonally adjust the data. Last record Q4 2019..*

Model-based analysis using historical data confirms the link between the decline in net revenues and investment.[35] We estimate a Vector Autogressive model – a VAR – and calibrate a demand shock that triggers a 27% downwards deviation in gross operating surplus. That compares to the unconditional projection obtained from the model and the deviation corresponds to a net revenue loss over total assets of 5.4%. The comparison between the conditional and unconditional projections leads to several conclusions. Firstly, the shock is largely unprecedented, for all the variables in the model and even compared to the global financial crisis. Secondly, the shock triggers a maximum decline of 10% in real GDP. This result is similar to projections of major institutions, such as the ECB, European Commission, International Monetary Fund (IMF) and the OECD in the summer of 2020. Thirdly, in 2020, the median corporate investment gap, calculated as the difference between the conditional and unconditional projections, is around 25%.

Model-based simulations strongly support the existence of the debt-investment trade-off. The model estimated with Bayesian techniques helps to make a number of projections. We randomly select 400 conditional projections for which we plot the projected decline within the year after the shock to corporate investment and external financing. The results, presented in Figure 34, clearly show the existence of a strong relationship between the two. A strong decline in external financing is accompanied by a strong decline in corporate investment. The correlation between external financing and corporate investment is 60%. The estimated model therefore confirms the trade-off between leverage and corporate investment illustrated by the two extreme cases considered in the scenarios.

35 We estimate a value-at-risk model comprising time series for real GDP, real corporate investment, three-month Euribor, gross operating surplus and external financing for the EU economy since 1999. Based on the model estimated with Bayesian techniques, we identify a demand shock with sign restrictions. See Maurin and Pal (2020) for more details.

Figure 33
The trade-off: larger investment decline or higher leverage?



Source: *Authors' estimates based on ECB and Eurostat.*
Note: *Decline in external financing (x-axis) and in corporate investment (y-axis) associated with scenarios generating a median gross operating surplus 25% below its unconditional projection in 2020. The dots represent the minimum values reached within one year after the shock.*

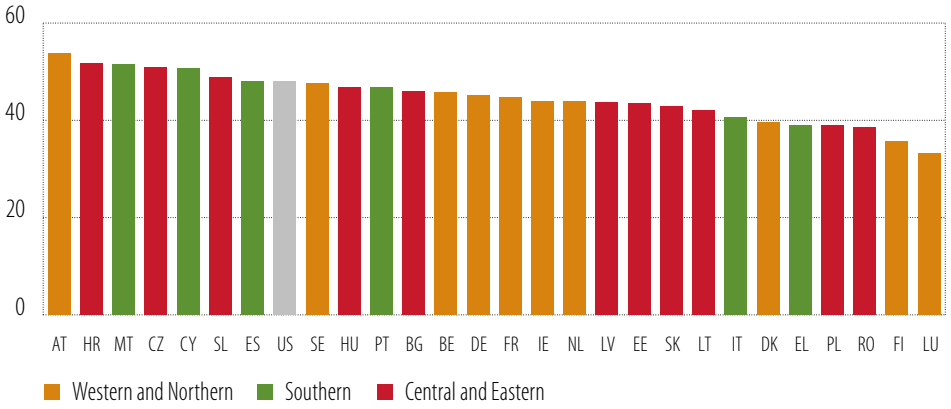
Survey-based evidence confirms that investment will be affected. Across the European Union, around 45% of European firms expect to maintain their investment plans, but a similar proportion, 45%, expect to cut or delay their investment plans. Figure 34 shows how firms plan to adjust their capital expenditure following the COVID-19 crisis.[36] The share of firms expecting to cut or delay investment plans is staggering, ranging from a low of 33% in Luxembourg to a high of 54% in Austria. A marginal share of firms expect to expand investment plans, possibly reflecting the digitalisation needs felt during the crisis or the need to increase the resilience of production chains.

The COVID-19 crisis is likely to exacerbate finance constraints and therefore the investment gap. Figure 35 depicts the proportion of firms reporting investment gaps for four categories of firms. The four categories separate firms by whether the COVID-19 will have/is having an impact on their activity in the short term and/or in the longer term. Each category separates firms into those that are finance-constrained and those that are not. In both cases, the proportion of firms reporting an investment gap tends to be higher when they are finance-constrained. The proportion is always higher for firms reporting that COVID-19 has a short-term impact, regardless of their region. Moreover, the difference in proportion is especially pronounced in Southern Europe and for those reporting a long-term impact.

36 The question is one of the specific questions raised this year to gauge the impact of the COVID-19 crisis.

Figure 34

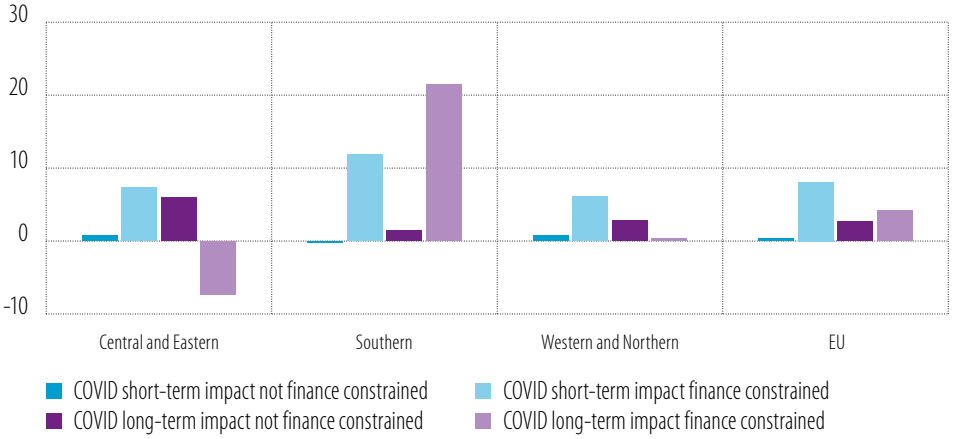
Corporates planning to cut investment as a consequence of the COVID-19 crisis (% of respondents)



Source: *EIBIS 2020.*
Note: *Orange represents countries in Northern and Western Europe, green is for Southern Europe, and red represents Central and Eastern Europe. The United States has a grey bar.*

Figure 35

Investment gap, finance constraints and COVID-19 impact



Source: *EIBIS 2020.*

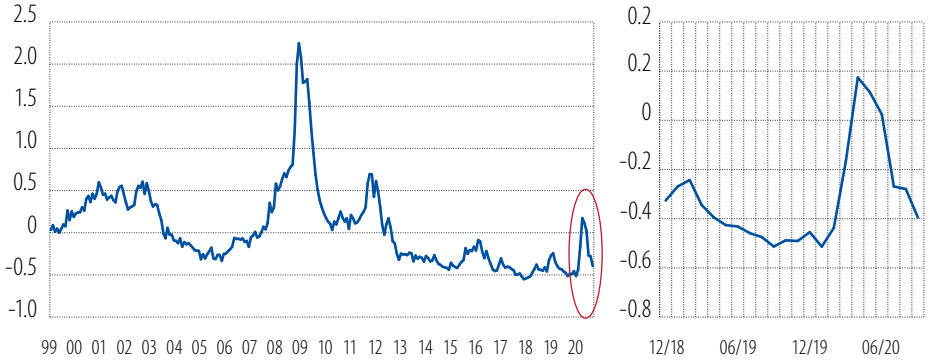
Longer-term uncertainty will likely have an impact

The policy measures have succeeded in restoring confidence and avoiding a protracted tightening in financial conditions. Figure 36 shows a financial condition indicator for the EU economy, a synthetic measure of the conditions for access to external finance based on more than 40 time series. Fuelled by high uncertainty, loss in confidence and a rise in risk aversion, the indicator rose sharply at the beginning of the crisis. The increase was short-lived, however, as various policy measures were announced and implemented quickly. These measures were forceful and credible enough to bring financial conditions back to their pre-crisis level. In Europe, the reappearance of cross-border market tensions has been avoided, but it is important to guard against pessimistic expectations that could become self-fulfilling (Pellegrino et al., 2020).

While acute financial constraints did not materialise, looming challenges will hamper the recovery in investment. The share of distressed firms at risk of default has started to increase (Figure 37). The rise is

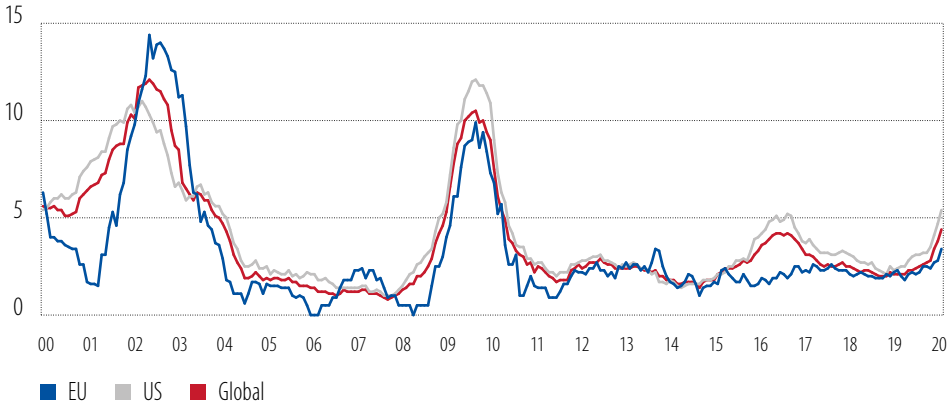
likely to continue and banks are expected to react to circumvent the rise in non-performing loans (IMF, 2020). In the June 2020 Bank Lending Survey, banks expect credit standards for enterprises to tighten considerably as credit risks rise.

Figure 36
Financial condition indicator (index, de-meaned)



Source: *ECB, Eurostat and EIB calculations.*
Note: *See Anderson et al. (2020). A rise indicates a tightening. Last record: September 2020.*

Figure 37
Trailing 12-month speculative default rate (%)



Source: *Standard and Poors and EIB calculations.*
Note: *The global trailing 12-month speculative grade.*

This uncertain environment affects investment planning (Leduc et Liu, 2020). In the EIBIS 2020, some 80% of EU firms consider uncertainty to be an impediment. Some 50% of firms even consider it to be a major impediment. The levels represent a substantial increase compared to previous years. As scientists discover more about the COVID-19 virus, policymakers are changing their response. Entrepreneurs are having difficulty anticipating what will happen. The possible succession of infection waves until a vaccine is widely distributed may lead firms to freeze their investment plans.

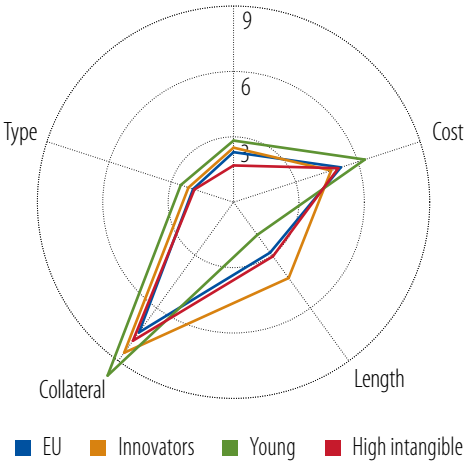
Investment spending in some types of asset could decline even further

Bank finance conditions remain more problematic for some types of firms. Figure 38 depicts the satisfaction of firms with the terms of their loan offer, distinguishing between young firms, those investing in R&D and those investing in intangibles. Compared to the average EU firm, those investing in intangibles

are relatively more dissatisfied across the entire loan offer. Innovative firms are the most dissatisfied with the maturity of their loan. Young firms tend to be the most dissatisfied with the amount, cost and collateral requirement associated with their loan. In 2020, the proportion of young firms that are finance-constrained is more than 2 percentage points above the average across the entire universe of EU firms.

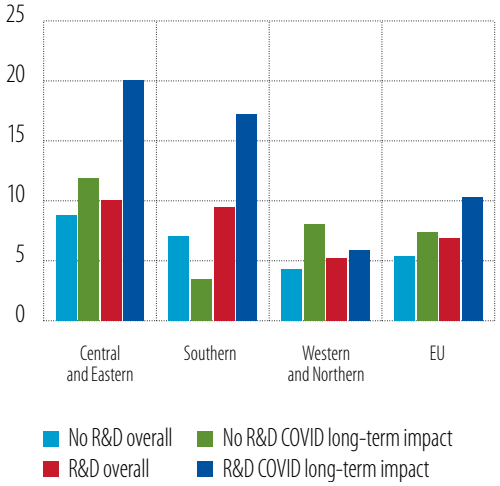
Quantity rationing, the provision of insufficient credit, is the main factor hindering borrowers' propensity to invest in knowledge assets (such as R&D, training or software) , while high costs and collateral requirements limit their ability to invest in intangibles. Segol et al. (2020) use European firm-level data from the EIBIS to document the impact of bank loan terms on investment in the intangible assets of non-financial firms. The authors show that when firms receive a loan that is smaller than requested, they tend not to invest in intangibles. When firms are satisfied with their loan size, unfavourable rates, maturity and/or collateral requirements have no significant effect on the likelihood that firms will invest in intangibles. However, the terms of the loan can negatively affect their willingness to invest in multiple intangibles simultaneously. Inadequate loan terms (in addition to size) undermine firms' ability to benefit from the complementary nature of these assets (for example, R&D and training), which have been shown to be critical for productivity.

Figure 38
Source of firms' dissatisfaction with a bank loan



Source: EIBIS 2020 and EIB calculations.

Figure 39
Impact of finance constraints and COVID-19 on R&D investment



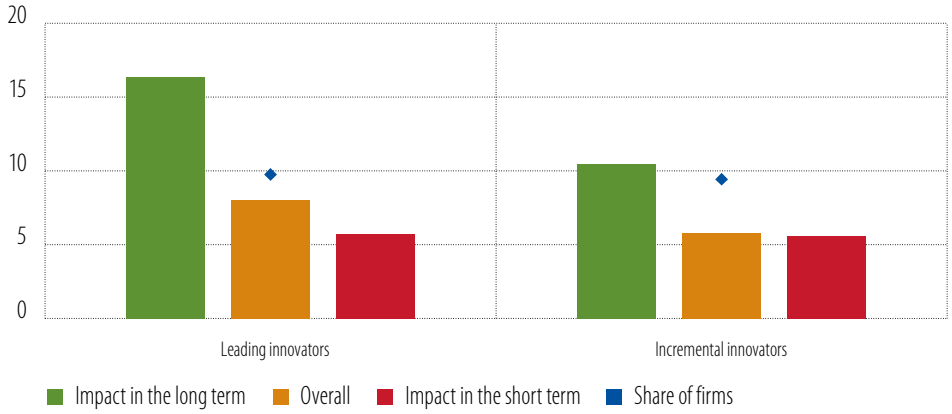
Source: EIBIS 2020 and EIB calculations.

R&D spending is beneficial to long-term growth. For its part, the financial environment can impact economic growth, or at least the types of assets financed (Levine, 2015). Outside of the COVID-19 crisis, the lack of financing for innovative firms is worrying because it could weaken long-term growth in the European Union. Levine (2015) and Thum-Thysen et al. (2017) show that R&D investments, which are key to competitiveness, raise economic growth. Generally, survey results show that firms investing in R&D and those that do not experience the financial environment differently. Finance is less available for R&D-investing firms, despite their higher profitability.

In the long term, COVID-19 will likely exacerbate the financial constraints faced by firms investing in R&D. Firms that invest in R&D face stronger financial constraints than those that do not (Figure 39). A higher share of firms investing in R&D investment are facing constraints, whether or not the crisis is expected to affect their business. Moreover, firms that report a long-term impact from COVID-19 tend to be more finance-constrained. Finally, the difference for firms with R&D investment holds across the European Union and in the three regions.

Innovators will need more support after the COVID-19 crisis. Figure 40 shows the proportion of leading and incremental innovators that report being finance-constrained. For each population, Figure 40 reports the share for the overall population as well as the share of sub-populations that expect the crisis to have a short-term or long-term impact on their investments. Firms that anticipate a long-term impact from the crisis tend to be more finance-constrained.

Figure 40
Innovators and finance constraints post-COVID-19



Source: EIBIS 16-20 and EIB calculations

Which policy measures should be taken to direct savings into real productive investments?

At the onset of the COVID-19 crisis, policy initiatives were quickly deployed to address firms' most urgent liquidity needs. These policies were initiated by governments, various national promotional banks and international financial institutions, including the EIB Group (the European Investment Bank and its subsidiary, the European Investment Fund). These initiatives included moratoriums, tax deferrals, guarantees, and adjustment to supervisory rules.

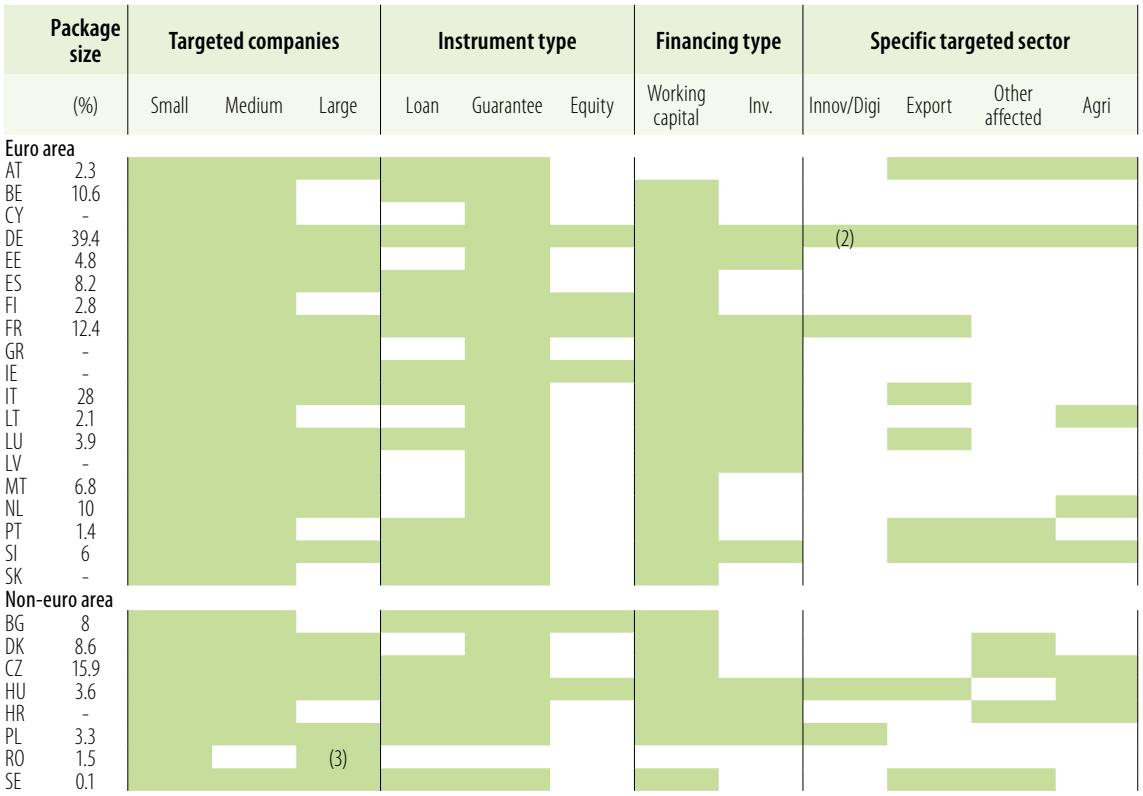
Large guarantee envelopes were created, with relatively low takeup until the end of the summer (Falagiarda et al., 2020). The amount of guarantees budgeted varies across the EU economy (Figure 41). Among the four larger EU economies, the support envelope varies from EUR 183 billion in Spain to EUR 756 billion in Germany. The huge differences in the amount of the guarantee package raised fears that firms in some countries would have an unfair advantage, which would erode the integrity of the single market. However, until the middle of the summer, headline numbers did not reflect actual commitments to individual companies. The take-up rate in Germany was much lower than in Spain and France. Guarantees covered around 50% of loan origination in Spain and France, 15% in Italy and 11% in Germany according to estimates from March to May 2020 (Anderson et al., 2020).

More exposed to liquidity risks, SMEs have been cushioned by credit guarantees. Credit guarantees are extensively used by financial institutions to alleviate the financial constraints of SMEs. National and regional guarantee institutions provide the main support for SME credit, but multinational providers such as the EIB Group can also play an important role.

The volume of guaranteed loans rose sharply at the beginning of the crisis. The share of guaranteed lending in newly issued small loans peaked at 44% in April, double the share at the beginning of the year (Figure 42). The rise was far above the level recorded for larger loans, suggesting that the guarantee measures were more beneficial to small businesses. While the category of guaranteed loans also included

collateralised lending, it is likely that the rise in guaranteed loans was driven by the surge in government guarantee programmes that aimed to address the urgent liquidity needs of European firms during the lockdown.

Figure 41
State support packages to the corporate sector



[1] *ECB estimates for EA countries. For non-EA countries IHS Markit.*
[2] *Start up programme by KfW and some at federal state level.*
[3] *Scheme announced on June 1 as part of the economic recovery measures, further details tbd.*
Source: *EIB calculations.*
Note: *Information collected on a best effort basis up to June 2020. ECB estimates for euro area countries. For non-euro area countries, IHS Markit.*

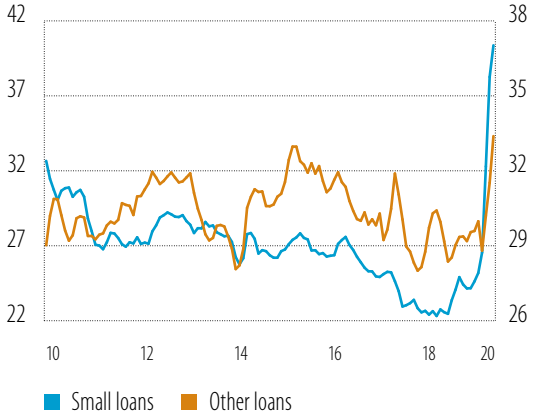
The decline in the proportion of small guaranteed loans with a maturity above ten years indicates that SME demand focused on the short term. The rise in short and medium-term SME lending support came at the expense of long-term lending support, as the share of guaranteed or collateralised lending with a maturity of over ten years plummeted from 83% to 52% (Figure 43). This could indicate that guarantee instruments were to some extent diverted away from supporting long-term investment at the onset of the crisis. Alternatively, companies may have used assets that would have normally served as collateral for long-term investment to secure much-needed liquidity. The guaranteed share in long-term SME lending started to increase again in June, but by August – the latest record available – it still remained below the long-term average. In terms of volumes, the amount of long-term lending is very small compared to medium-term lending. Short-term lending, however, continues to dominate, making up the bulk of SME lending (more than two-thirds during the first half of 2020).

Looking forward, abundant liquidity but a low-risk appetite in general calls for the use of other financial instruments. With reduced earnings and increased debt, the investment vs. debt trade-off will become more acute as economies come out of the COVID-19 crisis, and risk-absorbing instruments will become more supportive (Boot et al., 2020). Household savings increased during the crisis. The

policy support successfully froze the economy but the lockdown prevented households from following a normal consumption pattern and savings went up. The rise partly reflected precautionary savings in the context of weakened confidence, but it resulted in more in cash accumulation. An increase in bank deposits mostly reflects savings resulting from the inability of consumers to spend. These resources could be mobilised to finance investment (Asimakooulos et al., 2020).

Figure 42

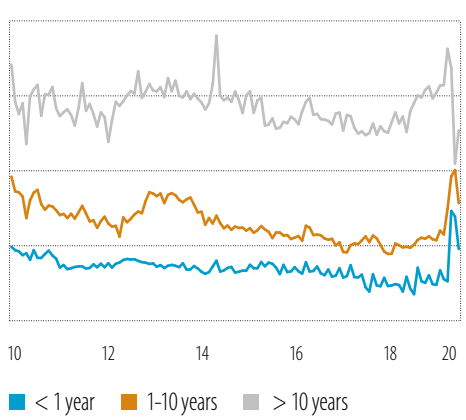
Share of guaranteed or collateralised corporate lending (%, three-month moving average)



Source: *ESBFO (Kraemer-Eis et al., 2020), based on ECB.*
Note: *New business volumes to euro area non-financial corporations. Last record: August 2020.*

Figure 43

Share of guaranteed or collateralised corporate small loans (%)



Source: *ESBFO (Kraemer-Eis et al., 2020), based on ECB.*
Note: *Small loans are less than EUR 0.25 million.*

The European financial system is ill-suited to financing productive investment. Each year, Europeans export one-fifth of their savings – around 3% to 4% of GDP – via current account surpluses. These savings will be needed to finance investments after the pandemic. In the EIBIS 2020, 40% of firms believe that in the long term, the pandemic will make it necessary to adapt their product/services portfolio, 40% think that it will affect their supply chain and more than 50% say that more digitalisation will be necessary. However, the European financial system is not properly integrated and does not support an adequate circulation of savings across the continent (Figure 44).[37]

European companies remain very reluctant to issue equities. Figure 45 reports the percentage of firms that would like equity finance to play a larger role in their funding. In the European Union, less than one firm in 50 wants equity to play a larger role. While this lack of interest is shared across the three regions, it is even more pronounced in Southern Europe. Several reasons exist for this, including the high cost of equity, a tax bias in favour of debt, the fear of dilution and losing control and a lack of financial literacy.[38]

Start-ups are uncertain about how the crisis will affect their equity financing plans. Some start-ups may revisit their funding strategies and turn to venture debt to fuel their expansion. Venture debt lending is a form of start-up financing for early and growth-stage venture capital-backed companies that lies at the intersection of venture capital and traditional debt[39] (de Rassenfosse and Fisher, 2016). Venture debt is best suited to companies that have already received equity-backed funding and have recently achieved profitability. It is used to finance growth, for example product development or the

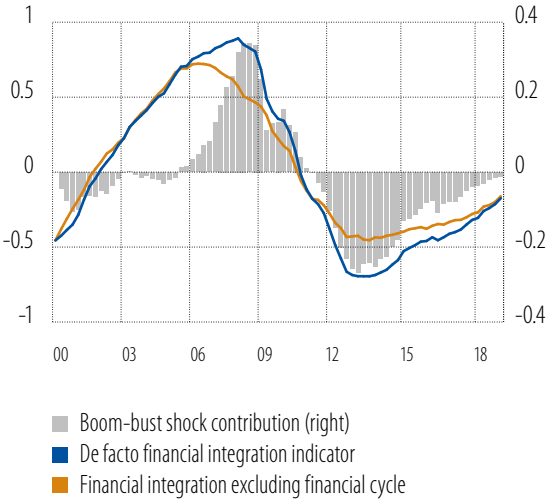
37 The index is built using a Bayesian Factor Vector Autoregressive model. See Lake and Maurin (2021, forthcoming) and EIB Investment Report (2017). The index is dimensionless and with a mean of 0. An increase reflects higher integration. In Figure 44, the light blue line plots the posterior median of the baseline financial integration indicator. The grey bars portray the posterior median contribution of the boom-bust shocks to the financial integration indicator. The dotted dark blue line plots the difference between the two.

38 For more details, see Chapter 6 in EIB (2018).

39 Looking at venture debt providers shows there is no clear consensus on the definition of venture debt; generally, it refers to a variety of debt financing products and usually serves as a complementary method to equity venture financing.

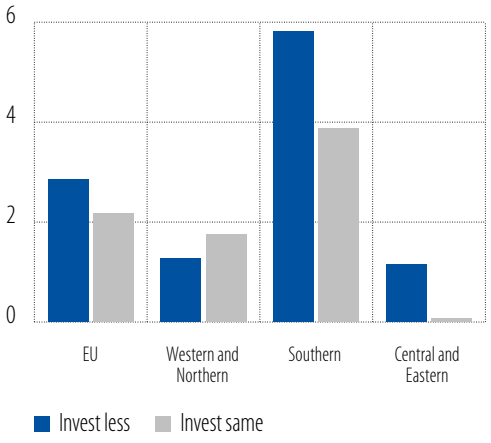
roll-out of new sites. Venture debt can provide additional funding between venture capital rounds and in conjunction with equity financing; it allows companies to reach each valuation round at a higher value. It can increase the runway of companies and therefore serve as a short-term cushion in case of unexpected events to enable them to reach the next valuation round.

Figure 44
Financial integration indicator



Source: *Based on Lake and Maurin (2021, forthcoming).*
See also: *EIB Investment Report (2017).*
Note: *See footnote 37.*

Figure 45
New equities as a preferred source of finance by corporates (% of respondents)



Source: *EIBIS 2019 and 2020.*
Note: *Based on question Q36: which type of finance would you like to play a larger role? New issued equity.*

Venture debt decreases dilution and loss of control over a startup through, for example, the granting of voting rights. It is a non-dilutive financing option and cheaper than equity when the path to growth is clear and predictable. On the downside, if a company fails to generate enough profits, the fixed-cost nature of debt can prove burdensome.[40] Therefore, debt service in unstable economic environments might lead to debt defaults and subsequently dilution through debt conversion into equity.

Venture debt is much more developed in the United States, but there is a growing interest in Europe. For instance, around 84% of all venture debt deals in the last decade took place in the United States and Canada, whereas only 6% were in Europe. The reasons for this might be a less developed, more risk averse start-up ecosystem, mostly relying on traditional bank financing. The majority of European venture debt transactions are concentrated around the United Kingdom, France and Germany (Deloitte, 2019). The main providers of venture debt in Europe are funds, banks[41] and international financial institutions such as the EIB. The EIB is Europe's largest provider of venture debt, with EUR 600 million per year in long-term financing for highly innovative companies.

40 Because startups usually cannot provide much collateral, lenders may expect higher interest rates of up to 15% as well as warrants on common equity.

41 Boost & Co., Bootstrap Europe, Harbert European Growth Capital and Kreos Capital are the main issuing funds and Barclays, Goldman Sachs and Silicon Valley Bank are the main issuing banks.

Conclusion and policy implications

Firms entered the COVID-19 crisis on a stronger footing. However, the scale of the economic upheaval caused by the pandemic has not been seen in peacetime since the Great Depression. Its magnitude pushes the boundary of standard textbook analysis of policy intervention during conventional recessions. It is clear that the end of the crisis relies on the widespread distribution of a vaccine, meaning that unlike economic recessions, economic policies will not be sufficient to trigger a rebound.

Public interventions have been key to maintaining the economic system during lockdowns and will be equally crucial in providing the conditions for a strong and swift recovery. In addition to the short-term effects of the crisis, investment capacity will be damaged, as internal financing resources shrink and indebtedness rises. This lower capacity is at odds with the need for more investment to reallocate resources across sectors, strengthen firms' digital capacities and shore up the resilience of the corporate ecosystem.

The policy response to the crisis has been strong and preventive enough to maintain the flow of credit to the economy, but it is unlikely to be sufficient to address future challenges. The deployment of policy support must rely on a proper sequencing of initiatives over time. At the onset of the crisis, the key priority was to immediately provide liquidity to firms. When economies reopened after the lockdown, the support ensured the credit channel functioned properly, providing funding and guarantee products for banks. This strategic sequencing is even more necessary now, as the second infection wave shows that a return to normal will not happen quickly.

The crisis will force some firms to decide whether they are willing to take on more debt to fund much-needed investments. Faced with a trade-off between debt and investment, firms need access to more equity-type financial products. Financial instruments that focus on equity tend to absorb losses and support risk-taking activities, and they need to be promoted. Work ongoing under the umbrella of the Capital Markets Union 2.0 for the European Union will provide an opportunity to redirect efforts to equity-type investments. The need for more developed capital markets will be even more pressing as the European Union comes out of the COVID-19 crisis.

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The EU invests 1.3% of GDP in climate change mitigation, vs. **0.8%** in the **United States** and **2.7%** in **China**

51%

of **EU firms** expect **to use more digital technologies** because of **COVID-19**

70%

of **EU municipalities** say **their climate change mitigation and adaptation investments** in the last three years **have been inadequate**

45% of **EU firms** have invested in **tackling the risks of climate change and the green transition**, vs. **32%** in the **United States**

76%

more **green and digital patents are produced** in the European Union than in the United States

EU regions exposed to **the twin risks** of the digital and green transition**:**

55% in Central and Eastern Europe

23% in Southern Europe

15% in Western and Northern Europe

PART II

Investing in the transition to a green and smart economy

Chapter 4

Tackling climate change: Investment trends and policy challenges

Despite the growing rates of investment in climate change in Europe, a greater share of Gross Domestic Product (GDP) must be spent to achieve carbon neutrality and make the European Union's infrastructure climate-resilient. Investment in climate change mitigation grew 2.7% in 2019, with increases in all areas except energy efficiency. Renewable energy investment increased 7.8% as a result of project commitments made in previous years, but this rise also masked a slowdown in new commitments. Estimates for investment in energy efficiency indicate flat investment over the last five years with a decline in 2019 offsetting increases in preceding years. The European Union's investment in adaptation remains very low compared to mitigation, despite growing from 2015 to 2019.

The pandemic will start to stifle investment soon, unless governments put green-growth stimulus packages in place. Experience of past economic slowdowns indicates that large projects like utilities already in the pipeline tend to be relatively unaffected in the short term. Energy efficiency and renewable energy installations in the construction sector will be hit much harder, however, as material deliveries are delayed, adjustments are made to protect employee health and safety, costs rise and quarantines and travel bans are put in place. In the first half of 2020, investment commitments in clean energy projects, a real-time indicator of the project pipeline, were down by 50% compared with the same period in 2019. This decline is expected to be reflected in the investments that will be made in the coming year.

For Europe to harness the full potential of decarbonised energy systems, investment is needed in more expensive and less mature clean energy technologies, such as hydrogen and carbon capture and storage. This investment suggests that the marginal abatement cost of greenhouse gas emissions will increase in the future. In parallel, given that fighting climate change requires a global collective effort, Europe should use its development and financing arms to boost the green transition in partner countries where great climate opportunities exist.

Staying on track with the Paris Agreement requires a coordinated effort from the European Union. The European Union's new ambitious target for emission reductions by 2030 means it will have to step up climate investments. The National Energy and Climate Plans, part of the Governance of the Energy Union and Climate Action, provide the strategic framework for Member States to align their policies with the European Union. Private and public-sector efforts must be calibrated more closely. Municipalities can contribute to the climate transition by shaping and implementing policy measures locally. At the same time, municipalities are also strengthening the public's awareness and ownership of the climate transition.

Introduction

The opening of this chapter aims to shed more light on clean energy investment flows and the corresponding investment trends in mitigation. Building on the EU taxonomy for sustainable finance, it quantifies investment in climate change, covering the United States, China, the European Union and its Member States. The analysis adopts a common methodology to facilitate the comparison across regions, countries and sectors by dividing investment activities into three categories: those that are already low-carbon, transition activities and those that facilitate low-carbon performance.

The chapter then turns to investment in climate adaptation. At the microeconomic level, these investments are widespread, influencing decisions regarding design and location in the public and private sectors. Estimates on climate adaptation investment are, however, not available at the macroeconomic level. Still, two important flows are tracked, namely public investments in Europe under EU programmes and flows of development finance from Organisation for Economic Co-operation and Development (OECD) to non-OECD countries for climate adaptation.

Finally, the chapter discusses investment challenges and opportunities for the European Union as it aligns itself and stays on track with the Paris Agreement, along with the role played by the private and public sectors in the transition towards a carbon-neutral economy. This discussion requires a clear understanding of the European Union, as well as the different national and local priorities. The data collected from the National Energy and Climate Plans, which outline individual countries' climate and energy goals, are analysed. The role of municipalities, which are the third layer in the policy dimension, is also discussed.

European energy and climate policy framework

Climate policy in the European Union has been undergoing a fundamental transformation since 2000. Europe has implemented a unique climate policy framework, with ambitious greenhouse gas emission targets set for 2020, 2030 and 2050. Its ultimate goal is to become the first climate-neutral continent in the world, and the current decade (2020-2030) is crucial to tackling climate change and ensuring that a heavier burden is not left behind for future generations. This involves many challenges, including the energy transformation of all economic sectors, massive investments for upgrading the European Union's capital stock, as well as the introduction and revision of governance structures and supporting instruments. How governments address these interlinked challenges will have a profound impact on EU members' efforts to reduce greenhouse gases, while also playing a unique role in strengthening the European Union's position as a global climate leader.

The Paris Agreement frames the European Union's current policy response to the climate crisis. The agreement sets an overall goal of mitigating climate risks and limiting global warming to "well below" 2°C vs. pre-industrial levels. Within this framework, and under article four of the agreement in particular, global greenhouse gas emissions should peak as soon as possible and then drop to zero in the second half of this century by balancing emissions with removals by sinks, such as forests, oceans or soil. Signatories of the agreement are obliged to submit National Determined Contribution plans (NDCs) every five years, presenting the progress made in comparison to the previous plan. In line with the agreement's goals and monitoring process, the European Commission issued in 2018 a strategy for achieving a climate-neutral economy by 2050, providing cost-efficient trajectories. In 2019, the European Union set the "energy efficiency first" principle[1] as part of the revision of the Energy Efficiency Directive.

1 To promote climate objectives, a large number of legislative actions were approved at EU level in the same period, including the Emissions Trading System, renewable energy sources, highly energy-efficient buildings and products, standards for car emissions and emissions from fluorinated gases.

Box A

Targets under the 2030 Climate and Energy Framework

According to the existing (2019) framework, the European Union has set the following three headline targets for 2030:

- At least a 40% cut in greenhouse gas emissions (from 1990 levels)
- At least a 32% share for renewable energy (of final energy consumption)
- At least a 32.5% improvement in energy efficiency (compared to the baseline 2007 scenario)

The 40% greenhouse gas target will be achieved collectively by the EU Emissions Trading System sectors (energy suppliers and energy-intensive industries), the Effort Sharing Regulation sectors (transport, agriculture and buildings) and land use, land use change and forestry regulation.

All three goals are part of the EU climate legislation under review, and the latest proposal in September 2020 focuses on greenhouse gas emissions and suggests increasing the reduction from 40% to at least 55% in 2030. The European Commission will come forward with proposals for the other two goals by June 2021.

The European Climate Law, the Governance of the Energy Union and Climate Action and the roadmap for the European Green Deal provide the guidelines for EU and Member States' efforts to meet the Paris goals. Each of the three policies establishes distinct processes:

- The European Climate Law makes the European Union's goal to become climate-neutral by 2050 legally binding and establishes a framework for achieving this objective.
- The governance regulation sets a five-year cycle – aligned with the review cycle of the Paris Agreement – for assessing progress towards the objectives and the alignment of national and EU policies. Member States will be asked to take corrective action when their trajectory strays from the overall EU climate commitments.
- The European Green Deal roadmap outlines the key policies and measures needed to transform the European Union into a fair and prosperous society, with a modern, resource-efficient and competitive economy. That economy will reduce its net emissions of greenhouse gases to zero by 2050, and economic growth will be decoupled from limited resources.

An integral part of the European Green Deal is the Green Deal Investment Plan, also known as the Sustainable Europe Investment Plan. This plan aims to finance a sustainable transition while supporting the regions and communities most exposed to its impact. In brief, it combines legislative and non-legislative initiatives and has three main objectives. First, mobilise funding of at least EUR 1 trillion from the EU budget and other public and private sources over the next decade. Second, put sustainability at the heart of investment decisions across all sectors. Third, provide support to public administrations and project promoters for creating a robust pipeline of sustainable projects. Around half of the EUR 1 trillion total is supposed to come directly from the EU budget, while other public (InvestEU, the Just Transition Fund) and private sources are expected to provide the remainder of the funds, mainly through leveraging.

The EIB is a key player in mobilising additional funding for the sustainable transition. In 2019, the EIB launched an ambitious new climate strategy that aims to support EUR 1 trillion of climate action and environmental sustainability investment over the next decade. The EIB plans to achieve that goal by dedicating at least 50% of its lending to climate by 2025, by calling a halt to its financing of fossil fuel projects by 2021 and by aligning all financing activities with the goals of the Paris Agreement from

the end of 2020. The EIB, under the European Green Deal, is expected to trigger investment of around EUR 250 billion (one-quarter of the total investment plan) under EU mandates. In November 2020, the EIB Group published its Climate Bank Roadmap, which sets up the path to achieve those commitments.[2]

In September 2020, the European Union stressed once again its strong commitment to leading global climate action and to continuing the significant progress made in this area over the last two decades. The European Commission's new assessment proposes increasing the target for reducing greenhouse gas emissions from 40% to 55% by 2030 with the goal of reaching net-zero emissions by 2050, factoring in the post-COVID-19 recovery, Brexit and National Energy and Climate Plans. The European Parliament added further impetus, calling for a 60% reduction in greenhouse gases.[3] The new strategy presents cost-effective ways of achieving a carbon-neutral economy by 2050 through a socially fair transition. Specifically, the strategy outlines a framework for the long-term transition and addresses investment and finance, research, innovation and deployment, economic and social impact. It also outlines the European Union's global role and the role of citizens and local authorities.

Against this background, the following sections aim to provide greater clarity on clean energy investment flows, and the corresponding investment trends for both mitigation and adaptation. Building on the action plan and the final report on the EU taxonomy published in March 2020, the investment trends in climate change mitigation technologies are discussed with reference to the United States, China, the European Union and its Member States. The analysis adopts a common methodology to facilitate the comparison across regions, countries and sectors.

The EU taxonomy and climate investments

As part of the European Green Deal roadmap, the European Commission adopted the EU action plan on sustainable finance (Sustainable Finance Action Plan) in 2018. This plan aims to channel private financial flows towards investments that support the Paris Agreement's target of a carbon-neutral economy by 2050, and more broadly the United Nations Sustainable Development Goals.

The Sustainable Finance Action Plan involves three key steps. First, establishing a framework for facilitating sustainable investment based on a unified classification system (or taxonomy). Second, introducing obligations for institutional investors and asset managers to disclose how they integrate Environmental, Social and Governance (ESG) factors in their risk assessment. Third, providing low-carbon and positive-carbon impact benchmarks to give investors a clearer understanding of the carbon consequences of their investments.

The first key action, the EU taxonomy, was adopted in June 2020, after the proposal of the EU technical expert group earlier that year. The adopted taxonomy serves as a guide for investors, companies, issuers, and project promoters for what constitutes environmentally sustainable economic activity. In other words, it sets a common language for sustainable finance through a framework of unified criteria.

The EU taxonomy identifies six environmental objectives and sets out Paris Agreement-aligned performance criteria for a set of economic activities. According to this framework, economic activity will be considered sustainable if contributes to one of these six goals, does not significantly harm any other activity, and satisfies at least some minimum safeguards[4] including human rights (Figure 1). The six environmental objectives are climate change mitigation, climate change adaptation, sustainable use and protection of water and marine resources, transition to a circular economy, waste prevention and

2 The EIB Group Climate Bank Roadmap focuses on four areas: a) accelerating the transition, b) ensuring a Just Transition for all, c) supporting Paris-aligned operations and d) building strategic coherence and accountability.

3 In December 2020, the European Council endorsed a new target for a 55% reduction of greenhouse gas emissions by 2030, compared to 1990.

4 These safeguards are set out in the regulation (including the OECD Guidelines for Multinational Enterprises, the International Labour Organization, etc.), together with the technical screening criteria developed by the Technical Expert Group.

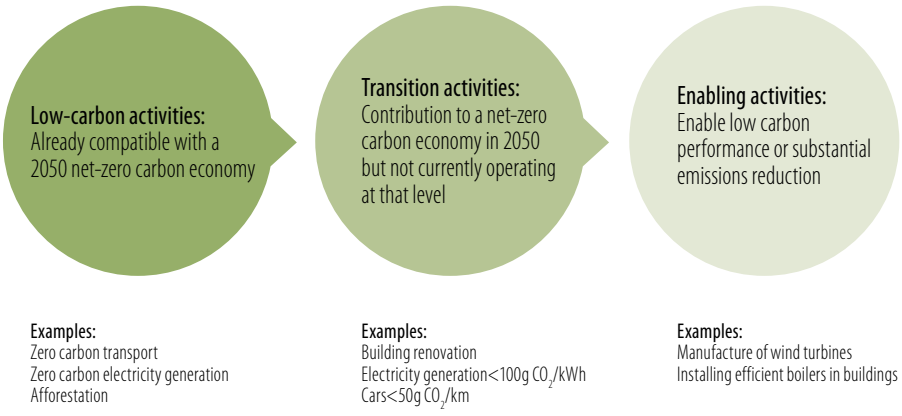
recycling, pollution prevention and control, and protection of healthy ecosystems. So far, the agreed taxonomy covers only the first two environmental objectives, while negotiations are still pending for the definition of the remaining ones.

Figure 1
EU taxonomy at a glance

Source: *Natixis.*

The EU taxonomy covers 70 NACE[5]-defined economic activities at a granular level across seven broad macro sectors. These macro sectors are: 1) agriculture and forestry, 2) manufacturing, 3) electrcity generation, 4) water, sewerage, waste and remediation, 5) transportation and storage, 6) information and communication technologies (ICT) and 7) buildings. The taxonomy covers activities that are classified as green, transitioning or enabling. It excludes mining and quarrying, fishing, glass manufacturing, paper and pulp manufacturing, aviation and maritime shipping. These activities will be addressed in the future.

Figure 2
Classification of climate change mitigation activities



Source: *Natixis.*

5 NACE stands for "Nomenclature statistique des activités économiques dans la Communauté européenne" and shows the statistical classification of economic activities in the European Community.

The taxonomy defines activities as contributing to climate change mitigation if they comply with specific standards, namely if they fall within specific thresholds[6] and adhere to the principle of doing no significant harm to other environmental objectives. These standards/thresholds are in line with the objectives of net-zero emissions by 2050 and a 55% reduction by 2030, consistent with the commitments made under the EU green deal.

Whereas the details of the taxonomy are applicable at project level, the climate change investment data reported in this chapter provide a high level of aggregation, with no specific project data included. Moreover, the investments reported in this chapter were made before the taxonomy was issued and it is not possible to judge the extent to which the component projects committed to in previous years would have met today's criteria. The taxonomy nevertheless provides some guiding principles.

The subsequent analysis of climate change investments shares a common structure with the EU taxonomy. For example, renewable energy investments and investments in forestry/sequestration correspond to low-carbon activities (Figure 2). Investments in energy efficiency correspond largely to transition activities. Research and development that will make future low-carbon investment possible corresponds to enabling activities, as does investment in transport infrastructure that provides the potential to switch from the use of fossil fuels to renewable energy.

Climate change investment by taxonomy-aligned sectors in the EU27, the United States and China

Regional comparisons of investment trends

China leads the world in clean energy investment, sustaining high investment rates over the last six years. Its current level of investment in climate change is approximately equal to that of the United States and the European Union combined (Figure 3). In 2019, China invested EUR 346 billion compared with EUR 175 billion in the European Union and EUR 152 billion in the United States. China's investment in climate change accounts for 2.7% of GDP, a much higher share than in the European Union at 1.3% or the United States at 0.8%. Moreover, China's investment is growing rapidly. Recent growth in the European Union and the United States has come from renewable energy generation, which has been subject to much more volatile swings. Investment in energy efficiency and transport have both been flat or declining in the European Union and the United States over the last six years. However, in China, all climate sectors have been ramping up quickly.

The European Union is second only to China for climate investment. In the EU27, investment in climate increased by 2.7% in 2019 to EUR 175 billion, with all segments of climate mitigation growing except energy efficiency. Renewable energy generation led the way with a rise of 7.8%, hitting a level not seen since 2012. The increase came largely from the wind and solar photovoltaic (PV) sectors. Estimates for energy efficiency investment indicate a modest decline in 2019 to EUR 55 billion. However, given the difficulty in estimating this kind of investment, it would be safer to say that no evidence exists of a substantial change in real terms over the last five years. In the transport sector, investment in rail and inland waterways grew by 3.6%, making up for the lower rates witnesses since 2014. Forestry grew by approximately 6%, and R&D by 0.8% with increases in government R&D making up for declines in the corporate sector.

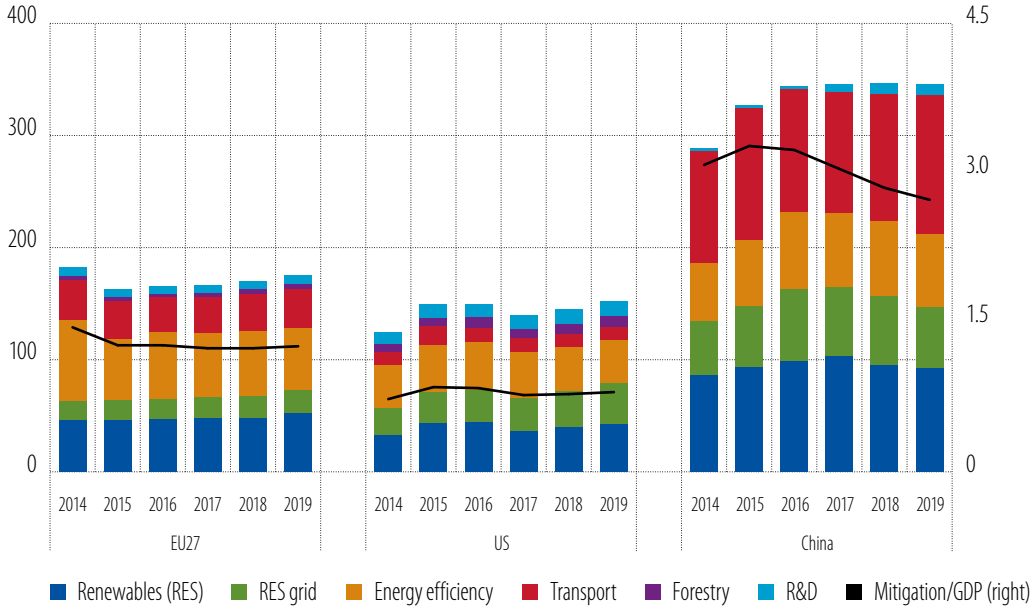
The European Union has already gone much further in climate mitigation than the other two regions. At 0.2 kg CO_2/GDP (2010 US dollars), the European Union has the lowest emissions of the three economies

6 Thresholds, defined as minimum standards, are used to distinguish activities that contribute to environmental sustainability from those that do not. Thresholds are set at the levels where improvements to existing assets would make a substantial difference to the performance of an activity or asset relative to environmental objectives. For example, electric power plants are considered a sustainable activity if they emit less than 262 g CO_2/kwh. Similarly, until 2025, road passenger cars should not emit more than 95 g CO_2/km to be considered a sustainable activity in the taxonomy.

by far. Greenhouse gas emissions per unit of GDP has been cut in half across the three economies from 1990 to 2017 (Figure 4), reflecting reductions in energy intensity as well as changes in the energy mix, such as the switch from coal to gas and renewable sources in electricity production. The European Union has been actively promoting these investments for a long period and has successfully decoupled its economic growth from energy-intensive inputs, meaning that it has the lowest carbon intensity across the three regions. China, however, and to a lesser extent the United States, still have many untapped opportunities. Lower income European countries or recent EU members also have room to improve rapidly, as they started their decarbonisation process later than high-income EU members.

Figure 3

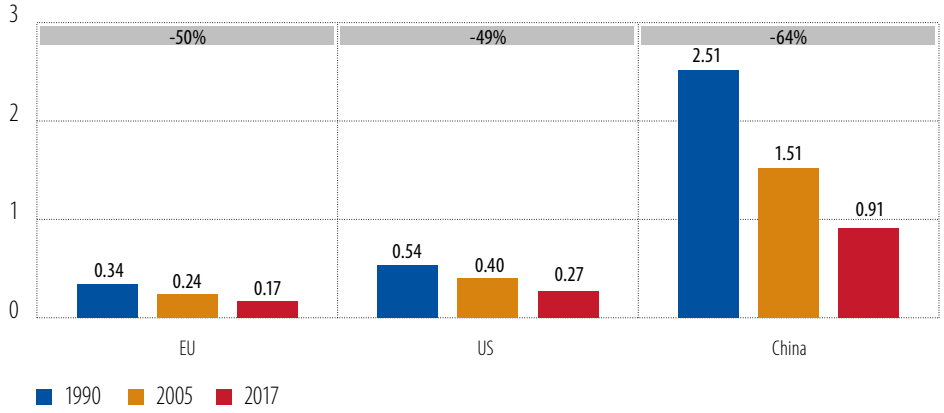
Climate change mitigation investment per sector (left axis: EUR billion; right axis: % of GDP)



Source: *International Energy Agency (IEA), Bloomberg New Energy Finance (BNEF), Eurostat, and authors' estimates.*
Note: *Data on investment in forestry in China were unavailable.*

Figure 4

Greenhouse gas emissions to GDP in the European Union, the United States and China (kg CO_2/GDP, 2010 USD)



Source: *OECD.*

Box B

Price indicators for climate mitigation, renewable and energy efficiency investments

Climate investments are of the utmost importance in the decarbonisation of specific sectors and the economy as a whole. To better illustrate the cost benefits of clean energy investment, the EIB Economics Department has developed indicators that estimate the price of greenhouse gas emissions or energy consumption avoided as a result of the clean energy projects in the European Union, the United States and China.

Specifically, the following indicators have been calculated as a measure of comparison among the three regions:

- Climate investment per tonne of carbon emissions avoided
- Renewable energy investment per tonne of carbon emissions from the power sector
- Investment in energy efficiency per tonne of avoided energy consumption

The carbon emissions or energy consumption of each region are given by the following factors:

$$E_t = A_t * I_t$$

Where E_t represents the either the total energy consumption or the carbon emissions at time t, A denotes the activity index, e.g. GDP, and I denotes the energy or carbon intensity depending on what is measured each time. In additive decomposition, the effects of the various driving factors from the baseline year 0 to the final year T are expressed as follows:

$$\Delta E_t = E_T - E_0 = \Delta A_t * \Delta I_t + I_0 * \Delta A + A_0 * \Delta I$$

The method used for decomposing the changes in the variables of interest follows the standard logarithmic mean Divisia index, (LMDI) methodology summarised by Ang (2015). According to this method, the avoided energy consumption or carbon emissions are based on the following:

$$[(E_T - E_0)/\ln(E_T/E_0)] * \ln(I_T/I_0)$$

For energy efficiency, avoided energy is calculated by decomposing the change in final energy consumption into the change due to improvements in energy intensity and the change due to GDP growth. The change due to the improvement in energy efficiency is then used as avoided energy consumption in the denominator. Similar methodology is applied for carbon, using carbon intensity instead of energy intensity.

The calculations were made for the EU27, the United States and China. Climate investment per tonne of carbon avoided and energy efficiency investment per tonne of energy consumption avoided were estimated over the six-year period from 2014 to 2019. Renewable energy investment per tonne of carbon emissions from the power sector was estimated over for 2014 to 2017.

On this basis, over the last six years the European Union has invested EUR 8 400 per additional tonne of avoided energy consumption compared with EUR 760 per tonne for China and EUR 1 600 for the United States.

The corresponding calculation for carbon implies that, over the last six years, the European Union has invested EUR 4 200 per tonne of avoided carbon compared with EUR 560 per tonne for China and EUR 890 for the United States.

Table B.1
Price indicators for climate change mitigation (CCM)**, renewable energy** (RE) **and energy efficiency** (EE) **investments**

	Avoided CO_2 emissions	Investment in CCM	CCM/CO_2	Avoided energy consumption	Investment in EE	EE/toe	Avoided CO_2 emissions	Investment in RE	RE/CO_2
	(tonnes)	(bn EUR)	(bn EUR/tn)	(Mtoe)	(bn EUR)	(bn EUR/toe)	(tn)	(bn EUR)	(bn EUR/tCO_2)
EU27	241	989	4.1	42	370	8.8	39	260	6.7
US	967	846	0.9	150	234	1.6	274	267	1.0
China	3 560	1 837	0.5	497	294	0.6	359	611	1.7

Source: *Authors' calculation.*
Note: *The data in the table show the cumulative totals over the six-year period (2014-2019) for total final energy consumption, energy-related carbon emissions, real GDP and investment in energy efficiency, and climate mitigation (adjusted to 2019 prices using the GDP deflator). Toe stands for tonnes of oil equivalent.*

In the power sector, the European Union invested EUR 6 800 per tonne of avoided carbon over for 2014 to 2017, compared with EUR 1 700 per tonne in China and EUR 980 in the United States.

Although there are differences across the three regions in the share of climate change and energy-efficiency investment in gross fixed capital formation (GFCF), they are much lower than the differences in the indicators presented above.

These comparisons need to be interpreted with caution, as they are not cost-benefit ratios for the following reasons:

- While investments take a long time to materialise, they result in lower energy consumption and reduced carbon emissions. In buildings, for example, the stock turns over only very slowly and the investments are long-lived.
- The European Union is already less energy-intensive and less carbon-intensive than the United States or China. As such, further reductions in energy intensity are expected to be relatively difficult in the European Union.
- The European Union uses less coal in the power sector so renewable energy displaces less carbon-intensive alternatives.
- Faster economic growth in China and the United States means that turnover is faster and the share of old appliances and equipment in the total capital stock is shrinking more rapidly. New equipment is more efficient. Faster growth therefore means faster improvements in energy intensity and carbon intensity.

Despite the caveats, these indicators show how different the approaches are in the various regions. They tell us nothing about the economic viability of the investments, but they do show that the European Union has already gone much further in climate mitigation than the other regions, which means that most of the low-hanging fruit have already been picked. While the European Union has been actively promoting these investments over a long period, untapped opportunities still exist in China and the United States and, more generally, in regions that have started their decarbonisation more recently.

Given that tackling climate change is a global challenge, the European Union should continue to support the green transition in partner countries through its development programmes, while fostering domestic efforts to harness the full potential of decarbonisation of its energy systems.

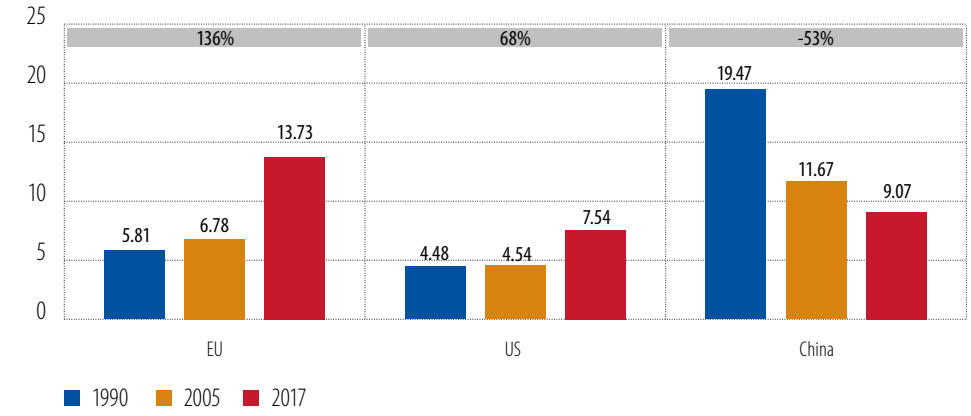
Investment in low-carbon activities

Low-carbon activities are those that are already compatible with a net-zero carbon economy in 2050. For example, renewable sources, when they replace fossil fuels, directly reduce greenhouse gas emissions. Forestry investments can play a role in sequestering greenhouse gases.

Renewable energy and networks

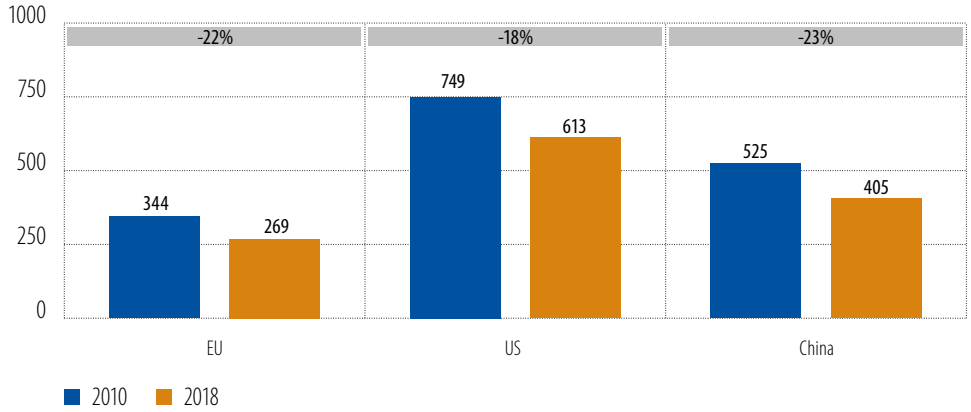
For renewable energy deployment, the European Union is well ahead of the other two countries. In the European Union, the share of renewable energy in primary energy consumption, the gross amount of energy consumed, has more than doubled since 2000, with the rise especially marked after 2005 (Figure 5). The United States showed a similar trend with an increase of 70%, whereas in China, the share of renewable energy was halved because of an unprecedented increase in the country's primary energy supply. Overall, the three regions succeeded in decarbonising their electricity generation from 2010 to 2018, reducing their carbon intensity at least by one-fifth. Of the three, Europe has been the most successful, recording the lowest carbon intensity at 269 g CO_2/kWh thanks to the rapid deployment of renewable energy and the phasing out of coal power plants (Figure 6).

Figure 5
Share of renewables in the primary energy supply (%)



Source: *OECD.*

Figure 6
Carbon intensity of electricity generation (g CO_2/kWh)

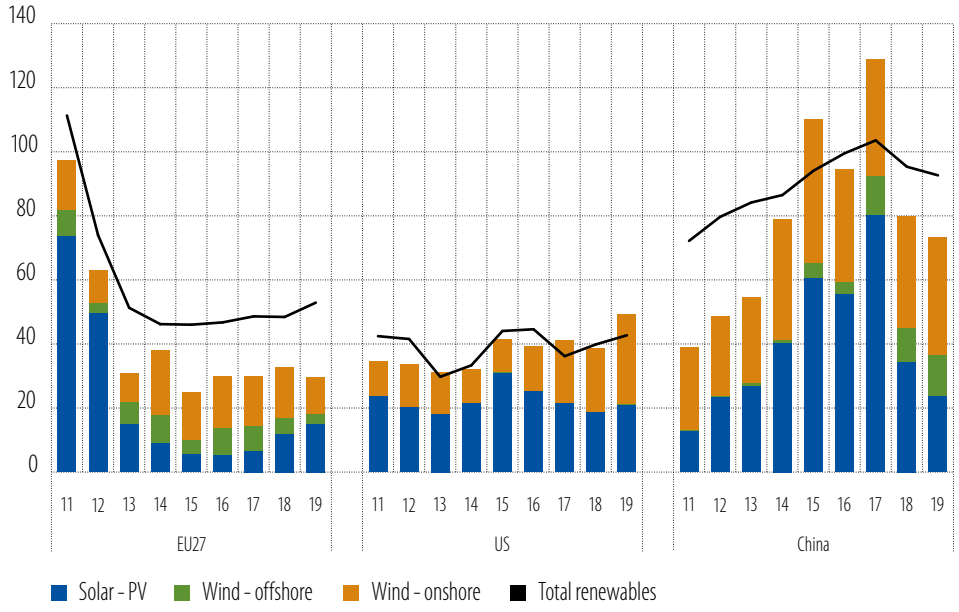


Source: *IEA.*

Nevertheless, the European Union is currently behind China and the United States for new investments. EU investment totalled EUR 74 billion in 2019, an increase of 7.8% from 2018 (Figure 3). That was roughly half China's investment, and 85% of US levels. China remains the world leader in investment in the solar PV and wind segments, but the United States and the European Union invest more in energy-smart technologies such as battery storage.

Figure 7

Investment commitments in wind and solar energy, and total investments made in renewable energy (EUR billion)



Source: *BNEF, IEA.*
Note: *The line presents the IEA's figures for investments in renewable energy that has become operational in a given year. The bars show investment commitments in renewable projects, for which the final investment decision was taken and construction has begun, but which might be completed after more than one year.*

The momentum of renewable energy appears to be slowing, as commitments from the European Union and China declined in 2019. By contrast, investment commitments in renewable energy increased in the United States (Figure 7). Both solar PV and onshore wind grew in the United States, while wind power declined in the European Union. In China, investment in solar PV declined as a result of changes to the government's support schemes.

Box C

The role of different financing sources in renewable energy

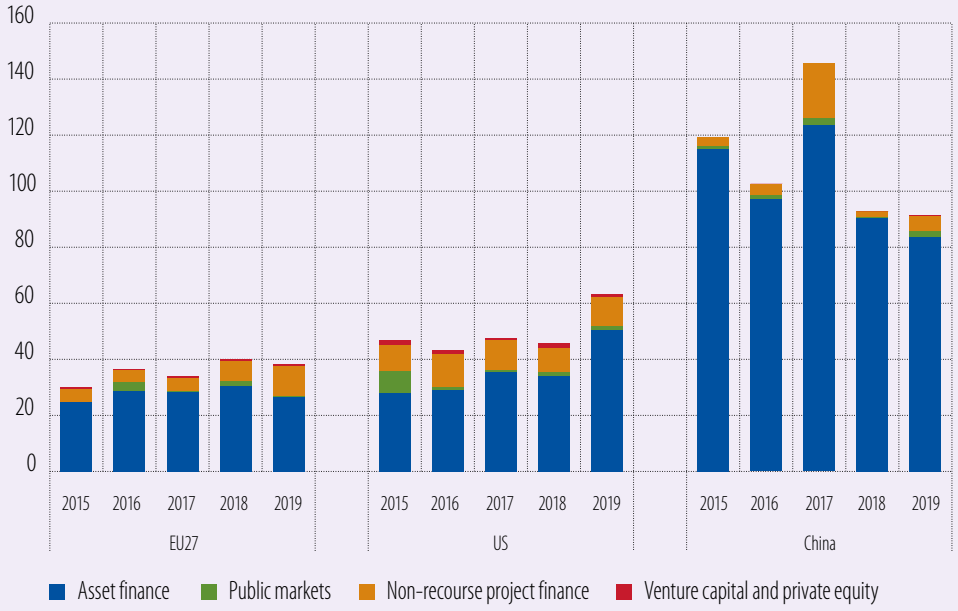
From 2015 to 2019, the bulk of investments in Europe, the United States and China were financed by four different sources: asset financing, venture capital and private equity, non-recourse project[7] finance and public markets.

Historically, asset financing – loans guaranteed by the companies' assets – was the main source of financing for renewable investment in all three regions (Figure C.1), especially in China, where it

7 Non-recourse finance is a type of commercial lending that entitles the lender to repayment only from the profits of the project the loan is funding and not from any of the borrower's other assets.

accounts for more than 90% of total funding. Non-recourse project finance, which is mainly driven by bank lending, is the second-largest source of financing for renewables, particularly in Europe and the United States. The projects funded by this type of finance mainly concern technologies with smaller market penetration, such as rooftop and other small-scale solar projects of less than 1 MW. Public markets, along with venture capital and private equity, are the least preferred sources of financing for renewable projects. In China, funding via public markets and venture capital is almost negligible.

Figure C.1
Financing sources for renewable projects in the European Union, the United States and China (USD billion)



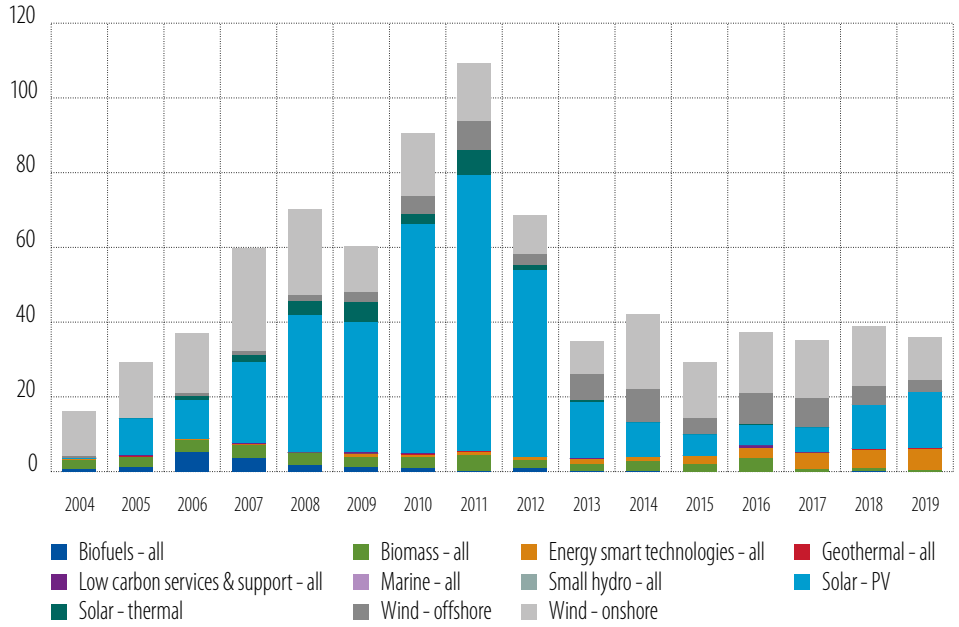
Source: *BNEF.*

In Europe, renewable energy now leads investment in the power sector, with fossil fuel investments much diminished. Investment in renewable energy (EUR 52.9 billion) in 2019 accounted for about 75% of total investment in power generation, with the remaining 25% shared approximately equally between fossil fuels and nuclear energy. The expansion of renewable energy also requires stronger electricity networks. The sporadic supply inherent in renewable energy places greater demands on electricity transmission networks. These demands include efforts to connect new electricity producers to the grid but also the need to transport power over longer distances. Factoring in the associated investments in electricity networks (EUR 20.7 billion), the total investment attributed to renewables in 2019 was EUR 73.6 billion.

EU investment in renewable energy is well below the level reached before the 2011 economic crisis. Despite recovering some ground since 2015, investment in 2019 was only at 56% of its level in 2011. The slower pace of renewable energy investment after the economic crisis can be attributed mainly to falling capital costs in solar and wind globally, and to the revised support schemes that reduced subsidies in many EU countries, resulting in fewer installations. In particular, annual new additions of renewable energy decreased from 32 GW in 2011 to around 16 GW.

While investments made in renewables grew by 7.8% in 2019, investment commitments to new projects declined by 8% (Figure 8). While these new projects do not cover all investments in renewable sources, they have so far been a consistent leading indicator of future trends. For example, project commitments for utility-scale investments are typically over several years and these future flows are locked in at the date of commitment.

Figure 8
Investment commitments per renewable technology in the European Union (EUR billion)



Source: *BNEF.*

EU investment in renewable generation is dominated by wind and solar PV. While investment in solar PV in the European Union has more than doubled since 2017, reaching EUR 15 billion, current levels are quite low in comparison to the peak of 2011. In 2011, solar PV reached unsustainably high levels of investment on the back of short-lived government incentives. Declines are also observed in onshore and offshore wind. In the onshore sector, countervailing forces are at play. On the one hand, the maturity of the sector means that there are limited opportunities for new investments. The most favourable locations in countries with the most supportive incentive regimes have already been taken. On the other hand, technological progress – larger turbines, more efficient management systems and higher load factors – is continuing to drive down costs and increase productivity.[8]

EU investment rates in biofuels, biomass and geothermal energy are also declining. After peaking around 2010-2011 (Figure 8), investments dropped more than 90% for biofuels and biomass – to EUR 90 million for biofuels and EUR 360 million for biomass in 2019. Investments in geothermal energy also declined around 60%, to EUR 90 million in 2019. The role of biomass and biofuels in climate change mitigation depends on the alternatives and the choices being made. For example, a switch from burning fossil fuels to sustainable biomass constitutes a reduction in greenhouse gas emissions. The greenhouse gases emitted by the combustion of the biomass are offset by those captured in the production of the biomass (for example, the forest recovers greenhouse gases, which are returned to the atmosphere when the woodchips are converted to electricity). By contrast, if the alternative to burning biomass is to allow the material to accumulate in the environment, then the climate change benefits are not so clear-cut. These trade-offs considerably affect investment in biomass.

In contrast, EU investment in energy-smart technologies has grown rapidly in the last five years, reaching EUR 5.8 billion in 2019 (Figure 8). A large part of these investments is related to battery storage. Other energy-smart technologies concern digital control devices that improve the efficiency of power

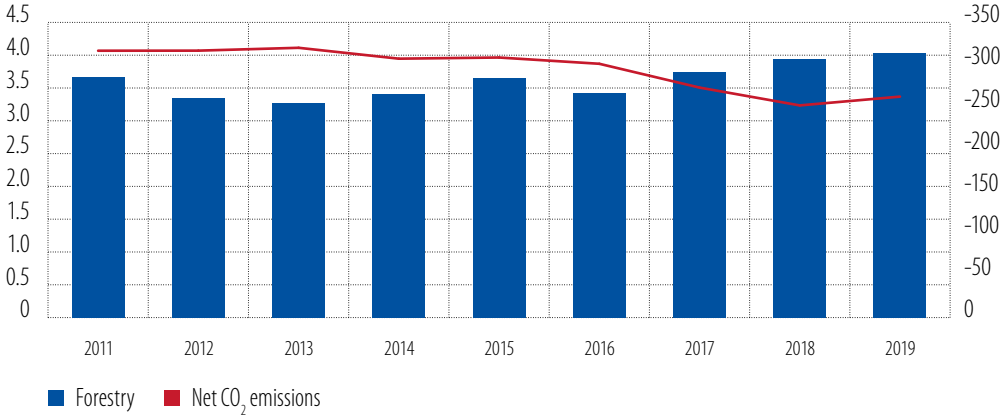
8 The cost of technology is also a significant factor in the offshore sector. However, investments are more concentrated in larger projects, and therefore the overall level of investment is driven by the timing of the new megaprojects.

generation capacity by making it more responsive to the needs of the system. These advances are being applied to existing capacity as well as to new investments in renewable energy. These advances increase a renewable energy power plant's ability to adapt more quickly to changing weather conditions. On the demand side, investment in smart meters is creating greater flexibility and allowing consumers more control over their consumption.

Agriculture, forestry and land use

The land use, land-use change, and forestry sector is considered to be a carbon sink. In the European Union, this sector has been sequestering more than 300 Mt of carbon equivalent on average over the last ten years[9] – which represents approximately 7.5% of current emissions (Figure 9). Forestry is by far the largest contributor to carbon sequestration while the rest of the activities in this sector, including croplands, settlements, wetlands, and grasslands, are small net emitters overall.

Figure 9
Investment in forestry and carbon reduction (EUR billion, Gtn of carbon)



Source: Eurostat.

Emissions from deforestation are decreasing while carbon sequestration from afforested areas is rising as new forests are established and recently established forests reach maturity. Investment in forestry is responding to the increased demand for bioenergy, which is a result of the renewable energy targets and the demand for material. These trends are driving up wood prices, which increases the value of forested areas and supports investment.

The latest Eurostat data indicate that forestry accounts for approximately 0.1% of total gross fixed capital formation (GFCF). This ratio has remained constant in recent years, which implies 2019 investment of slightly over EUR 4 billion, or 2.4% of the estimated total investment in climate change (Figure 9). Sweden and Finland are the largest investors in forestry, accounting for 42% of total EU investment in the sector.[10] In the United States, forestry investment is estimated to be around EUR 10 billion.

Investment in transition activities

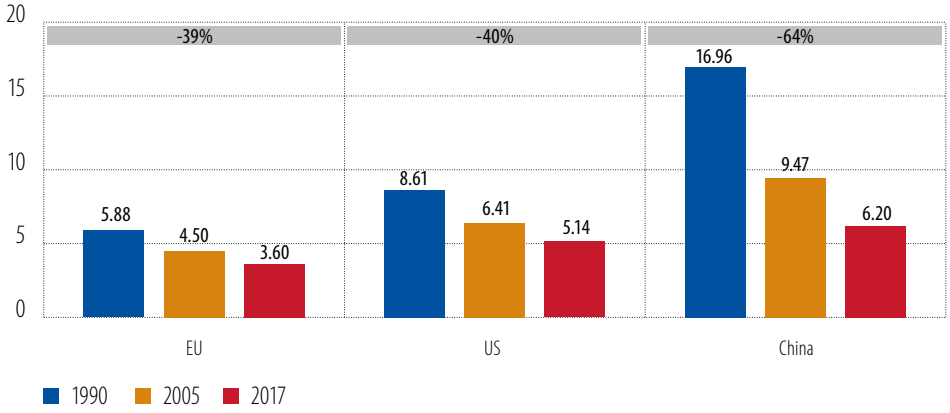
Transition activities contribute to achieving a net-zero emissions economy in 2050, but do not yet operate at the expected optimal level. For example, energy efficiency limits energy demand, but the investment lags are long and the required standards are not yet in place.

9 United Nations Framework Convention on Climate Change (UNFCCC) inventory data.
10 Unfortunately, data on investments in agriculture, forestry and land use for China are not publicly available.

Energy efficiency

The European Union's "energy efficiency first" principle is behind improvements in energy intensity. According to the latest available data (2017), Europe is a champion in decoupling its economy from energy use. The European Union boasts the lowest energy intensity across all three regions (Figure 10). Despite differences in the structure of their economies and investment in energy efficiency measures, the European Union, the United States and China continue to converge for energy intensity. Since 1990, the European Union and the United States have cut their energy intensity by 40%, and China by more than 60%. Energy efficiency efforts, adjustments in the power mix and, to a certain extent, a structural shift towards less energy-intensive industries helped achieve this reduction.

Figure 10
Primary energy supply per GDP (1 000 Btu/2015 USD GDP PPP)



Source: *EIA.*
Note: *PPP stands for purchasing power parity.*

The European Union surpasses the United States and China in energy efficiency investments. The European Union invested around EUR 60 billion in energy-efficiency improvements, in comparison to EUR 53 billion for China and EUR 37 billion for the United States (Figure 3). US energy efficiency investment accounts for about 1% of GFCF, or 0.2% of GDP, around two-thirds of EU levels. China, on the other hand, is much closer to the EU ratios.

In the European Union, energy efficiency investment has remained relatively flat over the last five years, even taking into account a small decline within the margin of error for the estimation (see Figure 3).[11] There are a number of possible explanations. Economic incentives for investing in energy efficiency declined, in line with energy prices: Brent crude prices averaged USD 58 a barrel from 2016 to 2019, significantly below the average of USD 93 for the previous four years. At the same time, the price of better insulation materials and more efficient appliances dropped.

Investment in enabling activities

Enabling activities are necessary for reducing emissions, though they act only indirectly (because, as their name suggests, they enable other activities). For example, investment in transport infrastructure allows fossil fuels to be substituted by electricity, as traffic is switched from oil-based road transport to electric trains. Research and development and demonstration projects (such as hydrogen or carbon capture

11 These data are based on the IEA's bottom-up methodology of calculating energy efficiency investment. The methodology looks at the cost difference between alternative investments that are similar except for their energy consumption. This additional cost is attributed to energy efficiency. The methodology has been refined over recent years (IEA, 2019).

and storage projects) can pull in fresh investment and highlight new ways of reducing emissions. The investment developments are discussed across the European Union, the United States and China, with a particular focus on EU developments.

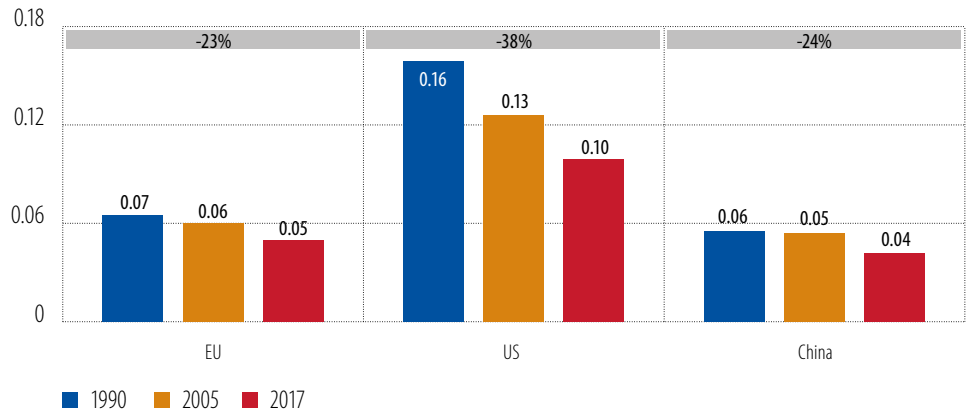
Transport infrastructure

Investment in transport infrastructure contributes to climate change mitigation by facilitating the switch to less carbon-intensive modes of transport. It dovetails with the investments in electric vehicles and other energy efficiency measures discussed above. Urban mass transit systems and infrastructure that promotes the transfer of road freight to rail are two examples of investments that reduce transport's carbon footprint. These transport modes emit less carbon per passenger kilometre or per tonne kilometre of freight.

However, the net impact of these investments on greenhouse gas emissions must be seen in the context of the transport system as a whole. In Europe, where key areas of the transport system are already congested, adding new capacity increases overall demand while also promoting the shift to less carbon-intensive modes of transport. For example, upgrading mass transit in congested urban areas might have a limited impact on the number of private car journeys, even though the number of journeys in the overall mass transit system has increased.

Nearly all investments in inland waterways and rail infrastructure are classified as climate mitigation investments. The only exception would be transport links for the transportation of fossil fuels. Many investments in waterways and rail infrastructure projects include infrastructure that helps shift transport patterns in addition to increasing capacity.

Figure 11
Carbon intensity of transport (kg CO_2 /GDP 2010 USD PPP)



Source: *IEA.*

The transport sector remains almost entirely based on fossil fuels in all three regions. Transport accounts for about one-quarter of global carbon emissions. Consequently, it holds great potential for energy efficiency and emission reductions. Yet, in the European Union, as well as in the United States and China, transport is expected to become the largest source of greenhouse gas emissions after 2030 (European Environment Agency (EEA), 2018). The carbon intensity of the transport sector in the United States is twice as high as in the European Union and China (Figure 11). All three blocs have improved their carbon efficiency over time.

China is particularly focused on decarbonising transport, which is driving its total clean energy investment.[12] In 2019, China invested EUR 124 billion (Figure 3) in this sector. It has a leading position in high-speed rail technology, and has far more capacity than anywhere else in the world. EU investment in rail and inland waterways is estimated at EUR 35 billion (0.3% of GDP) for 2019, while the corresponding investment in the United States stood at EUR 11.8 billion. The US rail-freight system is almost entirely privately owned, unlike road, air and waterways where public ownership is significant. Investment in railway infrastructure and rolling stock in the United States is financed by private freight companies, and investments ultimately depend on earnings from freight charges, which are regulated by the government.[13]

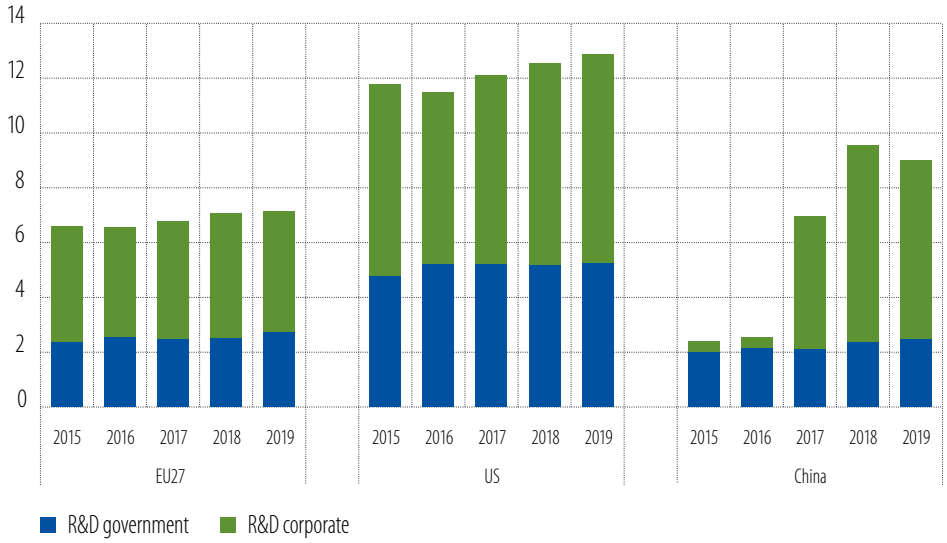
Transport infrastructure accounts for 20% of total EU mitigation investments. However, this figure is probably underestimated because it does not include all transport mitigation projects. Transport integration and city planning, transport management and intermodal terminals would positively affect climate change mitigation efforts.

Research and development

EU investment in R&D in climate mitigation activities has grown slowly over the last five years, whereas the increase in the United States and China has been stronger. The United States remains the world leader in climate-related R&D, but China is catching up rapidly (Figure 12). China overtook the European Union in 2018 and, despite a small nominal contraction in 2019, it now has a significant lead.

The EU performance is mostly driven by the corporate sector, despite continued increases in public sector R&D (which accounts for 40% of total R&D expenditure). Corporate R&D declined by 3.6% in 2019, following growth of 6.1% in 2018. Energy-related automotive R&D is estimated to have stabilised in 2018 and 2019 after growing steadily for several years. Automotive is central to overall R&D spending. The pullback might reflect a weakening outlook for car sales combined with the imperative to invest in new models and upgrade manufacturing supply chains. Automakers' margins on electric vehicles remain very tight.

Figure 12
Government and corporate investment in R&D (EUR billion)

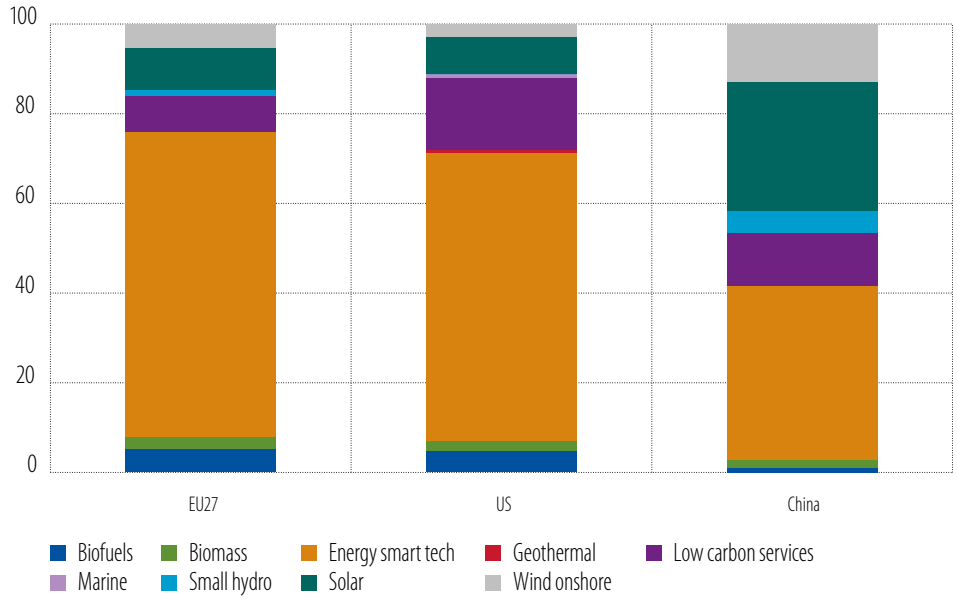


Source: *BNEF, EIB.*

12 https://www.railjournal.com/in_depth/china-rail-investment-2019
13 https://railroads.dot.gov/rail-network-development/freight-rail-overview

The sectoral composition of R&D investment in the European Union is broadly comparable to the United States, but quite different from China. Both the European Union and the United States spend approximately two-thirds of their total R&D speding on energy-smart technology (Figure 13). Most of the remainder goes to R&D in low-carbon services and solar power, with a smaller amount to biofuels and biomass. However, in China, solar, wind and small hydro projects make up a larger proportion of the total, accounting for 46%. This difference in composition reflects China's strong global position in manufacturing equipment and components, particularly for solar PV and wind power.

Figure 13
Government and corporate investment in R&D (EUR billion)



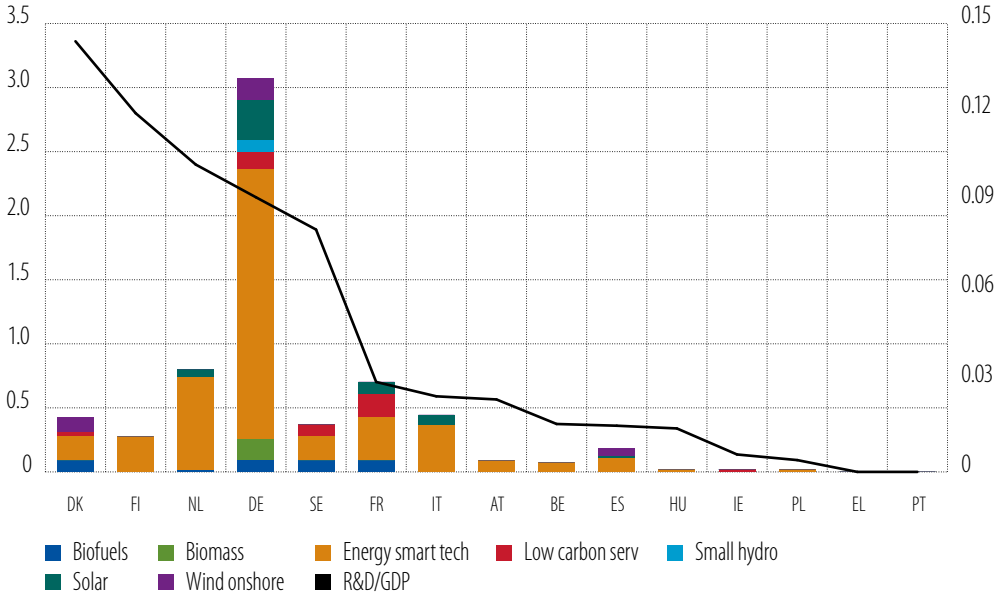
Source: *BNEF.*

Climate-related R&D is an important part of EU policy under the European Green Deal and the expanded Horizon Europe R&D programme. The coronavirus pandemic may make it hard for implementing agencies to execute projects in 2020 even though the funding is in place. Some public groups are calling for the pandemic response to focus on climate issues. In this case, climate-related R&D would likely be included in the fiscal stimulus package.

The European Union spends 0.05% of GDP on climate-related R&D. Investment varies widely between EU members, depending on their national priorities. France and Germany each account for approximately 20% of EU government expenditure on climate-related R&D, followed by Italy with 12% and Finland with 9% (Figure 14). As a proportion of GDP, Finland and Sweden are the largest spenders in the European Union, while countires in Southern and Central and Eastern Europe spend the least.

R&D plays a special role in facilitating other climate activities. A strong case exists for boosting R&D to increase overall energy efficiency, along with the efficiency of low-carbon power generation, power networks and transformation technologies. Estimates for the amount of R&D vary widely, with USD 4.5 billion to USD 78 billion needed for 2010-2029 globally and USD 115 billion to USD 126 billion for 2030-2049 (Bloomberg New Energy Finance (BNEF), 2020).

Figure 14
Investment in R&D for selected EU countries (EUR billion, % GDP)



Source: *BNEF.*

Investment in adaptation

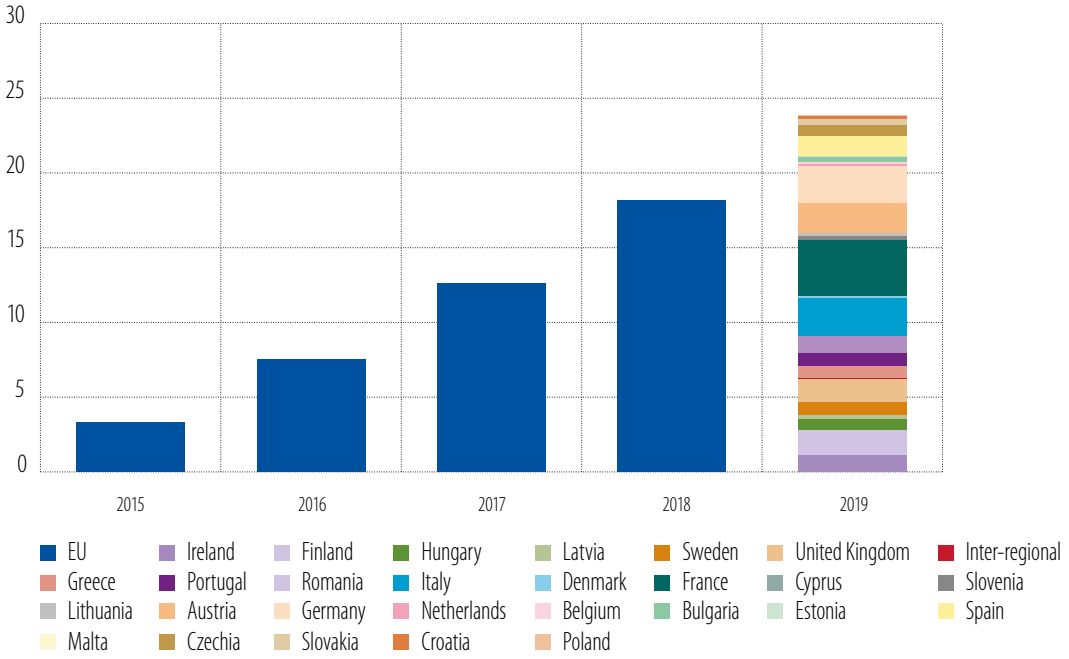
Investment in adaptation is much harder to track than investment in mitigation. Adaptation is more diffuse, and can be included in a wide range of investments across many economic sectors. It is impossible to track this type of investment with any accuracy without a globally accepted reporting method. Investors typically do not identify adaptation investments separately in their accounts.

Two categories of adaptation investment are identified and tracked, namely: i) major projects supported by EU public institutions and ii) flows of adaptation finance from OECD to non-OECD countries. However, these two categories very likely represent only a small part of the total. Adaptation investments by individual firms are not tracked, nor are, for the most part, those undertaken by other government entities and local authorities. The adaptation investments that are not covered by the data could be substantial, including for example costs related to the location of factories and warehouses and the associated engineering works, design and location of housing, plants and machinery, and so on.

Climate change adaptation is integrated in EU policies through the European Structural and Investment Funds (Figure 15). Projects include flood protection, land rehabilitation, forest fire protection, habitat conservation and risk management. The projects are funded with a combination of EU and national budgets. Total spending in 2019 reached EUR 23.8 billion, expanding rapidly from EUR 3.3 billion in 2015.

Adaptation funds provided by development finance and international finance institutions are approximately USD 30 billion a year. Almost one-fifth (19%) of the amount comes from development finance institutions. The fund is predominantly used for water and wastewater management, agriculture and forestry and disaster risk management projects in developing countries that are particularly vulnerable to climate change. However, the activity is small compared to the estimated USD 180 billion a year needed to adapt to disruptions in food production, urban services and infrastructure, as well as disaster risk management (Global Commission on Adaptation, 2019).

Figure 15
EU climate change adaptation and risk prevention programmes, total cost (EUR billion)



Source: *European Commission.*

The impact of COVID-19 on clean energy investments

The pandemic is significantly affecting climate change investment, but the size of the impact varies greatly by market segment. Depending on the EU policy response, investment in energy efficiency, electric vehicles, and other domestic/commercial sector activities is likely to be hard hit. However, renewable energy investment, and in particular utility-scale projects, will be less affected in the short term. Big projects can be worth hundreds of millions of euros, and they are subject to detailed regulatory and planning approval. Financing such projects, in offshore wind for example, typically depends on long-term legal agreements covering pricing and offtake[14]. By contrast, investment in energy efficiency could be easily postponed unless it is dictated by regulations.

In 2020, project announcements appear to be continuing, while financing and contracts are lagging behind compared to 2019. Based on Bloomberg New Energy Finance (BNEF) data, which are available for the first 27 weeks of 2020 (52% of the year), 2020 announcements have already reached 68% of total new additions in 2019, but financing has reached only 33% and contracts 22%. However, these data must be read with caution. They are sensitive to a small number of large projects and financing and contracting schedules are not evenly spread out throughout the year. Commissioning in the offshore wind sector, for example, is particularly sensitive to the seasons.

Similarly, the International Energy Agency (IEA) forecasts a decline of 17% in European energy investment in 2020. According to IEA analysis, electricity grids, wind, and energy efficiency measures are holding up better than solar PV and oil and gas investments (IEA, 2020). Nevertheless, investments in energy efficiency and end-use applications are also expected to decline 10-15% in 2020 as vehicle sales and construction activity weaken as do purchases of more efficient appliances and equipment.

14 An offtake is a Power Purchase Agreement (PPA) between a power producer and the power buyer (also known as the offtaker).

Investment in utility-size renewable energy projects is less affected by the economic downturn, compared to other types of generation capacity. Some renewable energy projects have experienced construction delays because of labour problems or issues with procurement. By and large, however, these investments are already committed, and the promoters are financially sound companies. At the same time, the revenue from renewable energy production are protected by guaranteed[15] access to the market. New utility-scale projects are nevertheless subject to risk. While the majority of planned renewable energy licenses have been issued, some have been postponed. Longer term, government policies are at risk of supporting schemes when energy demand is depressed and the economy is in a recession. Distributed investments in renewable energy (smaller projects such as commercial and household installations) and energy efficiency are more exposed to downturns in the market.

The role and investment needs of EU members and municipalities in the energy transition

The transition to a carbon-neutral economy represents a major, unprecedented challenge for all EU members. The transition involves all participants in the energy chain – all residents and market players – and a host of competing developments, opportunities, barriers and trade-offs. Above all, it requires massive investment in renewable energy plants, grids and pipelines, storage facilities, carbon-free fuel alternatives, as well as in building renovation, efficient industrial processes and appliances, new transportation technologies and smart energy systems.

The energy, climate and environment policies of the European Union – incorporated in its governance and regulatory framework – are driving the economy towards climate neutrality and sustainable growth. One of this framework's cornerstones is the governance regulation[16] (see Box D), under which the Member States have prepared their National Energy and Climate Plans (NECPs) defining their climate strategy. Second, the European Green Deal will help bring climate action and environmental sustainability into the mainstream, contributing to the overall target of devoting 30% of the EU's long-term budget, the 2021-2027 Multiannual Financial Framework, to climate-related expenditure. While Member States are bound to adopt EU policies such as the upcoming European Climate Law (not yet passed), they are also supplementing this framework with their own approaches and policies.

15 Priority in the dispatching schedule.

16 The 2018 EU regulation on the Governance of the Energy Union and Climate Action aims to support the reliable and transparent governance of the Energy Union to help the European Union meet the energy and climate policy goals set for 2030 and beyond.

Box D

The EU framework governing the climate transition

The Governance of the Energy Union and Climate Action bases its framework on the five dimensions of energy policy. These are energy efficiency, renewable energy and a reduction in greenhouse gas emissions (all under the umbrella of decarbonisation), interconnections, and research and innovation. The NECPs are an integral part of the effort to coordinate national and supranational strategies to facilitate and accelerate the transition towards a carbon-neutral economy. The national goals also provide the basis for an ongoing open-dialogue between the European Union and Member States.

In 2018, the European Commission asked EU members to present their long-term plans and strategies for meeting the overall objective of carbon neutrality by 2050, along with intermediate targets for reducing greenhouse gas emissions by 40% for 2030. In September 2020, the European Commission assessed all NECPs, inviting members to take action in various domains to address remaining gaps

and shortcomings. While the Commission will revise its key climate and energy-related legislation by 2021, EU members have until 2023 to fully implement and update their NECPs, reflecting the more ambitious EU energy and climate targets.

The governance process incorporates, and is also supplemented by, other elements aiming to ensure that the necessary resources are devoted to the climate transition. In addition to the 30% of the 2021-2027 Multiannual Financial Framework being allocated to climate-related expenditure (a 10 percentage point increase from the previous budget), 30% of the EUR 750 billion NextGenerationEU financial package will also be dedicated to climate investments. In addition, regional policy sets aside specific sums for the climate transition. In the 2014-2020 Multiannual Financial Framework, EUR 40 billion from the European Regional Development Fund and the Cohesion Fund went to climate-related spending. For research and innovation, Horizon 2020 includes climate action as a major objective. In 2020, a regulation establishing the Just Transition Fund was proposed and an EU hydrogen strategy adopted, with many more initiatives forthcoming in 2021.

In this governance framework, members define their approaches by adopting EU rules and adding their own policy tools. According to the European Environmental Agency (EEA), more than 1 500 policies and measures had already been adopted in the European Union in 2018, the most recent data available. Some 74% of these measures relate to the implementation of EU policies. The other 26% (around 400 measures) were rolled out without a direct link to EU directives or regulations. In addition, 89% were economic, using incentives to reduce greenhouse gas emissions (infrastructure programmes, subsidies, investment programmes, feed-in tariffs, loans/grants and trading schemes) or regulatory (binding standards and regulations).

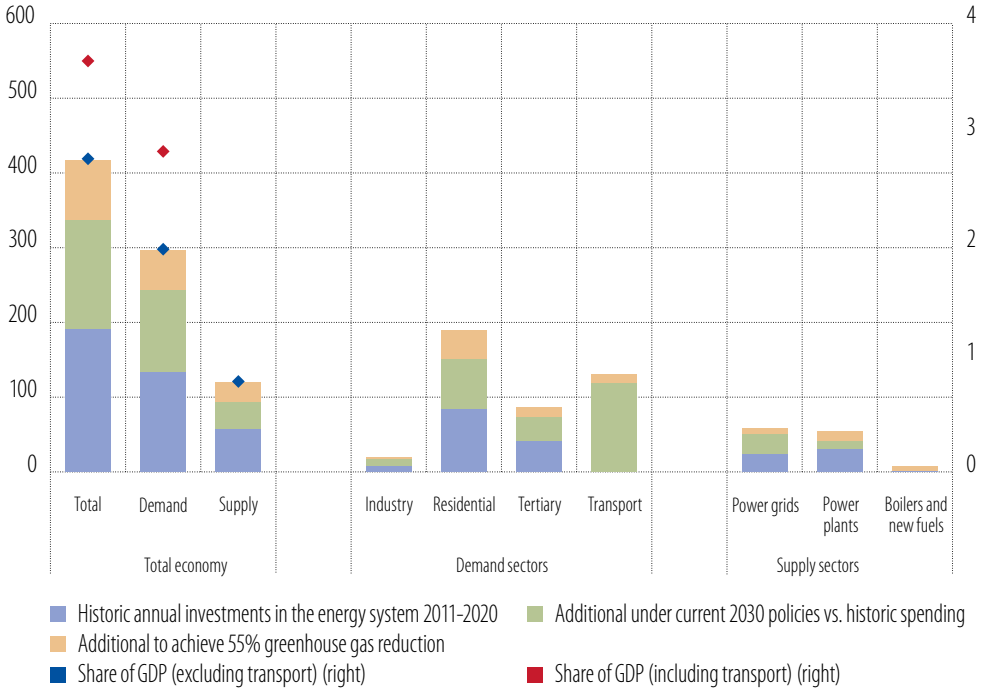
According to the EEA's assessment, 84% of policies and measures were adopted by central governments while 16% were introduced by regional or local authorities. However, local levels of government, and particularly municipalities, are key players in areas such as waste management, public and private transport as well as residential energy efficiency. Recognising this role, the European Union launched the Covenant of Mayors for Climate & Energy in 2008. The aim was to facilitate networking among municipalities willing to adhere to or exceed EU targets for climate and energy. Another initiative involving municipalities in Europe is the Urban Agenda for the European Union, established in Amsterdam in 2016, which also recognises municipalities as key hubs for innovation and experimentation in the climate field. The principle of networking and replicating the best practices of other Member States' policies has a powerful influence on municipalities as well.

Overview of total EU investment needs

The European Commission's latest impact assessment analysis (2020) indicates that annual energy-related investment of around EUR 550 billion is needed throughout the current decade. The new proposal to cut greenhouse gas emissions 55% by 2030 increases the annual energy-related investment needed by an average of about EUR 100 billion a year compared to the baseline scenario in 2021-2030 (Figure 16) and close to EUR 200 billion for 2031-2050. To achieve both the new greenhouse gas target by 2030 and carbon neutrality by 2050, spending would have to increase steeply to around 3.1% of GDP a year in the current decade (excluding transport investment needs), then decline over the next five years to 2.5% of GDP before ramping up again to around 3%.

The European Commission estimates that around 2% of the European Union's GDP is currently invested annually in the energy system and related infrastructure. This estimate includes spending on conventional technologies and excludes spending on transport for 2011-2020 (Figure 16). The baseline envisages a broadly similar investment-to-GDP ratio, implying around EUR 340 billion, or 2.3% of GDP a year up to 2030. The new proposed greenhouse gas emission reduction target of 55% increases the annual additional investment needs by about EUR 220 billion (excluding transport) compared to historic trends.

Figure 16
Annual investment expenditure, 2021-2030 vs. 2011-2020 (left axis: EUR billion; right axis: % GDP)



Source: *European Commission.*

While all economic sectors will need to contribute to the transition, the scale of the challenge is not the same. Some sectors (Figure 16) will have to invest more to reduce their energy and carbon intensity and play their part in the EU climate plans. In the current decade, the largest portion, namely 65-75%, of total additional investments are expected to come from final energy consumers, involving building insulation, the improvement of industrial processes, efficient equipment and new transportation technologies. By contrast, the majority of additional investments in 2031-2050 should come from the energy suppliers, involving the development and strengthening of energy infrastructure, the building of renewable energy power plants and facilities for storing energy, as well as the production of carbon-free hydrogen and synthetic fuels.

Box E
Zoom on global scenarios for future climate investment needs

The IEA (World Energy Investment 2019, p30) compares the current level of investment and the required level in two global scenarios, the New Policies scenario and the Sustainable Development scenario. Under the Sustainable Development scenario, investment in the power sector is one-third less than what is needed for decarbonisation and electrification. The requirements include a two-fold increase in spending on renewable power as well as higher spending on nuclear and electricity networks.

One of the IEA highlights the relative lack of policy attention to energy efficiency and consumers.

The Intergovernmental Panel on Climate Change (IPCC) reviews a number of models looking at global investment needs, broken down between the OECD and non-OECD blocs. When climate policy

constraints are absent, the models show a reliance on fossil fuel energy, particularly in the non-OECD countries. Introducing climate policy objectives results in a reduction in fossil fuel investment and an increase in renewable energy. This implies an increase of approximately 100% in the global annual investment in renewables, nuclear and electricity generation, and carbon capture and storage over from 2010 to 2029.

European Union's experience backs up this idea. Nearly all investment in the European Union has gone towards renewable energy, with very little dedicated to fossil fuels.

However, the same kind of shift has not happened outside the European Union. Some Asian economies, for example, are still making significant investments in fossil fuel generation.

The analyses from different bodies (Box E) all indicate that the current level of climate investment falls short of what is needed to meet environmental objectives. The estimated investment rates in the previous sections indicate that the European Union is struggling to maintain a level of investment that was already insufficient for achieving climate goals.[17] Although climate investment is not calculated on the same basis as other investment trends, climate investment has declined slightly as a share of GDP and of GFCF since 2016, a trend that will likely continue in 2020. The gap between the investments made and climate objectives seems to be increasing.

The gap is small, particularly considering the uncertainties of long-term climate projections. It is still cause for concern, however, because it suggests that the European Union is moving in the wrong direction. Climate investments are slowing whereas all of the climate scenarios indicate that they need to increase. Although falling costs for renewable energy generation mean that more capacity is being installed per euro of investment, the price drop is not likely to be enough to compensate for the lack of investment. European markets are mature and an increasing proportion of investment is going towards replacing existing capacity rather than building new capacity.

Overview of National Energy and Climate Plans

The investment needs[18] set out in Member States climate plans are not sufficient to achieve EU climate objectives. Concretely, EU members have assessed their investment requirements for the climate transition in different degrees of detail, with at least one paragraph devoted to this issue in the last chapter of each NECP. The sum of the Member States' investments is slightly below the EUR 260 billion required annually to meet the 40% emission reduction target, according to the European Commission's calculations. In line with the new target of 55%, investments should be scaled up to around EUR 340 billion a year. Figure 17 summarises the current plans and the estimated increase in investment needed to achieve the new target.

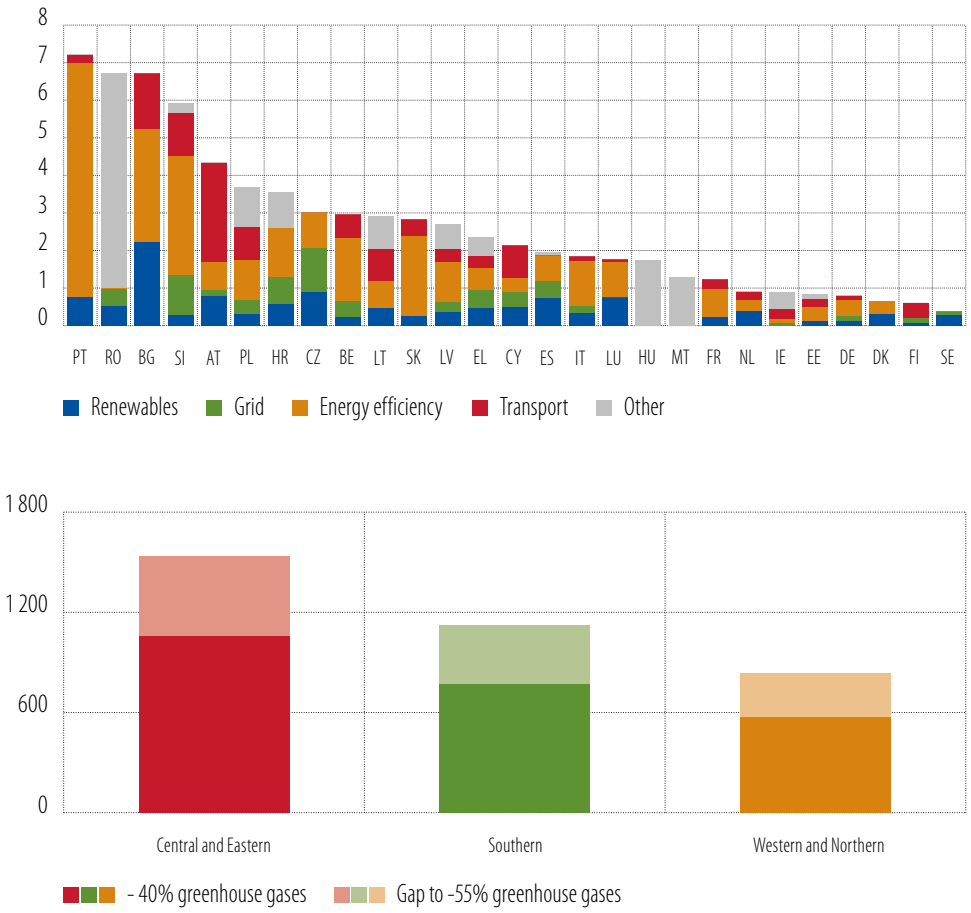
Investment needs are higher for Central and Eastern Europe (as a share of GDP), and for energy efficiency measures. As a share of GDP, the stated investment needs fall into three groups: Eastern European countries, where investment needs are very high; the large countries of Southern and Northern and Western Europe, where investment needs are mid-range; and the countries for which the transition is more advanced (Finland, Sweden and Denmark), where investment needs are lower. Central and Eastern European countries started the decarbonisation process later than Western European countries, and more effort is needed for them to catch up. Once again, the NECPs show that almost half of the investment needs concern energy efficiency investments (45%), with 20% of the total going to renewable energy, 10% to investment in grids and distribution networks, and 15% to transport-related investment. The remaining 10% falls into a variety of other categories.

17 (European Commission, 2020; IEA, 2020; IPCC, 2019)

18 The collected data refer to total investments, apart from Germany and Luxembourg (additional investments), Malta (public costs), and France, Italy and Portugal whose amounts are for total investments apart from transport (additional). Finland and Sweden reported only on part of the categories.

Figure 17

Climate investment needs[19] by country and category, targets of 40% vs. 55%



Source: *NECPs.*

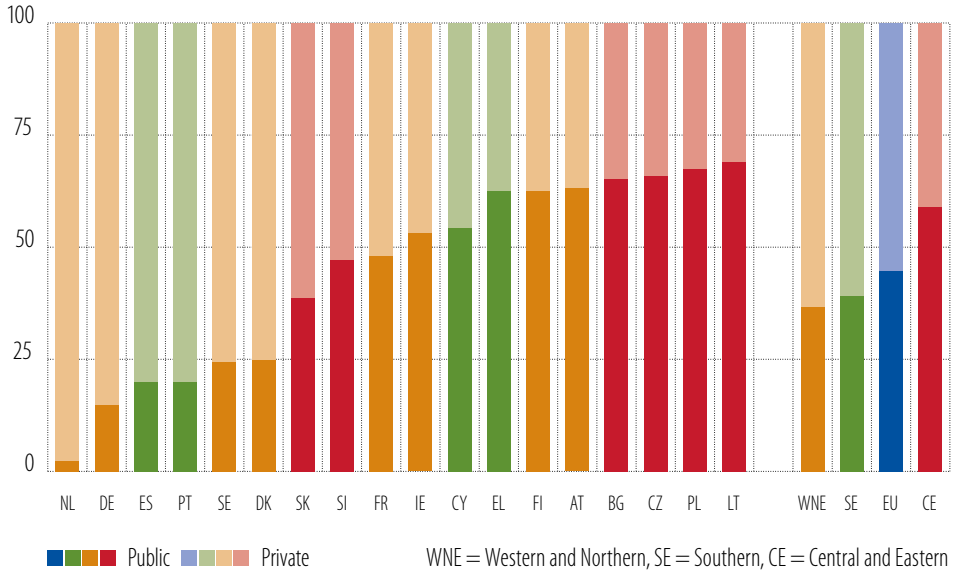
Note: *The first panel represents annual investment needs by country as a share of GDP (by category), the second panel represents investment needs corresponding to the 40% and the 55% emission reduction targets. The new investment needs are calculated with the contributions of country groups kept at a constant.*

Private investment has a more prominent role in Western and Northern Europe and Southern Europe. The plans refer to the overall investment needs, in many cases providing details on public-sector efforts (national or local authorities or European programmes) and expectations for the private sector. Public-sector investment needs are linked to the creation of required infrastructure in the energy distribution or transport networks, infrastructure built for zero- or low-carbon mobility, or increased energy efficiency in public buildings. In their NECPs, five Central and Eastern European countries explicitly quantify fairly high investment needs in their distribution networks. In addition, a significant share of their electricity production still relies on coal, which, as it is phased out, will require other (mainly public sector) investments.

19 Note that some of the Member States' expenditure with no explicit climate-related goals was excluded from the table, and it is possible that other amounts that should have been included were not captured. One example of an excluded amount is the EUR 759 billion that the Italian plan shows as investment in vehicles, including "the gradual and natural renewal of the vehicle fleet." The table here includes only the incremental expenditure due to the policies mentioned in the plan (to be adopted) with respect to the baseline (at current policies). This difference amounts to EUR -27 billion (page 321, table 78 of the Italian plan). The same applies to Portugal, Cyprus and France.

At both national and local level, governments provide incentives (directly or in the form of tax expenditure[20]) for mobilising private investments. Private investments are encouraged through incentives for retrofitting buildings or production processes, energy production feed-in tariffs[21], auction prices, and offtake agreements[22] as envisaged by the NECPs. While it is not easy to determine how much of the overall EUR 2.6 trillion investment needed over the next decade will come directly from public investment, information contained in the NECPs suggests that around 45% on average (unweighted), with a much larger share (due to the EU funds' contribution) in Central and Eastern Europe (at almost 60%) and a more contained role in other countries (37% in Western and Northern Europe and 39% in Southern Europe, Figure 18). This issue is of particular relevance considering the current crisis that could hamper the private sector's propensity to invest.

Figure 18
Public and private sources of needed investments



Source: *NECPs.*

The targets embedded in Member States' renewable energy projections indicate a huge increase in wind and solar power as sources of energy. The NECPs suggest that from 2021 to 2030, installed capacity for wind (particularly offshore wind) will increase substantially, and solar energy is likely to see triple-digit growth rates in many countries (see Figure 19). In this period, the production of energy from biomass will also grow, but much less than from solar and wind power.

The NECPs indicate that Member States' production capacity based on solar PV (photovoltaic energy) will almost quadruple in Southern Europe and Central and Eastern Europe, while wind power capacity will almost double in the two regions. This heady growth has three consequences. The first is that integration in the grid will require investment in additional infrastructure by the network manager (often a state-owned enterprise), mainly to overcome discontinuities in the energy supply. The second is that this strong growth could generate a larger-than-projected decline in unit costs due to technological advances.

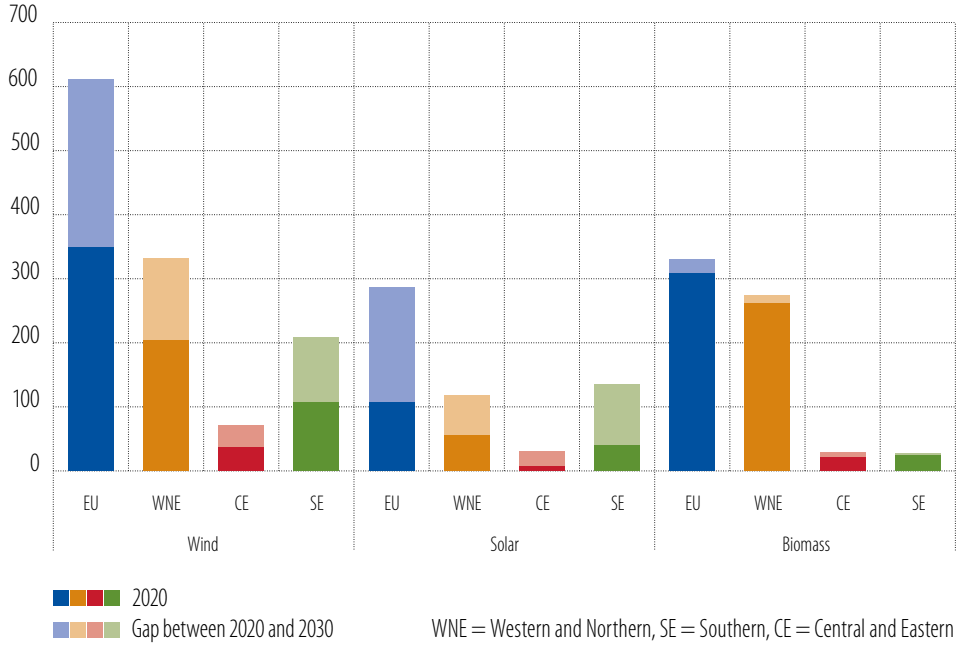
20 Tax expenditures are defined as a transfer of public resources that is achieved by reducing tax obligations with respect to a benchmark tax, rather than by direct expenditure.

21 Feed-in tariff is a mechanism designed to accelerate investment in renewable energy technologies by offering long-term contracts to renewable energy producers.

22 Offtake agreements are negotiated in advance, helping the renewable energy producer to sell their product at a locked in price, thereby improving the financial attractiveness of such projects.

The third is the need to provide storage capacity when renewable energy is produced, but not used[23], and the most obvious use of excess renewable energy is to produce hydrogen (through electrolysis[24]).

Figure 19
Planned growth in renewables[25]



Source: *NECPs.*
Note: *The unit of measurement is TWh.*

The NECPs highlight the growing role of hydrogen, mainly in Power-to-X[26] technologies, but also in other areas. A majority of national plans rely on hydrogen technologies for the climate transition (19 out of 27 countries, with only one country not mentioning it at all – see Figure 20 and Box F on hydrogen technologies).

Member States do not typically report on carbon capture, utilisation and storage technologies. While installations to capture and store carbon dioxide are recognised as necessary for achieving carbon-neutrality to compensate for unavoidable emissions, explicit reference to this technology is not frequent in NECP plans. In fact, almost half of countries do not mention carbon capture or include only generic references to it (Table 1). The theme is included among the research topics (with explicit financing) in seven plans, four of which allude to international (or EU-sponsored) collaboration. Currently, two pilot projects are operational (and one has been abandoned).

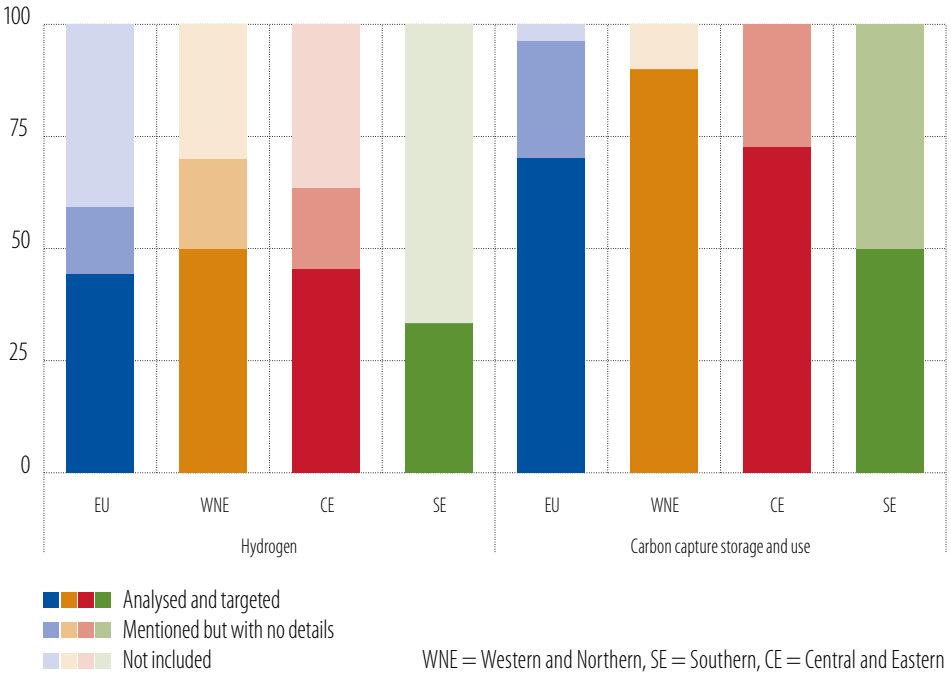
23 During the summer months, a large share of energy demand in some EU countries is already satisfied by renewable energy. Excess solar or wind energy should be stored by accumulators or transformed into a zero-carbon fuel like hydrogen.

24 Electrolysis is a clean method of producing hydrogen, by splitting water into hydrogen and oxygen using renewable energy.

25 Note that the table presents data harmonised using different sources and partially different concepts. Some EU members present targets referring to installed capacity, others to production and a third group to final demand. The concept of capacity was converted into the concept of consumption using the implicit conversion rate in the tables on the two concepts presented on page 43 of the German NECP.

26 Power-to-X refers to the transformation of surplus renewable electricity into fuel (hydrogen in this case).

Figure 20
Hydrogen and carbon capture, utilisation and storage in the NECPs



Source: *NECPs.*

Table 1
Implementation of key technologies in the climate transition, by country group

	Hydrogen				Carbon capture and storage			
	EU	WNE	CEE	SE	EU	WNE	CEE	SE
Explicit targets for charging station/ vehicles	8	4	3	1				
Research projects with allocated spending	11	5	3	3	7	3	3	1
International collaboration	11	7	3	1	4	1	2	1
Pilot projects	5	1	2	2	2	2	0	0

Source: *NECPs.*

Box F
Hydrogen

Hydrogen, which can be used to store excess renewable energy and as a fast-recharging fuel for a wide range of vehicles, has significant untapped potential. Hydrogen solutions – such as renewable hydrogen, which is produced by electrolysis using renewable electricity, and combinations of low-

carbon hydrogen generated from steam methane with carbon capture and storage – can help decrease carbon emissions, yet none of these technologies have been scaled up in the European Union. Apart from reducing carbon emissions, hydrogen holds the possibility of creating jobs and adding more value than what is currently outlined under the NECPs. Some pilot projects are focusing on hydrogen infrastructure, by reusing or adapting exisiting methane infrastructure. But for the industry to reach its potential, proper regulation needs to be put in place, and the barriers to hydrogen's development overcome. Some top issues are:

(1) adequate hydrogen transport and supply infrastructure needs to be developed;
(2) the best hydrogen technologies need more time to mature and become competitive.

While specific government initiatives can support transport and infrastructure, to reach maturity, global, sector-neutral measures are needed such as ambitious targets set by Member States to reduce greenhouse gas emissions, as well as the application of a sufficiently high carbon tax.

The EU Hydrogen Strategy is the most ambitious energy transition policy internationally to date. While the strategies of countries such as Japan, South Korea and China prioritise the use of natural gas for hydrogen generation, with or without carbon storage, the European Union's EUR 430 billion pledge to the hydrogen strategy focuses more on renewable hydrogen.

The Clean Hydrogen Alliance, which consists of the European Commission, Member States and industry, is the cornerstone of the EU Hydrogen Strategy. Coordinated actions among EU members are needed to roll out hydrogen projects. A number of projects are already ongoing. Denmark and Germany are constructing a 3-5 GW offshore wind energy power plant to fuel trucks, buses, ships and aircrafts through a hydrogen electrolysis facility. Spain plans to construct a power plant with 100 MW of capacity, including a battery storage system and an electrolysis-based hydrogen production system.

What is exciting about hydrogen is that it can transform and store excess renewable energy. Countries that are already endowed with a large natural gas infrastructure have a strong start (Spain, Hungary). Hydrogen can also be used in private and public transport, for instance, it already powers buses, trains (Portugal and Germany, with the latter already operational since 2018), trucks, ships (Malta, Croatia) and planes. In a few countries, a significant number of charging stations are already functional (particularly in France). The number of charging stations is set to increase, while nine countries have targets for either the number of charging stations or the share of hydrogen in transport. A partnership between the Port of Rotterdam and Air Liquide aims to create a hydrogen corridor connecting the Netherlands, Belgium and West Germany by 2025. The project involves setting up the related infrastructure and electrolysis capacity to produce enough hydrogen to power 1 000 hydrogen-powered trucks. Sweden is working on an advanced industrial project for fossil-free steel production based on hydrogen. Luxembourg has also set the goal of making steel production more sustainable using hydrogen based on renewable energy.

Hydrogen is thus seen as an alternative for hard-to-electrify transportation or industry. However, the bulk of investment in hydrogen (and, to a lesser extent, renewable energy in general), is expected to take place at a relatively late stage, with costs falling as the technology matures.

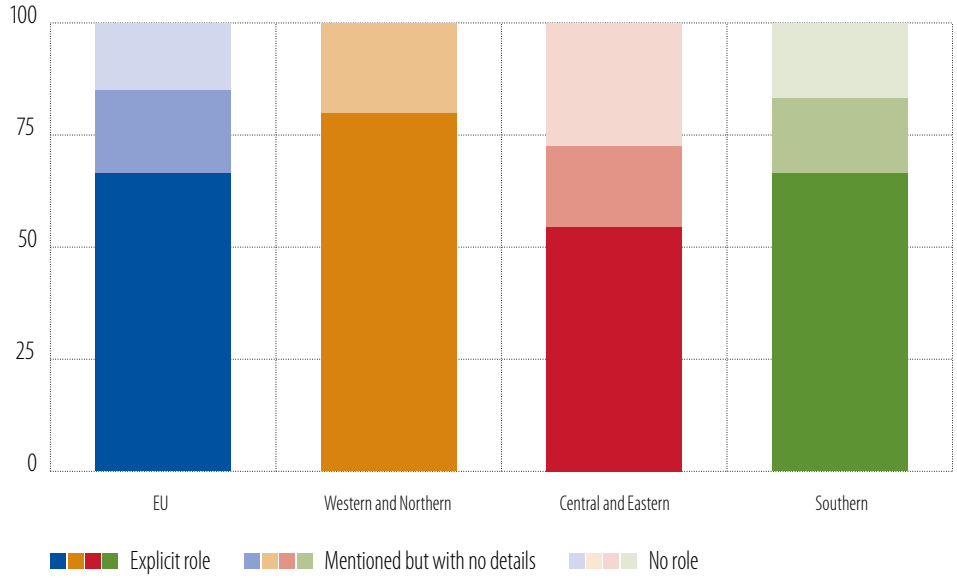
Around 50 hydrogen projects are in the early stages of development worldwide, and annual hydrogen demand is expected to grow to 8.7 million tonnes by 2030. According to the Institute for Energy Economics and Financial Analysis (IEEFA), the projects already in development phase have a combined annual production capacity of 4 million tonnes of hydrogen, total renewable power capacity of 50 GW, and an estimated capital cost of USD 75 billion. Although delays are probable, large-scale hydrogen facilities are expected to start operating by 2022-2023 and 2025-2026.

Member States need to make better use of regional cooperation when setting climate objectives, using that cooperation to build on the NECPs. The European Commission pointed this out in its EU-wide assessment of the national plans (2020). Some existing forums already address energy transition priorities such as energy efficiency, transport, smart grids and renewable energy (skill shortages in renewable energy, for instance), but the transition could still be enhanced through regional cooperation. Four existing groups are especially worth mentioning: the Northern Seas initiative, the Baltic countries' plans for joint auctions of offshore wind, the Pentalateral Energy Forum, and Central and South Eastern Europe Energy Connectivity (CESEC). Regional planning for offshore wind would facilitate a steady pipeline of projects in a cost-effective way, provided a harmonised regulatory environment supported those projects. Beyond offshore wind, fast-charging networks for electric vehicles along Europe's main TEN-T transport corridors could also be developed regionally.

Local policies and coordination among municipalities

Municipalities are one of the key players in implementing green policies. In many countries, municipalities are responsible for the implementation of policies for energy efficiency, transport or waste disposal. In addition, municipalities issue regulations and provide a system of incentives and penalties with the potential to heavily influence people's individual choices (particularly in the areas of transport and energy efficiency). For this reason, local governments were active in the NECP consultation phase in all Member States. As Figure 21 shows, their role in shaping policies and implementation is explicitly mentioned in two-thirds of NECPs (eight out of ten NECPs in Western and Northern Europe, four out of six in Southern Europe and five out of 11 in Central and Eastern Europe).

Figure 21
The role of municipalities in the NECPs



Source: *NECPs.*

The municipalities' role is explicitly mentioned in transport, energy efficiency and waste management policies. While energy efficiency and mobility-related issues such as pollution and the time spent driving have local implications for the quality of life in an urban setting, municipalities are themselves greenhouse gas emitters and can therefore address their own carbon footprints. For transport (see Table 2), many policy measures can be effectively imposed locally, such as incentives encouraging public transport and low-carbon vehicles while limiting private vehicle use, topped up with direct investment in low-carbon public transport and infrastructure for vehicles using alternative fuels.

Table 2
NECPs highlighting the role of municipalities in climate-related areas

	EU	Western and Northern	Central and Eastern	Southern
Role in transport policies	10	4	2	4
Role in energy efficiency policies	12	6	3	3
Role in waste management policies	4	2	1	1
Renewables generation	2	2		
Data measurement	2	1		1
Association with Covenant of Mayors	5	1	2	2

Source: *NECPs.*

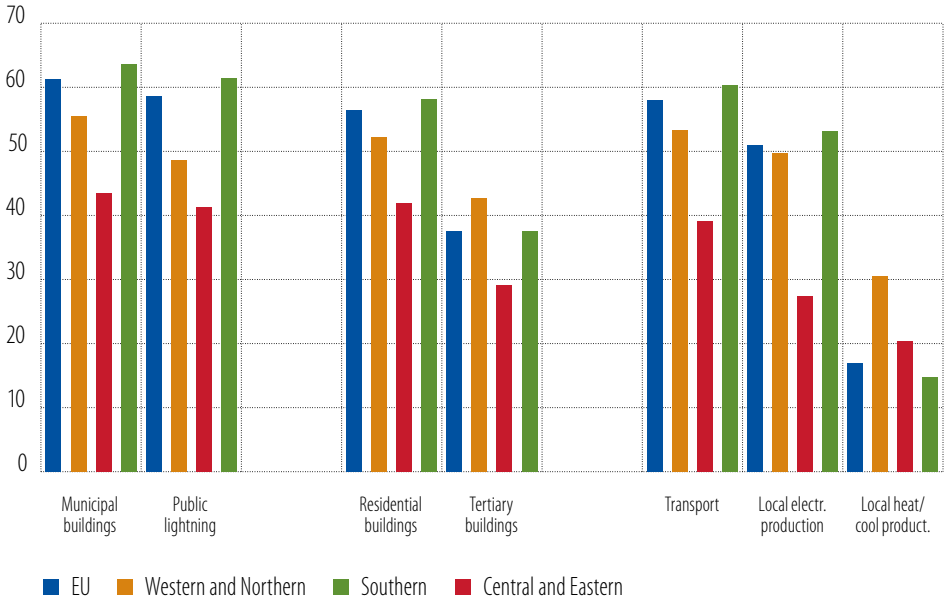
The NECPs also underline the role of the Covenant of Mayors, the largest EU network of municipalities, in the energy transition. There are various initiatives that bring together local governments voluntarily committed to implementing EU climate and energy objectives. The covenant now involves around 10 000 municipalities (10.5% of all municipalities in the European Union), with the majority (more than 80%) of adhering municipalities located in Southern Europe. Other countries also have widespread participation, such as Belgium in Western and Northern Europe or Hungary and Romania in Central and Eastern Europe. Municipalities that are part of the covenant commit to submitting a climate action plan within two years of their signature, describing targets and planned steps in climate mitigation or adaptation. By 2020, more than 6 500 (63%) of covenant signatories submitted an action plan with over 5 000 (50%) assessed and accepted by the European Commission's Joint Research Centre, while more than 3 100 (30%) already have monitoring reports.

Six out of ten climate action plans submitted to the Covenant of Mayors include climate mitigation actions that directly impact municipality operations. These climate actions can include public lighting or energy efficiency in municipal buildings (Figure 22), but a majority, 50% of plans, also involve the private sector (energy efficiency in residential buildings). More than half of the plans involve transport and local energy production. There are geographical differences, however. Southern European municipalities are less active in local heat production, and Central European municipalities are less active in local energy production.

The importance of coordination among municipalities is also highlighted in the EIB Investment Survey (EIBIS), which surveys municipalities' attitude towards networking (see Chapter 9). The related question asks "…how often, if at all, does your municipality/city coordinate its investment projects with networks of cities/municipalities with similar policy priorities, incl. associations such as Covenant of Mayors, or UN compact of mayors."[27] In what follows, "networking municipalities" are defined as those that answered "always" or "frequently" to this question, while the others are considered "not networking municipalities."

27 The answer options are "always", "frequently", "occasionally", and "never".

Figure 22
Targeted sectors in municipality climate action plans submitted to the Covenant of Mayors (%, by country group)



Source: *Covenant of Mayors' data.*

Municipalities that report being part of a network that shares policy priorities are smaller, more frequently located in Southern Europe and in areas leaning more towards manufacturing. Based on the responses, the group of networking municipalities is composed of smaller municipalities (the average number of inhabitants is 59 500 in networking municipalities vs. 105 500 in the whole sample). This difference is most pronounced in Southern European municipalities (with the average population of networking municipalities being less than half that of the whole sample), but the trend also shows up in Western and Northern Europe.[28] Municipalities coordinating with networks are more frequent in Southern Europe, particularly in Cyprus, Greece, Spain and Portugal (but also in Czechia, Slovenia, Slovakia and France). Municipalities that participate in networks seem to be proportionally more active in the manufacturing sector (26.6% of networking municipalities report that manufacturing is the most important employer in their area, vs. 19.8% for the others).

Table 3
Overview of networking municipalities (by country group)

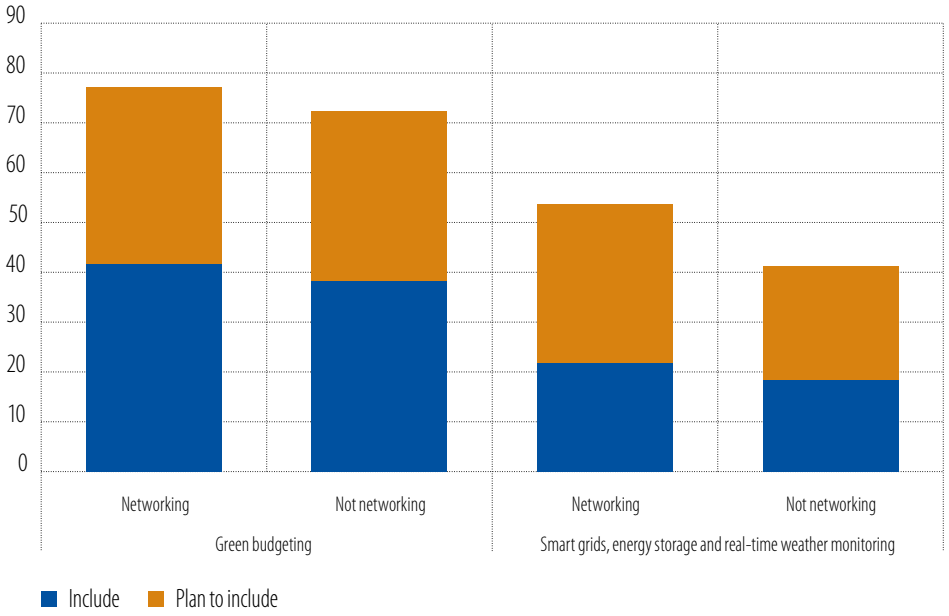
	Networking municipalities	Average population	
		Networking	Non networking
Central and Eastern	27.6%	58.1	49
Southern	37.0%	67.9	219.2
Western and Northern	26.0%	50.7	88.5
EU	30.3%	59.5	125.6

Source: *EIBIS Municipality Survey, population in thousands.*

28 In Central and Eastern Europe the reverse happens, as networking municipalities are bigger than the others.

EIBIS networking municipalities tend to focus more on climate change measures and policies. Figure 23 shows that regarding infrastructure investment, networking municipalities include (or plan to include) green budgeting more often. Similarly, they include projects for smart grids, energy storage, sensors and real-time weather monitoring more frequently than their non-networking counterparts do. The results are consistent whether using alternative definitions of networking, such as coordination with direct neighbour municipalities[29] or with municipalities in the same region.[30] Municipalities that coordinate locally with their peers are also likelier to embark on climate projects.

Figure 23
Adoption of green budgeting and climate investments in municipalities (%)



Source: *EIBIS Municipality Survey.*

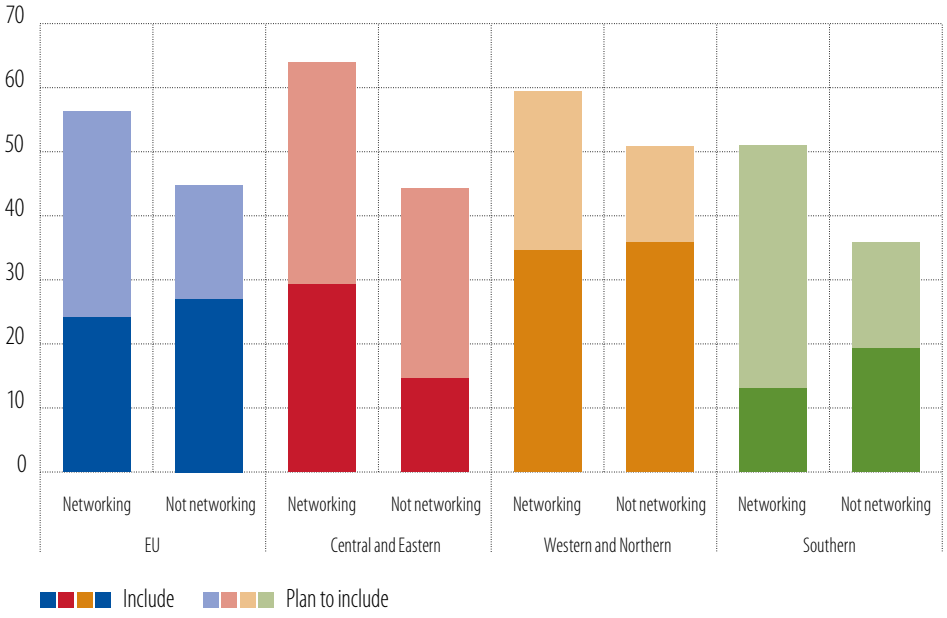
Networking municipalities tend to measure and analyse their carbon footprint more frequently, but large variations exist across country groups (Figure 24). The gap in measuring the carbon footprint between networking and non-networking municipalities is larger in Southern Europe and Central and Eastern Europe than in Western and Northern Europe. Similarly, the share of networking municipalities that plan to measure their carbon footprint is largest in Southern Europe. However, Western and Northern Europe rank first in the number of municipalities that already carry out carbon footprint exercises.

In recent years, networking municipalities have invested more in climate adaptation than non-networking ones (47.5% vs. 39.1%). The same is true of waste and water treatment (49.1% vs. 38.2%) and transport (48.2% vs. 36.3% for networking vs. non-networking municipalities respectively), while more networking municipalities consider their level of climate investment to be adequate (44.7% vs. 27.0%). In addition, networking municipalities have adapted their investment plans after the coronavirus pandemic more often (Figure 25, left-hand panel). Interestingly, their reaction seems to be in line with the European Union's strengthened climate-related ambitions. Municipalities are ready to step up their efforts (Figure 25, right-hand panel).

29 The related question asks ". . .how often, if at all, does your municipality/city coordinate its investment projects with neighbouring municipalities." The overlap with networking municipalities is 56%.

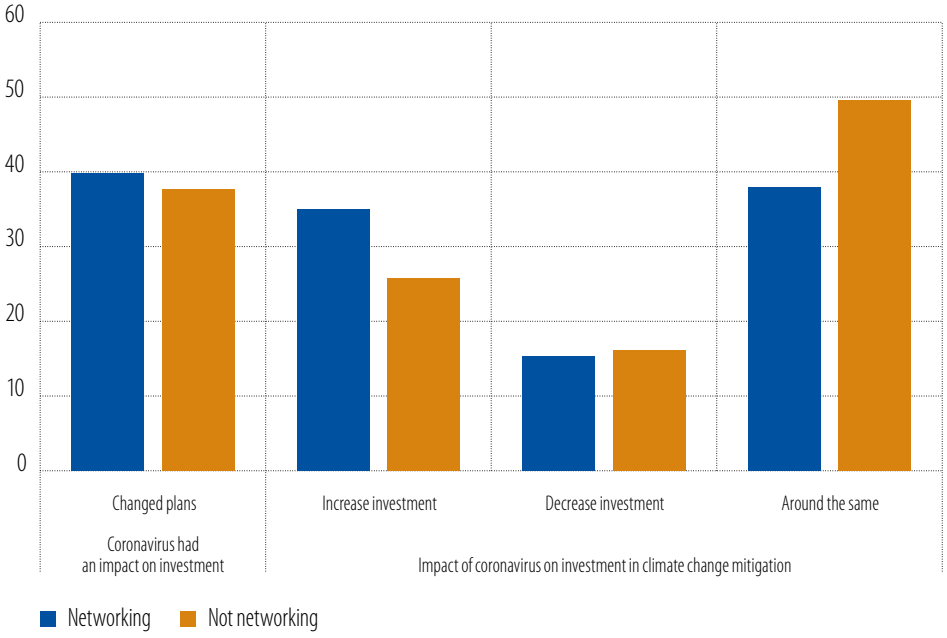
30 The related question asks ". . .how often, if at all, does your municipality/city coordinate its investment projects with other municipalities in your region (excluding your immediate neighbouring municipalities)." The overlap with networking municipalities is 66%.

Figure 24
Carbon footprint inventories of municipalities (by country group, %)



Source: *EIBIS Municipality Survey.*

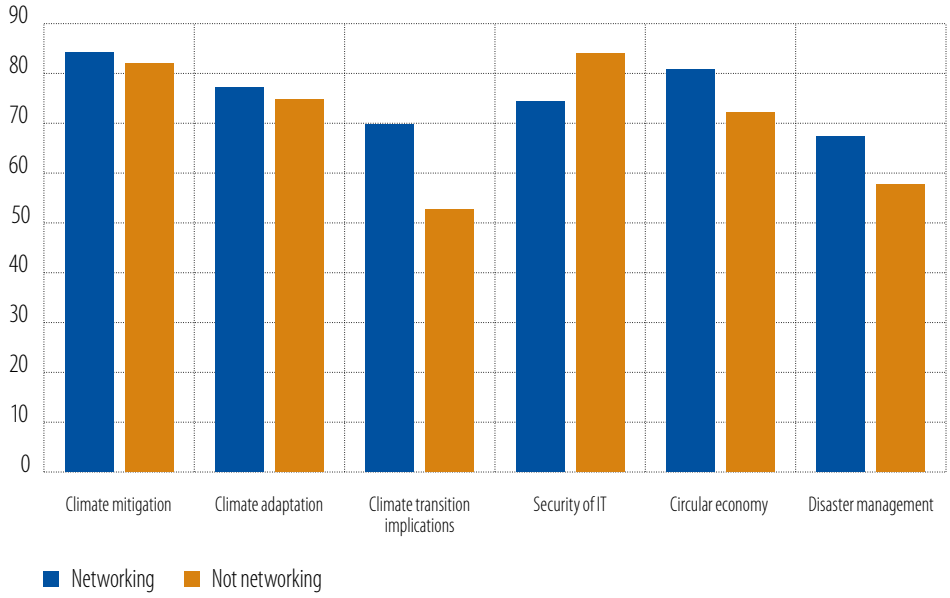
Figure 25
The impact of coronavirus on climate change adaptation and mitigation (%)



Source: *EIBIS Municipality Survey.*

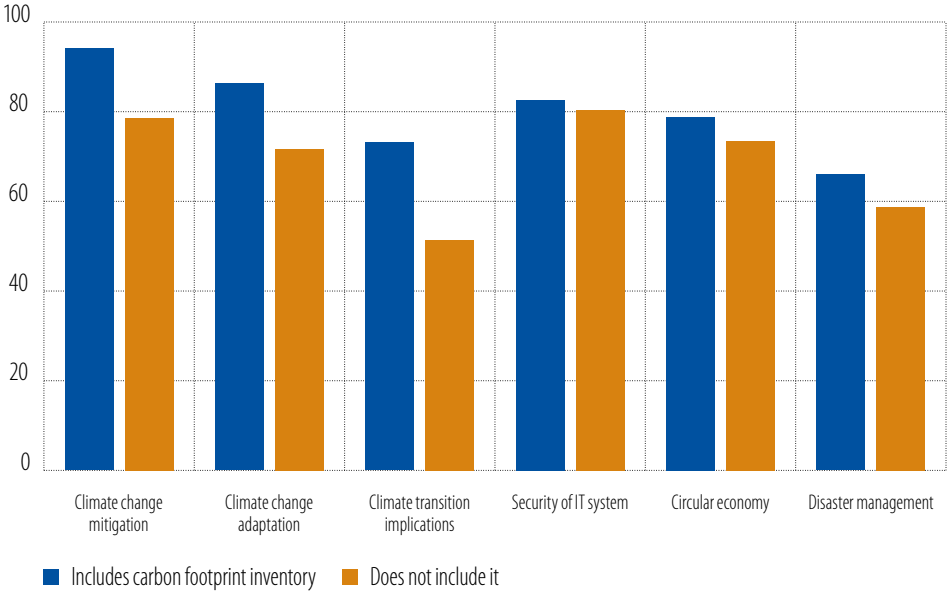
Networking municipalities plan to invest more frequently in climate-transition projects than others (Figure 26). The difference is most pronounced for the circular economy and climate change adaptation.

Figure 26
Climate-related and other investments by municipalities, networking vs. not networking (%)



Source: *EIBIS Municipality Survey.*

Figure 27
Climate and other investments and carbon footprint inventory (%)



Source: *EIBIS Municipality Survey.*

Climate action is correlated with awareness and the willingness to invest. Municipalities that have measured their carbon footprints[31] or have green budgeting procedures in place[32] are increasing their

31 Or which plan to measure their carbon footprint in the future.
32 The same is true for municipalities that have included or plan to include smart grids, chargers, sensors and real time weather monitoring in their investment projects.

investment in climate mitigation more frequently than municipalities without a (planned) carbon footprint exercise. Their plans also tend to include other climate change-related items more frequently.

The EIBIS Municipality Survey shows that municipalities are more sensitive to climate-related themes when they coordinate with a network with similar policy priorities. These municipalities may have more knowledge of available investment alternatives, can share plans and experiences and are exposed to the best practices of network peers. It also shows that a precise framework of measuring phenomena (carbon footprint inventory) or the transparency concerning climate-related expenditure (green budgeting) is associated with more active climate investment behaviour.

Conclusion and policy implications

Additional investments are needed for decarbonisation and to contain the fallout of climate change. Simply put, replacing carbon-emitting production facilities and fuels with cleaner sources as well as maintaining and upgrading existing assets requires continuous capital investments. The level of these needed investments rises with climate ambitions. Europe has been a global frontrunner in decarbonisation and more successful in lowering its carbon footprint than the United States and China. To get there, EU investments in climate change focused on two main areas: renewable energy and energy efficiency.

Yet the rate of investment needs to increase if Europe wants to become the first climate-neutral continent. The analysis of the NECPs and the European Commission's ambitions to reduce greenhouse gas emissions by 55% by 2030 indicate that energy-related investment would have to rise substantially – by around EUR 350 billion a year (including transport) over the current decade, compared to today's investment rates. The scale of the investment challenge is not the same across all economic sectors or EU countries. Some sectors, mostly energy-intensive ones, and certain countries, mainly in Central and Eastern Europe, will have to invest more to reduce their energy and carbon intensity and meet the EU climate plans.

Europe is a decarbonisation leader China and the United States, but China is rapidly catching up. Investment trends reflect climate policy priorities, with China following Europe in its climate ambitions and pledging to be carbon-neutral by 2060. However, the three regions are at different decarbonisation phases, which partly explains why Europe has to spend more to to lower its carbon emissions or improve energy consumption compared to China and the United States. Regions that have made more progress in curbing their emissions will eventually be forced to invest in more costly, less mature technologies, such as hydrogen and carbon capture and storage, to cut emissions further. This challenge will be global, and will become more evident as the world fights climate change. Europe should therefore support the scale-up of investment in these global technologies while using its financial and development arms to continue fostering the green transition in partner countries, where big gains can be made from the existence of much "low-hanging fruit."

In addition to investing in climate change mitigation, Europe should make its infrastructure more climate-resilient. Despite the significant increase (seven-fold) in adaptation investment from 2015 to 2019, resiliency efforts should be stepped up because the amounts spent on it are considerably lower than on mitigation. Resiliency investments are mainly funded by the public sector, as adaptation projects do not attract as much private-sector interest. Nevertheless, the pandemic has underlined the importance of planning for crises and physical risks, either acute or chronic, which will intensify in the future. It is therefore crucial for the European Union to make its infrastructure more resilient to extreme weather events by spending more on water and waste management, agriculture and forestry, and disaster risk management projects, in addition to investing in climate mitigation projects.

The pandemic is expected to stifle investment unless governments put in place stimulus packages focusing on green growth. The various actions proposed to fight the coronavirus pandemic could be crucial in determining Europe's climate success. The European Union's policy response, together with the benefits of the single market and economic and monetary union, could provide the impetus needed for a strong and green European recovery. The European Commission's 2020 recovery plan, NextGenerationEU, is likely to prove an important turning point. The size of the recovery support packages, the policy areas chosen for support, the financial instruments available to support them, and the willingness of the EU members to move towards a greener economy, could provide the crucial support needed for climate investments. Moving towards a carbon-neutral economy is a win-win situation, with more investments in climate and specifically in R&D, innovation, green technologies and digitalisation a potential boost for Europe's recovery and future growth.

Better coordination across Member States and municipalities would help the European Union achieve carbon neutrality by 2050. The European Union sets the targets and provides the EU-wide framework

governing the Energy Union, while the Member States shape and align their policies accordingly. Coordination has started recently and could benefit further from discussions on common plans that could achieve the economies of scale needed for transformative technologies. However, given the coronavirus crisis, the reliance on private investment in Member States' climate plans could be too optimistic. The need to step up efforts to combat climate change and the need to support the economy call for public intervention and a strong role for public investment at all levels of government. Local governments are best placed to provide direct answers to local challenges in climate mitigation and adaptation. As the EIBIS shows, networking municipalities are more aware and responsive when it comes to measuring their carbon footprints and introducing green budgeting, and they are more willing to invest in climate mitigation, adaptation and the circular economy.

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Chapter 5

Climate change risks: Firms' perceptions and responses

The transition to a carbon-neutral society presents a major opportunity for all firms. The decisions that firms will take today about tackling climate change will affect their competitiveness and show whether they will play their part in the energy transition. Firms are critical to closing the gap in the investment needed for the European Union to reach the carbon-neutrality goal. Most of the necessary investment will have to come from the private sector.

Nevertheless, less than half of European firms invest in climate measures and significant differences exist among EU members. While 50% of the firms in Western and Northern Europe invest in climate measures, only 32% of Eastern European firms do so. Furthermore, small and medium-sized enterprises (SMEs) and firms in the services and construction sectors are much less likely to invest in climate-related measures. Therefore, firms should step up their efforts.

Several factors are influencing the decisions of EU firms to invest in climate, with regulatory uncertainty and taxation being the most frequently identified obstacles. Regulatory uncertainty and taxation affect the cost-benefit analysis of climate investments, and they need to be structured in a way that supports long-term climate objectives. EU firms are also constrained by the availability of skilled staff, the high upfront cost of climate investments, and to some extent by the limited availability of finance – uncertainties about climate change and existing technologies also weigh on their decisions. These issues should be tackled to boost climate investment.

Firms might not have fully internalised climate change risks yet. Consequently, increasing firms' risk awareness could be also key to increasing investment in climate-related measures. Around one in five European firms state that they are significantly affected by physical climate risks, particularly in Southern Europe and in the infrastructure sectors. In parallel, the majority of EU firms believe that the transition to the net-zero carbon future will have little or no impact on their reputation, supply chain or market demand. While EU firms are more worried about physical and transition risk than US firms, policies to enhance awareness about the impact of climate change are necessary to adjust perceptions and to steer firms towards appropriate climate action.

COVID-19 has been the dominant force in 2020, and the related downturn in the European economy is likely to limit investment in climate-related measures. Around 43% of EU firms that planned climate-related investment are expected to postpone their plans due to the COVID-19 crisis. However, the pandemic could be turned into an opportunity, as at least 30% of the Multiannual Financial Framework (2021-2027) and NextGenerationEU funding will be spent on climate objectives. Europe's response to the economic fallout reflects the European Union's commitment to implementing the Paris Agreement and may act as a once-in-a-lifetime opportunity to accelerate the fight against climate change.

Introduction

Climate change and related policies are pressing, systemic issues that pose high risks to firms' business environments. Besides the most direct physical risks, such as operational impacts and supply shortages caused by extreme weather events, firms also face transition risks that arise from society's response to climate change. These include changes in technologies, markets and regulation. Transition risks may increase the cost of doing business by influencing energy and product prices and, consequently, may undermine the viability of existing products or services, or affect asset values.

Climate change risks are something that all economic players face. These risks are affecting, in one way or another, the competitive environment and may affect certain companies, industries and sectors more than others. Some analysts consider energy-intensive businesses and particularly energy producers to be the most vulnerable to the negative effects. Others highlight geographic risks and say, for example, firms in Southern Europe are more directly affected than firms in Northern Europe. The reality is that today no one is entirely safe from climate risks.

Nonetheless, climate change also offers several business opportunities. For example, firms can engage in energy efficiency improvements to reduce their energy costs and enhance their competitiveness. Similarly, other firms can reduce their reliance on price-volatile commodities, such as fossil fuels and precious metals, by shifting towards more sustainable solutions. Another opportunity is to invest in innovation aimed at developing new products and services that are less carbon-intensive or reduce emissions. All these actions can boost competitiveness and offer firms new market opportunities.

Climate-related risks and opportunities mean that firms cannot continue with business-as-usual strategies, and explain why there is a call for business transformation. Firms must incorporate climate change into their core strategies to take advantage of the emerging opportunities and gain a competitive edge in this changing market environment. This means not only focusing on adapting to the changes that are already here but also preparing for the significant regulatory and economic changes that are likely to materialise soon.

It is no longer enough for firms to view climate-related investments through the prism of core business investments. Firms must begin planning today or risk losing ground to more forward-looking competitors. The energy transition to the net-zero carbon economy will create winners and losers. Only the best-prepared, creative firms that have already built up expertise will thrive in the long term. Others run the risk of lagging behind.

A carbon-neutral world is inevitable and many business opportunities are emerging in the changing landscape. It is essential to analyse whether firms are prepared for the upcoming challenges. In other words, do they evaluate climate risks adequately and do they act on their perceptions by making climate-related investments? To gain a better understanding of how companies perceive the issue of climate change, the EIB Investment Survey (EIBIS) asked firms across the EU27, the United Kingdom and the United States how they perceive physical and transition climate risks, whether they invest in climate-related measures and what the obstacles are to achieving greater levels of climate investment.

The chapter is divided into four sections, all analysing the answers given by the firms in the survey. The first section presents firm-level perceptions of physical and transition climate risks. The second section evaluates investment in climate-related measures made by European firms. The third section discusses the perceived obstacles that prevent firms from investing in climate action. The final section highlights the potential impact of COVID-19 on the investment in climate-related measures and the potential mitigation effects of the NextGenerationEU package. The chapter concludes by discussing how the information collected with the EIBIS can provide useful insights for designing the policies needed to accelerate climate investment by firms and help achieve the overall climate objectives.

Do firms understand the severity of climate change risks?

Analysing how firms perceive the severity of climate risks is key to understanding their decisions to invest in climate mitigation and adaptation. As shown in the literature (such as Sorrell et al., 2006), awareness of climate risks is a core element of climate investment decisions. Firms will only invest if the perceived benefits of investment exceed the associated costs. This assessment depends directly on their perception of climate risks – if firms perceive climate risks to be severe, they are likely to evaluate the investment benefits more positively and the investment costs more negatively. Appropriate assessment and pricing of climate-related risks could lead to more informed capital allocation decisions.

Two main types of climate-related risks affect firms: physical risks and transition risks. Physical risks cause physical damage to assets. They can be an outcome of a natural disaster such as a drought, flood or a wildfire (acute risks), or can relate to longer-term shifts in the climate (chronic climate risks such as rising sea levels or temperatures). Physical risks are likely to become more severe as climate change continues (Intergovernmental Panel on Climate Change (IPCC), 2018). Transition risks are policy and regulatory risks that are driven by the introduction of stringent climate policies that affect the cost of doing business and the returns on assets. Increasingly stringent climate policies are likely to affect the profitability of carbon-intensive firms and might well result in stranded assets. Physical and transition risks are not independent from one another (Bellon, 2019). In particular, a rapid changeover to a low-carbon economy creates transition risks, but also reduces the physical risks arising from climate change.

Understanding the drivers of firms' perceptions of climate change is crucial to designing successful climate-related policies. The literature (Sullivan and White, 2019; Leiserowitz, 2006; Lorenzoni and Pidgeon 2006) suggests that the perceived risks are based on a subjective judgment of potential damage, which is driven by cultural and ideological factors such as trust in institutions and personal experience. Generally, existing studies show a tendency for individuals to perceive climate change as less threatening to themselves than to people in geographically distant locations and in different sectors than the one in which they operate. In this context, the first part of this section focuses on how European firms perceive physical climate risks and the second part analyses their perception of the transition risks. The section also provides possible explanations for the differences between the perceived risk levels likely to drive climate investment decisions.

What are firms' perceptions of physical climate risks?

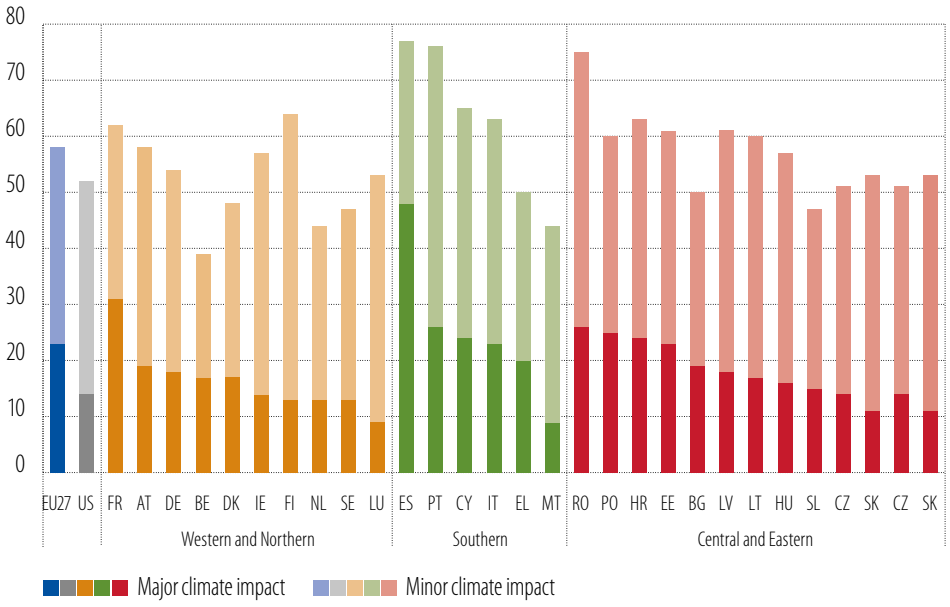
As the climate continues to change, the negative effects from extreme weather events and long-term shifts in climate patterns will intensify for firms. The consequences of climate change will differ from region to region and small and medium-sized enterprises (SMEs) might be disproportionately impacted because they usually operate locally and are less able to diversify their customer base geographically. Overall, climate change will result in increased maintenance and materials costs, as well as higher prices that will affect firms' competitiveness and the economy as a whole.

Climate change impacts all economic sectors, with some more vulnerable to acute events and others to chronic risks. In particular, acute events appear to have more of an impact on buildings and all kinds of infrastructure because of their design (low resistance to storms, for instance) or location (if they are built in areas prone to floods, landslides or avalanches). Some sectors, including energy, agriculture and tourism, are vulnerable to both acute and chronic risks. In the energy sector, climate change is shifting energy supply and demand patterns, often in opposite directions. Furthermore, droughts limit the output of hydropower plants. Agricultural production is also substantially affected – for crop yields and the locations where crops can be grown. Similarly, in tourism, climate change affects the timing of holidays, specifically those related to winter sports.

The economic consequences of climate change will differ from region to region, depending on how regional economies are structured. For example, regions that depend heavily on tourism, such as Southern and Central Europe, are most vulnerable. Southern Europe is expected to be hit hardest due to high temperatures, water shortages and extreme weather events that may cause lower or more variable agriculture yields. In this region, the risks of fire and disease are also higher, resulting in deteriorated ecosystems. Moreover, fire seasons are expected to be even longer and more severe in the future. Similarly, the energy sector will have to invest more in tackling the increasing need for air conditioning in Southern Europe. By contrast, climate change might prove less destructive in the northern parts of Europe because of the reduced demand for heating, the possibility of diversifying into new crop varieties and the increase in tourism.

While physical risks driven by climate change may be extremely severe for businesses, firms only partially take them into account. This disparity between the potential threats and how they are perceived may be attributed to the nature of climate risks and the social context in which those risks occur. As described by Bellon (2019), climate risks are often seen as remote, deniable and manageable – "remote" because climate change is frequently seen as a risk to future generations, with the more immediate effects disregarded; "deniable" because climate risks are uncertain and can often be denied and ignored; and "manageable" because firms tend to overstate their ability to adapt to climate change in the future.

Figure 1
Share of firms whose business activities are affected by physical climate risks, by country
(% of firms)



Source: *EIBIS 2020.*
Base: *All firms (data not shown for those who said don't know/refused to answer).*
Question: *Thinking about climate change and the related changes in weather patterns, would you say these weather events currently have a major impact, a minor impact or no impact at all on your business?*

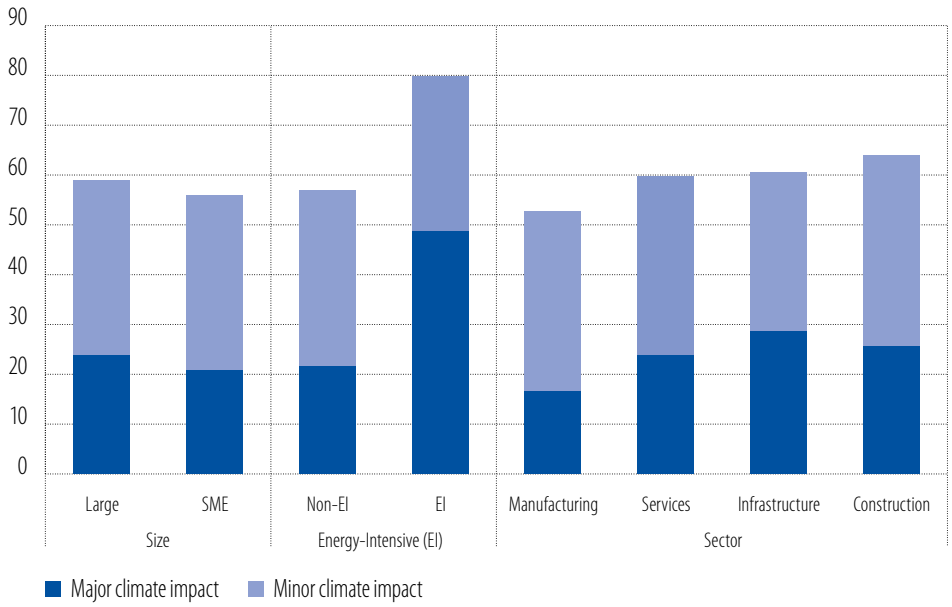
The discrepancy between the short investment horizons of firms and the long-term, often underestimated, impact of climate risks is likely to result in insufficient investment in adaptation measures. Since climate investments compete with other types of investment, this discrepancy is likely to discourage firms from investing in adaptation. Furthermore, even if climate risk forecasts do exist, managers are often reluctant to act until a natural disaster occurs (Connell, Miller and Stenek, 2009). As a result, unless the firm is located in an area characterised by high risks of natural disasters, it is unlikely to perceive the climate as a risk or to make subsequent investment in climate measures. To capture how the

business sector perceives the severity of physical climate risks, the EIBIS asked firms to evaluate whether they have been affected by climate extreme events.

Nearly three in five European firms consider themselves to be vulnerable to physical risks, with less than a quarter perceiving the risk as major. In the United States, a lower share of firms (52%) state that the climate impacts their business activities, with less than 15% saying they face a major risk (Figure 1). In the EU regions, firms in Southern and Central and Eastern Europe feel the impact of extreme climate events more. Across EU countries, Spain displays the highest percentage of firms that say the climate could affect their activities. Around 77% of Spanish firms cite climate events as a risk (with almost 50% considering them a major risk). Firms in Portugal and Romania are also worried about climate risks (Figure 1). In Western and Central Europe, the share of firms in France that consider climate change to be a major risk stands out at 31%. The figure rises to 62% overall when minor impacts are considered. The share of French firms considering climate to be a major risk is high compared to the other countries in this region, where the share of firms citing the importance of physical risks oscillates at around 45%, and only 20% of firms consider climate change to be a major risk.

Figure 2

Share of firms whose business activities are affected by physical climate risks, by sector and size (% of firms)



Source: *EIBIS 2020.*
Base: *All firms (data not shown for those who said don't know/refused to answer).*
Question: *Thinking about climate change and the related changes in weather patterns, would you say these weather events currently have a major impact, a minor impact or no impact at all on your business?*

Firms in energy-intensive[1] sectors as well as firms with operations more vulnerable to extreme weather events are more likely to single out physical risks (Figure 2). Almost 80% of firms in energy-intensive sectors indicate the impact of weather events on their business activities. Furthermore, firms with operations more vulnerable to extreme weather events – such as the infrastructure sectors, including electricity, utilities, transport, construction and services (most likely accommodation) – perceive physical risks as significant. Infrastructure sectors are also the most energy-intensive and their operation depends

1 Energy intensive sectors are the following (using the four-digit NACE classification codes for economic activities): 3511, 3520, 3521, 3522, 3523, 3610, 4950, 4950, 4950, 3530, 2410, 2420, 2431, 2432, 2433, 2434, 2442, 2014, 2013, 2351, 2016, 5100, 5110, 5121, 5223, 5223, 5223. With the exception of energy producers (gas, coal and electricity) that are considered as infrastructure sectors, the majority of these NACE codes comprise firms that operate in the manufacturing sector.

heavily on weather conditions, as is the case for instance in hydropower electricity production and water utilities. Contrary to what might have been expected given the disproportionate effects of climate change on SMEs, firms in all size classes perceive climate change effects in a similar fashion.

How do firms perceive transition climate risks?

Limiting global warming to well below 2°C compared to pre-industrial levels will require a transformation of business models, ultimately leading to the reprioritisation of economic activities. Besides tackling physical risks, firms will also have to prepare for the transition risks caused by the shift to a net-zero emissions future. Transition risks arise from the need to transform and to adapt to new regulations, with changing market preferences and standards emerging as a country embarks on the path to decarbonisation.

Firm assets that are carbon-intensive or heavily reliant on fossil fuels are the most exposed to transition risks. These risks potentially increase the likelihood of assets becoming stranded. Although the stranded assets discussion often focuses on fossil fuels, it is not only the firms that extract oil, gas and coal that could be put at risk by the transition. Firms that use fossil fuels for production, or are otherwise energy or carbon-intensive, could also be affected by new climate legislation, technological advances or a shift in demand.

However, the energy transition may also bring opportunities. From a cost perspective, these opportunities result from the efforts to reduce energy costs, for instance by investing in resource efficiency or by implementing renewable technologies. Resource or energy efficiency activities could cast light on "low-hanging fruit" – actions or initiatives that are simple, ready for operation, and require very little investment. These include the introduction of automation, insulation materials and ventilation and air conditioning, or more capital-intensive investments that improve production processes. From a profitability perspective, opportunities include potential profits that could be captured through the development of new technologies, products and services, which would open up new markets and sources of funding.

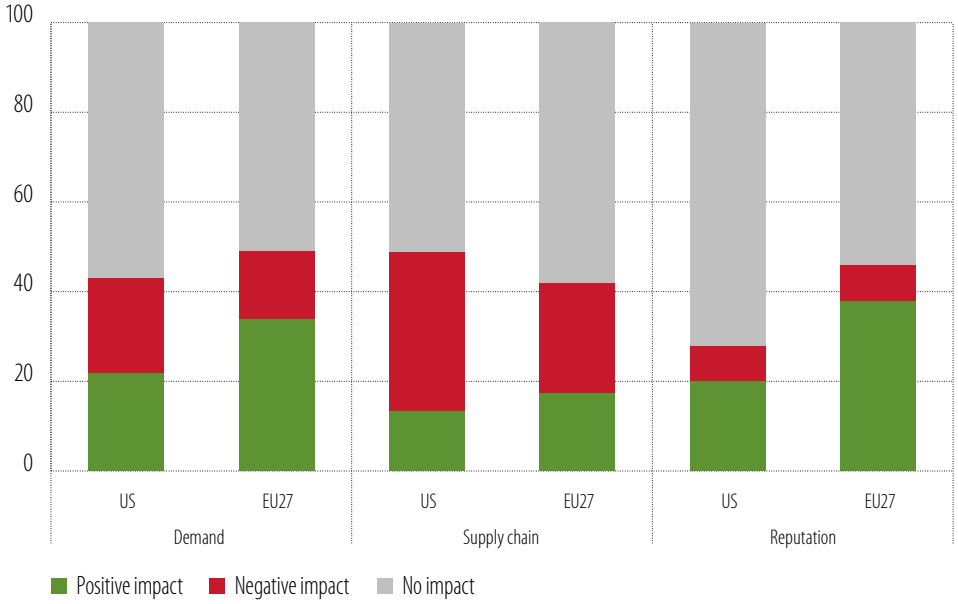
Transition risks are expected to increase over time because the EU climate framework obliges countries to take action to stay on track with the Paris Agreement. This action will gradually lead to stricter environmental regulations, placing a heavy burden on firms that fail to integrate climate change into their strategies. To capture how they see the transition to a net-zero emissions future, the EIBIS asked firms to provide their views on three core business elements: market demand, supply chain and reputation.[2] Since transition risks may have varying effects on the selected areas, the firms were asked to state whether the energy transition will have a positive, negative or no impact at all on their business activities.

The EIBIS shows that EU firms tend to disregard the relevance of transition risk for their own business. Most firms perceive transition risk as having little or no impact on their business. This is observed across the three core business elements – demand, supply chain and reputation (Figure 3). US firms hold similar views. Still, a higher share of all firms associate the climate transition with a positive rather than negative effect on their reputation and demand. This is not the case for the supply chain where more firms expect a negative effect than a positive one. Differences also emerge in the European Union, with firms located in countries in Central and Eastern Europe appearing to be less concerned about the effects that the transition will have on their business activities (Figure 4), especially on their supply chain and reputation.

2 These areas were selected based on the recommendations of the report of The Task Force on Climate-related Financial Disclosures (2019).

Figure 3

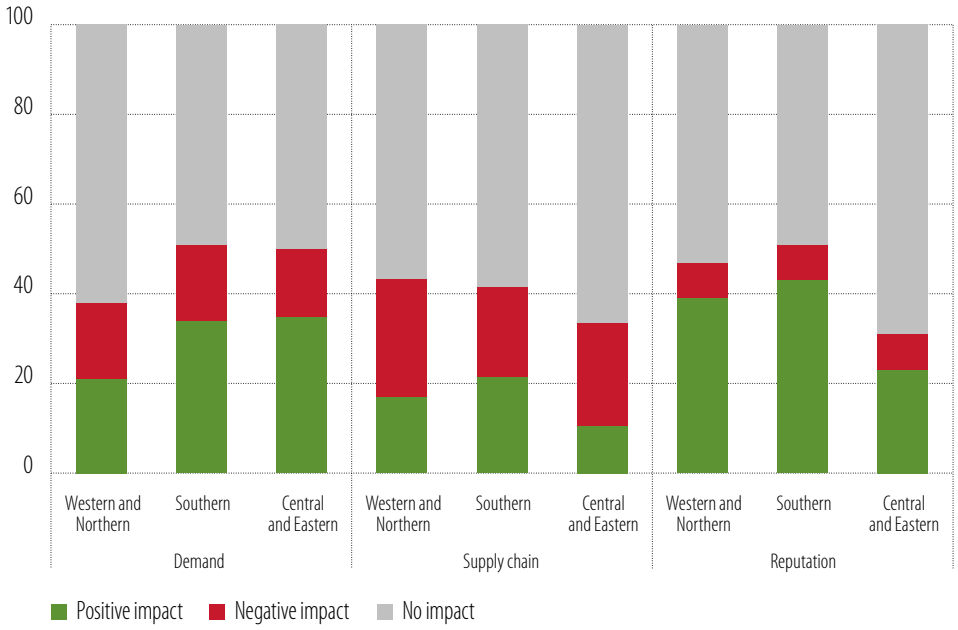
Impact of the energy transition on market demand, supply chain and reputation for firms in the United States and European Union (% of firms)



Source: *EIBIS 2020.*
Base: *All firms (data not shown for those who said don't know/refused to answer).*
Question: *What impact, if any, will this transition to a reduction in carbon emissions have on …….. over the next five years?*

Figure 4

Impact of the energy transition on demand, supply chain and reputation by EU region (% of firms)

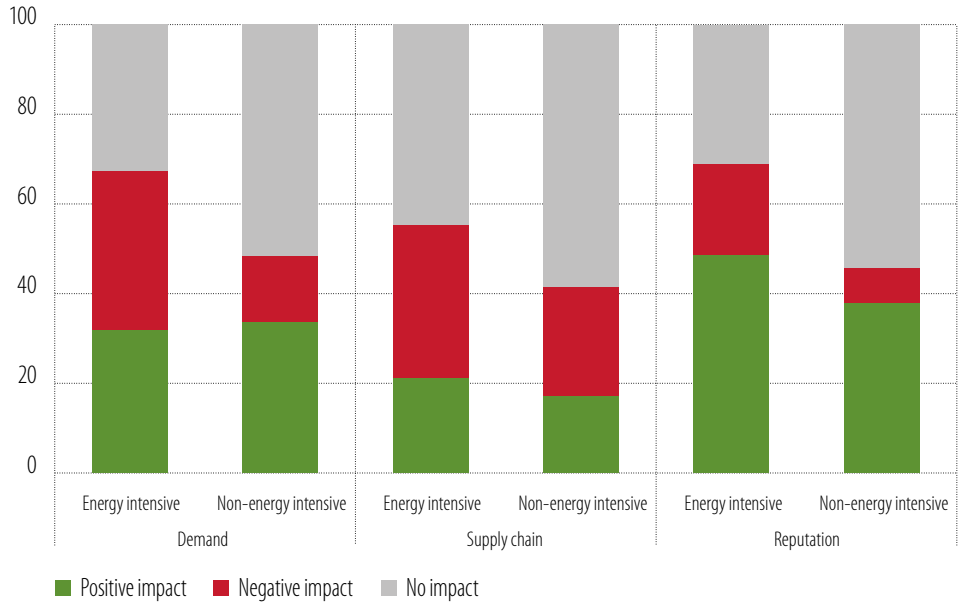


Source: *EIBIS 2020.*
Base: *All firms (data not shown for those who said don't know/refused to answer).*
Question: *What impact, if any, will this transition to a reduction in carbon emissions have on …….. over the next five years?*

Firms' energy intensity plays a part in whether they think they are exposed to climate risks. EU firms in energy-intensive sectors believe that the energy transition will significantly affect market demand and supply chains, with slightly more firms seeing negative effects than positive ones (Figure 5). Energy-intensive sectors are often subject to regulations related to local air quality, water, soil pollution and safety. Firms risk losing their licence to operate or becoming less competitive (due to the higher cost of doing business) if they do not comply with the appropriate regulations. As a result, firms in energy-intensive industries are more likely to state that the anticipated regulations will have an impact on their core business areas. In sectors that are not energy-intensive, firms consider these impacts limited and expect the overall net effect to be positive. In terms of reputation, all types of firms seem to believe that the energy transition will have a net positive effect.

Figure 5

Impact of the energy transition on demand, supply chain and reputation, energy-intensive and non-energy-intensive sectors (% of firms)

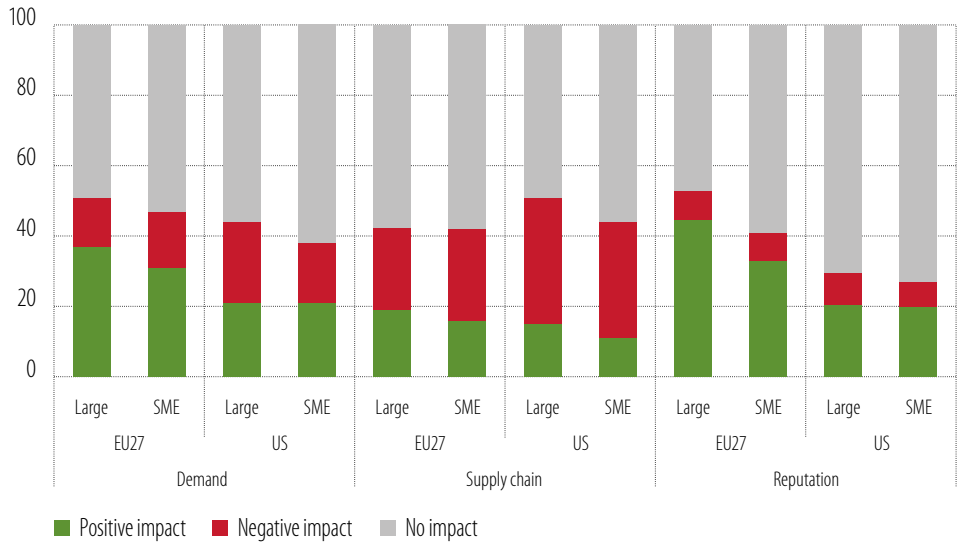


Source: *EIBIS 2020.*
Base: *All firms (data not shown for those who said don't know/refused to answer).*
Question: *What impact, if any, will this transition to a reduction in carbon emissions have on …….. over the next five years?*

To meet the long-term climate objectives, energy-intensive sectors need to accelerate their decarbonisation transition. In recent decades, these industries have made significant improvements in resource and energy efficiency. Nevertheless, meeting the EU 2050 climate goals requires further and much more developed low-carbon innovation. Such substantial decarbonisation involves not only technological changes, through low-carbon innovation, but also requires a broader socio-technical transition that entails changing user behaviour, culture, policy, industry strategies, infrastructure and science (Wesseling et al., 2017).

Large firms tend to view more positively the impact of the energy transition on demand for their products (37%) and their reputation (39%) (Figure 6). This is in line with the findings of multiple studies that show that large firms are more likely to engage in corporate social responsibility and pay attention to their environmental footprint given the pressure from consumers and investors (Perrini, 2007). The positive views may be driven by the fact that these firms are often subject to regulations such as the EU Emissions Trading System (ETS) and have already accounted for the energy transition objectives in their business strategies.

Figure 6
Impact of the energy transition on demand, supply chain and reputation, by firm size
(% of firms)



Source: *EIBIS 2020.*
Base: *All firms (data not shown for those who said don't know/refused to answer).*
Question: *What impact, if any, will this transition to a reduction in carbon emissions have on …….. over the next five years?*

While the majority of the EU firms state that the energy transition does not affect their supply chains, those that do observe an impact tend to hold negative views. Nearly three in five EU firms (58%) state that the energy transition will have no impact on their supply chains (Figure 3). Some 25% of firms in the European Union expect the transition to hurt their supply chains. This share is higher in the United States (some 35%). The negative perception could be explained by the fact that the energy transition might increase supply costs (costs of energy and non-energy raw materials). If suppliers incur greater costs due to new regulations, they might try passing them onto their consumers.

Box A
Which firms report an impact from climate change?

This box presents the results of simple econometric modelling aimed at understanding how firms' characteristics correlate with their own perception of physical and transition risks.

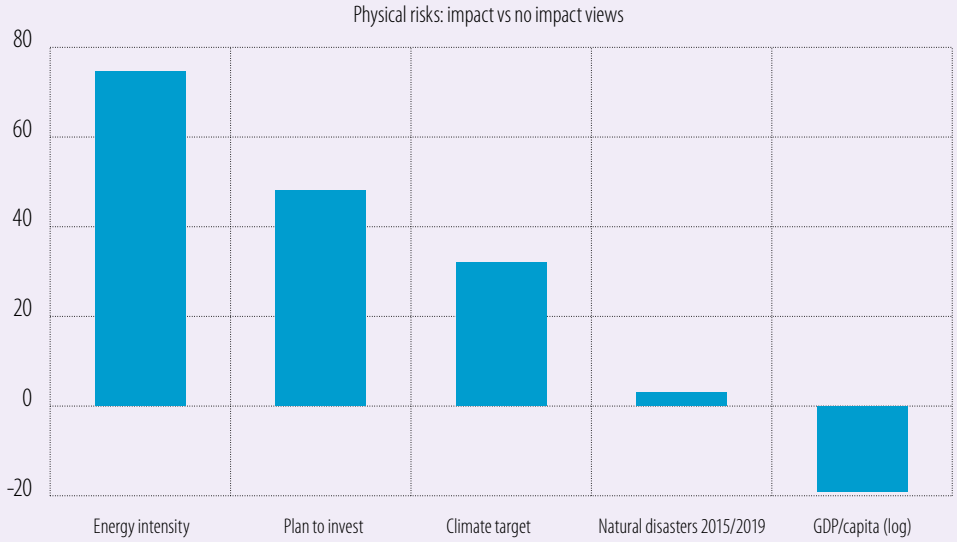
Accordingly, climate risk perceptions are regressed against firm-specific and country-specific attributes:

$$\text{Climate Risk}_{i,k} = \alpha + \beta\ \text{Firm Characteristics}_{i,k} + \gamma\ \text{Geography}_{k} + \varepsilon_{i,k},$$

where $\text{Climate Risk}_{i,k}$ indicates either: a) perceptions of physical risks, such as extreme weather events or b) perceptions of transition risks, related to the effects on the firm's market demand, supply chains and reputation. These risks are reported by firm i in country k. $\text{Firm Characteristics}_{i,k}$ is a vector of firm-specific attributes. These attributes include the firm's size (log of sales) and energy intensity (dummy representing energy-intensive sectors), and whether the firm has defined climate targets.

Geography$_k$ is a vector of country-specific attributes. For example, the physical risk equation includes the impact of gross domestic product (GDP) per capita and the frequency of extreme events on climate perceptions. The transition risk equation includes the country transition risk scores estimated by the EIB Economics Department. These scores are defined in a unit interval, ranging from 0 (best performer) to 1 (worst performer) after taking into each country's performance in emission and energy intensities, renewable penetration, fossil fuel rents[3] and climate policy objectives.

Figure A.1
Differences in predicted probabilities of perception of physical risks (percentage points)



Note: *The predicted probabilities were estimated using a logit model that accounts for clustered error terms. The figure presents coefficients that are significant at a level lower than 10%. The dependent variable takes the value of 1 if firms consider the impact of climate events as minor or major risks to their business activity and zero otherwise. Explanatory variables (other than the impacted predictor) are set at their mean.*

Figure A.1 presents the difference in the estimated probabilities associated with a number of predictors (firm characteristics). For each of those predictors, it shows how the predicted probability (of firms citing that climate change has an impact on their business) responds to changes in firm characteristics (from 0 to 1 for discrete variables or by one unit for continuous variables), while holding all other independent variables at their means.

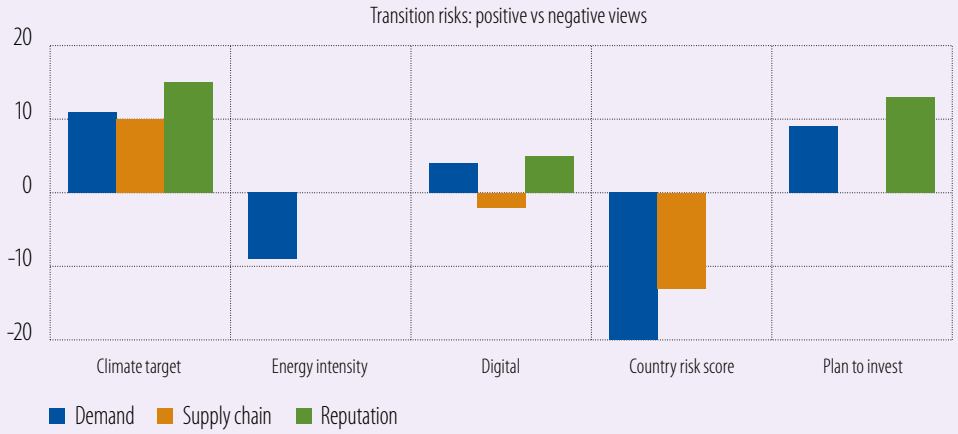
The probability of firms assessing that climate change has an impact on their business is greater when they are energy-intensive, have plans to invest in the next three years or have set climate targets. Firms are also more likely to identify the risks of climate events if they are located in countries more directly exposed to those events. By contrast, the probability of firms identifying physical risks as relevant for their business activity is inversely related to the GDP per capita of their country of operation. Higher-income countries most likely have a greater capability (fiscal space) to tackle physical risks, making firms and the public feel that their domestic infrastructure is more resilient to physical climate risks.

Focusing on transition risks (Figure A.2 compares the probability of holding positive views vs. negative ones), firms with climate targets are more likely to cite positive impacts of the transition to a carbon-neutral future on their demand, supply chain and reputation. This is also observed (except for supply chains) for firms that adopt digital technologies and plan to invest in climate measures,

3 Fossil fuel rents are the difference between the value of fossil fuel production at world prices and the total cost of their production.

which would most likely like to benefit from the first-mover advantage and see this as a climate opportunity. Conversely, in countries where the transition risks are higher, as reflected by their climate performance, the probability of firms holding negative views about the energy transition is higher, especially for their demand and supply chain. This is also the case for energy-intensive firms that tend to hold more negative than positive views on the impact of transition on their market demand.

Figure A.2
Differences in predicted probabilities of perceived transition risks for selected outcomes (percentage points)



Note: *The predicted probabilities were estimated using an ordered logit model that accounts for clustered error terms. The figure presents coefficients that are significant at a level lower than 10%. The dependent takes the value of 1 if firms believe that the transition to net-zero carbon future will have a negative impact, 2 if they do not perceive any impact and 3 if they see this transition as a positive development for their demand, supply chain and reputation.*

How do firms respond to climate change risks?

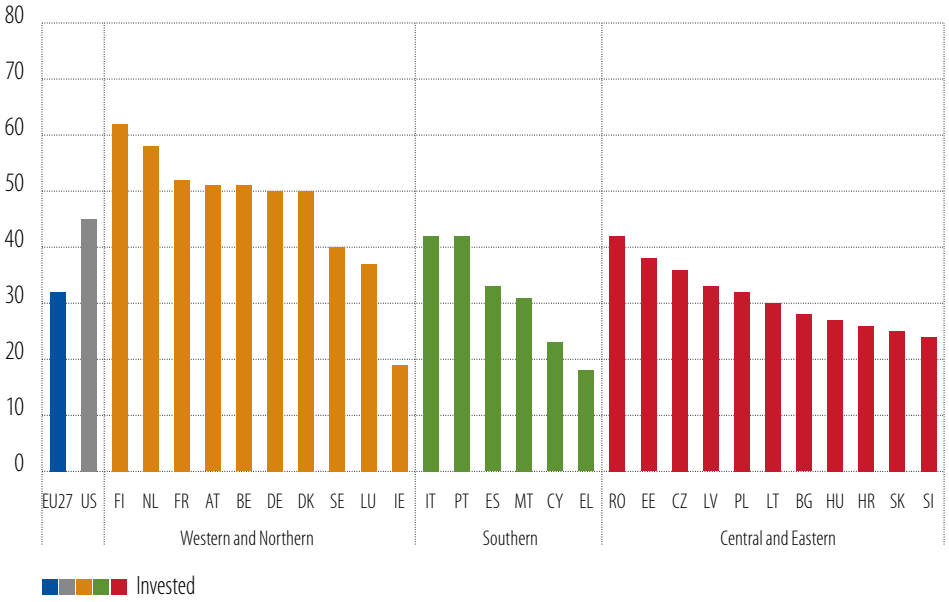
Firms have a crucial role to play in tackling the climate emergency and addressing the associated climate risks. There are two main options for addressing climate risks (through investment in mitigation measures or in adaptation measures), but each option addresses very different challenges.[4] Mitigation measures reduce emission levels, preventing rapid temperature increases. As a result, they address a global challenge that does not respect borders and requires international action. Adaptation is a response to, rather than a slowing of, climate change. It diminishes risks that are likely to be much more localised. Combating climate change requires investment in both mitigation and adaptation. Firms should develop and implement mitigation strategies that target global challenges, while also addressing local risks driven by climate change.

Climate investment can be a business opportunity for companies. Technological improvements or innovations that support the transition to a lower-carbon, more energy-efficient economic system can have a significant impact on businesses. For example, the development and use of emerging technologies such as renewable energy, battery storage, energy efficiency and carbon capture and storage will affect the competitiveness of businesses, their production and distribution costs, and ultimately the demand for their products and services from end users.

Climate investment is likely to differ by geography and sectors. This is because climate investment requires an awareness of climate effects, upfront capital and needs to compete with other potential investment projects – all of which tend to differ by country and industry.

4 For more information on mitigation and adaptation measures and investment trends in these areas, please see Chapter 4.

Figure 7
Share of firms investing in climate-related measures to tackle climate change risks (%)



Source: *EIBIS 2020.*
Base: *All firms (data not shown for those who said don't know/refused to answer).*
Question: *Has your company already invested to tackle the impacts of weather events and reduction in carbon emissions?*

Nearly half of European firms invest in climate measures, but there is a considerable difference among regions. In 2020, 45% of European firms invested in climate measures, whereas the proportion for US firms was much lower at 32% (Figure 7). Climate investment in the European Union differs significantly between regions. While 50% of firms in Western and Northern Europe invest in climate measures, only 32% of Eastern European firms do so.

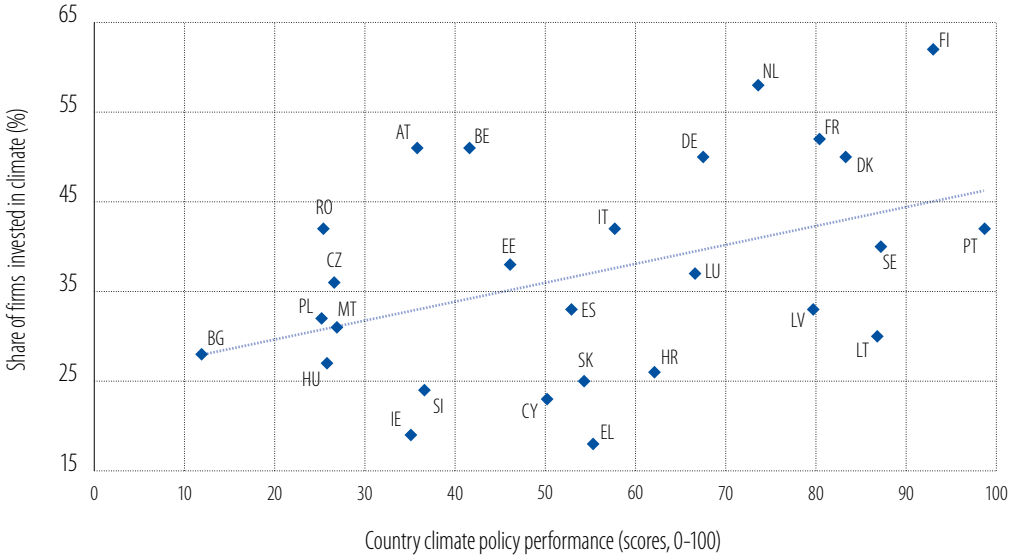
The differences between individual EU countries are even more pronounced. Firms in Finland and the Netherlands are at the forefront of climate investment: 62% of Finnish firms and 58% of Dutch firms invest in climate measures (Figure 7). By contrast, other EU countries are lagging behind in this area, with only 24% of Slovenian firms, 23% of Cypriot, 19% of Irish and 18% of Greek firms making this kind of investment.

Geographic differences in climate investments may be attributed to differences in the enabling environment in the EU Member States. As shown in Figure 8, investment in climate-related measures is positively correlated with the climate policy framework[5] of the country (Germanwatch, 2019). Finland, the country with the highest share of firms that invest in the climate, is ranked second for the stringency of climate policy and the prevailing conditions for climate-related investments. At the other end of the spectrum is Bulgaria – a country where only 28% of firms invest in climate measures and the climate policy is the least stringent. This relationship shows that the policies implemented by governments can play an important role in supporting investment in climate-related measures.

5 The index category "Climate Policy" covers the most recent developments in national climate policy frameworks, including (1) national climate policy and (2) international climate policy, and the qualitative data for these is assessed annually in a comprehensive research study by Germanwhatch (2019).

Figure 8

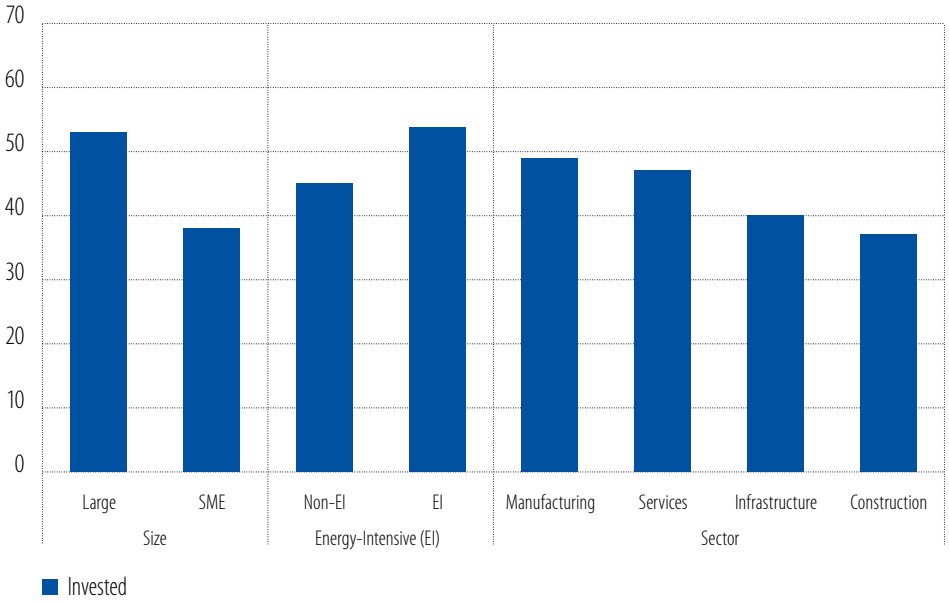
Country-level climate policy stringency, and share of firms that invest in climate-related measures



Source: *EIBIS 2020 and Germanwatch.*
Note: *Countries are ranked based on their climate policy performance. Higher scores indicate a better enabling environment for climate investment.*

Figure 9

Firms' characteristics and investment in climate-related measures (% of firms)



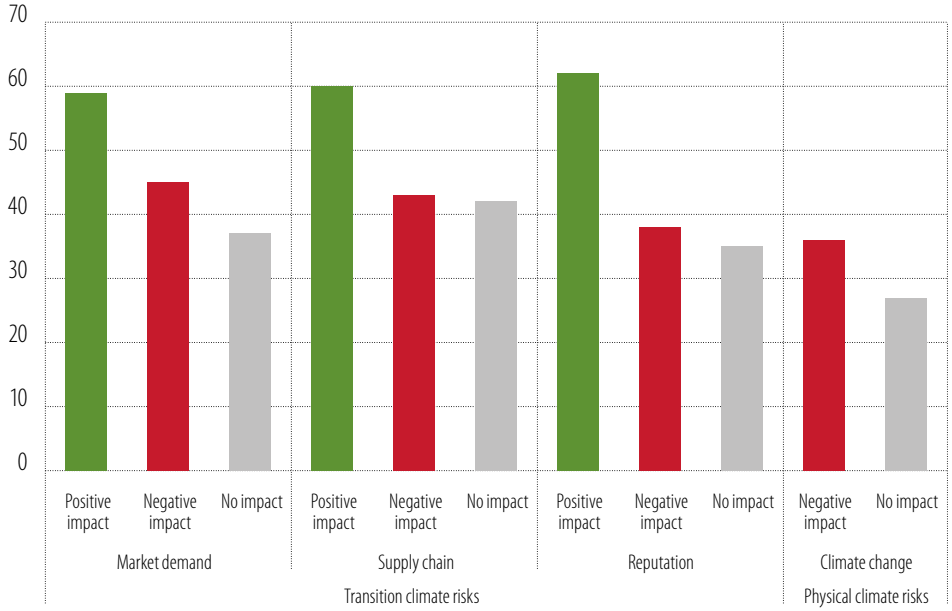
Source: *EIBIS 2020.*
Base: *All firms (data not shown for those who said don't know/refused to answer).*
Question: *Has your company already invested to tackle the impacts of weather events and reduction in carbon emissions?*

Large European firms and firms in manufacturing and infrastructure are much more likely to invest in climate-related measures. More than half of large firms make climate investments, while only 38% of SMEs do so (Figure 9). This difference is probably because energy tends to be an important cost driver for large firms. Firms in energy-intensive sectors are more likely to invest to address climate risks. Manufacturing and infrastructure sectors also invest more often in climate-related measures: 49% of manufacturing firms and 47% of infrastructure firms do so. These firms tend to be large, are subject to significant investment costs, and are often covered by the EU Emissions Trading System. Investing in climate-related measures may significantly reduce their costs, and they are therefore more likely to invest despite upfront costs. This stands in contrast to, for example, construction firms, 37% of which invest in climate measures.

The EIBIS shows that European firms aware of physical and transition risks tend to invest more in climate-related measures. In 2020, 36% of the European firms whose business is affected by climate change – those that consider the climate to pose major or minor risks – invested in climate measures. The share of firms that see no impact but still invested is only 27% (Figure 10). Furthermore, the share of firms investing rises among firms that see the energy transition as an opportunity.

Around three in five EU firms that expect the energy transition to have a positive impact – on market demand, their supply chain or their reputation – invest in climate-related measures. In contrast, the shares are much smaller for firms that don't expect the transition to impact their business activities: 37% for market demand, 42% for the supply chain and 35% for reputation (Figure 10). (Smaller) differences exist when comparing firms with a negative perception of the transition to those that do not see any impact. Seeing the energy transition as an opportunity may significantly increase the share of firms that invest in climate measures.

Figure 10
Climate investment by firms, according to their perception of physical and transition risks
(% of firms)



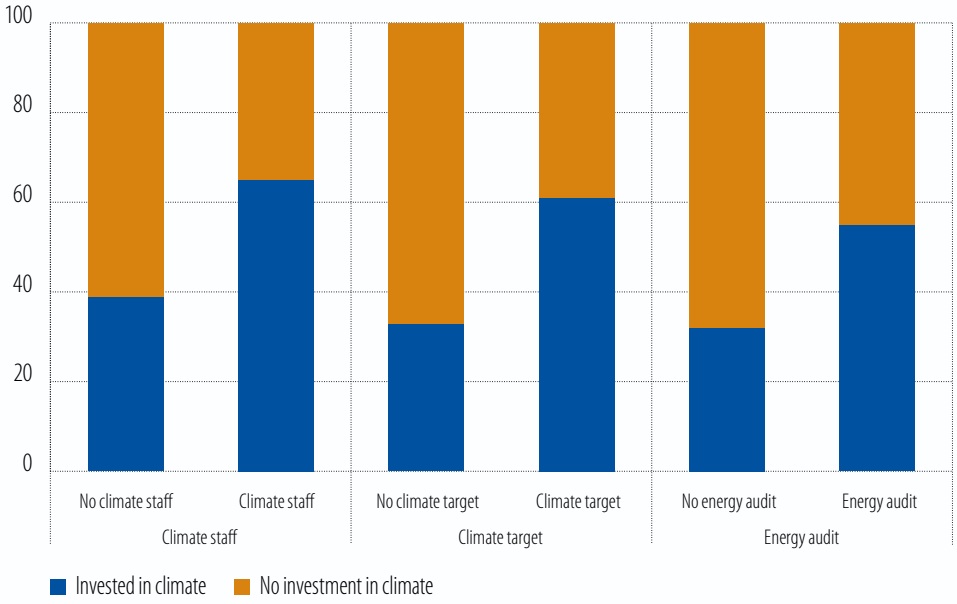
Source: *EIBIS 2020.*
Base: *All firms (data not shown for those who said don't know/refused to answer).*
Question: *Has your company already invested to tackle the impacts of weather events and reduction in carbon emissions?*

Understanding firm-specific climate needs could help increase climate investments. The gap between firms' objective responses to the transition and physical climate risks and their subjective perceptions decreases when firms are better informed about their climate needs (Sorrell et al., 2004). Firms may gain

access to important information by having dedicated staff members responsible for climate issues, setting internal climate targets and completing an energy audit.

A clear positive link exists between implementing measures to improve access to information about climate needs and investment in climate-related measures. European firms that make efforts to improve their information (dedicated staff members, energy audit and climate targets) are more likely to invest in climate measures (Figure 11). Around 65% of firms that have dedicated climate staff, 61% of firms that have internal climate targets and 55% of firms that had an energy audit in the past four years invested in climate measures. In contrast, only 39% of firms that do not have dedicated climate staff, 33% of firms that do not set internal climate targets and 32% of firms that have not had an energy audit in the past four years invested in climate measures.

Figure 11
Climate characteristics of the firms and climate investment (% of firms)

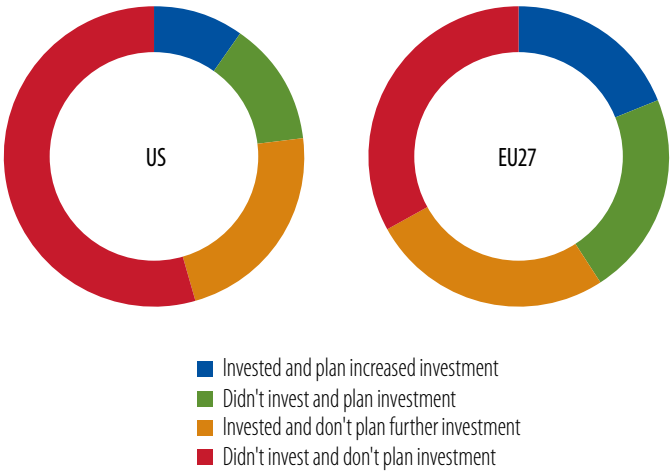


Source: *EIBIS 2020.*
Base: *All firms (data not shown for those who said don't know/refused to answer).*
Question: *Has your company already invested to tackle the impacts of weather events and reduction in carbon emissions?*

Looking ahead, two in five European firms suggest that they have plans to invest more or to invest for the first time to address climate issues. More European firms plan to invest in climate measures than in the United States, where only 23% of firms plan investment (Figure 12). Focusing on the distribution of firms that have plans to invest, 19% of firms have invested in the past and plan further investment and 21% plan to invest for the first time. The respective shares stand at nearly 10% and 13% for the United States. However, it is important to mention that the majority of the European firms (three in five) do not plan climate investment in the next three years. More than half of firms that invested in climate in the past do not plan to do so again.

Climate investment plans of firms also vary among EU members. The share of firms that have investment plans is higher in Western and Northern Europe (Figure 13). In Finland, 68% of firms are planning climate investment in the next three years, of which 76% have already invested and would like to continue to invest, and 24% plan to invest for the first time. The share of firms with climate investment plans is also high in Belgium (51%) and Germany (48%). At the other end of the spectrum are Slovakia and Greece. In Slovakia, 18% of firms are planning climate investments, while in Greece only 22% are.

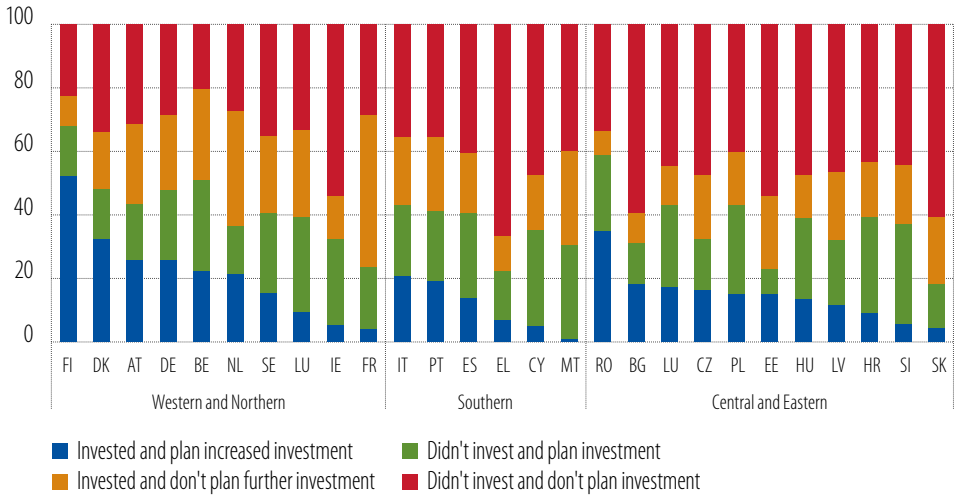
Figure 12
Past and planned investment in climate-related measures in the European Union and the United States (% of firms)



Source: *EIBIS 2020.*
Base: *All firms (data not shown for those who said don't know/refused to answer).*
Question: *Has your company already invested to tackle the impacts of weather events and reduction in carbon emissions? Does your company plan to invest (more) to tackle these impacts in the next three years?*

Fewer firms in Southern and Central and Eastern Europe have invested in climate measures. That is expected to change, however, in the future. Around 30% of firms in Malta and Cyprus and nearly 27% of firms in Spain that have not invested in climate in the past plan to do so in the next three years (Figure 13). The situation is similar in the eastern part of the continent: 31% of Slovenian firms, 30% of Croatian firms and nearly 28% of Polish companies that have not invested in the past plan to invest in the next three years. These large shares are likely related to the current climate investment gaps between the EU members. While many Western and Northern European countries have already invested in climate measures in the past, this investment been much more limited in Southern and Central and Eastern Europe, and firms in these are regions more likely to have immediate climate investment needs.

Figure 13
Investment in climate-related measures and planned investment in EU members (% of firms)



Source: *EIBIS 2020.*

Box B

Which firms plan to invest in climate action?

Similarly to Box A, this box presents the results of simple econometric modelling aimed at understanding how firms' characteristics correlate with their plans for climate investment.

Accordingly, investment decisions are regressed against a few simple firm-specific variables:

$$\text{Investment Decision}_{i,k} = \alpha + \beta\ \text{Firm Characteristics}_{i,k} + \gamma\ \text{Geography}_{k} + \varepsilon_{i,k}, \quad (1)$$

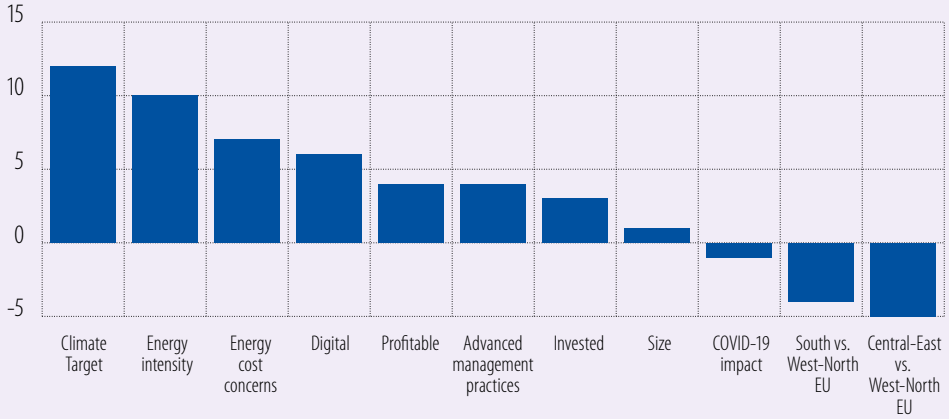
where $\text{Investment Decision}_{i,k}$ indicates plans to invest in climate-related measures in the next three years. These are reported by firm i in country k. $\text{Firm Characteristics}_{i,k}$ is a vector of firm-specific attributes, including the firm's size and sector; whether they are digital, young (less than ten years of operations), and profitable; whether they have climate targets; and whether they have implemented advanced management practices. Geography_{k} indicates a vector of regional dummies that control for unobserved regional-specific factors that might drive firms' responses. The dummies represent Western and Northern Europe, Southern Europe and Central and Eastern Europe.

Figure B.1 presents the difference in the estimated probabilities associated with a number of predictors (firms' characteristics). For each of those predictors, it shows how the predicted probability (of firms planning to invest in climate-related measures in the next three years) responds to changes in firm characteristics (from 0 to 1 for discrete variables or by one unit for a continuous variables), while holding all other independent variables at their means.

The probability of firms planning to invest in climate measures in the next three years is higher for firms that have set climate targets, are energy-intensive, have energy cost concerns and have adopted digital technologies. The probability differential is also positive (although smaller) for firms that follow advanced management practices, are profitable, have invested previously in the climate and are larger in size. By contrast, firms located in Southern Europe have significantly smaller climate investment plans than those located in Western and Northern Europe, a development that is even more pronounced for those in Central and Eastern Europe. Finally, companies with a negative outlook on the overall consequences of the COVID-19 crisis are also likely to develop climate investment plans.

Figure B.1

Differences in predicted probabilities of firms reporting plans to invest in climate measures (percentage points)



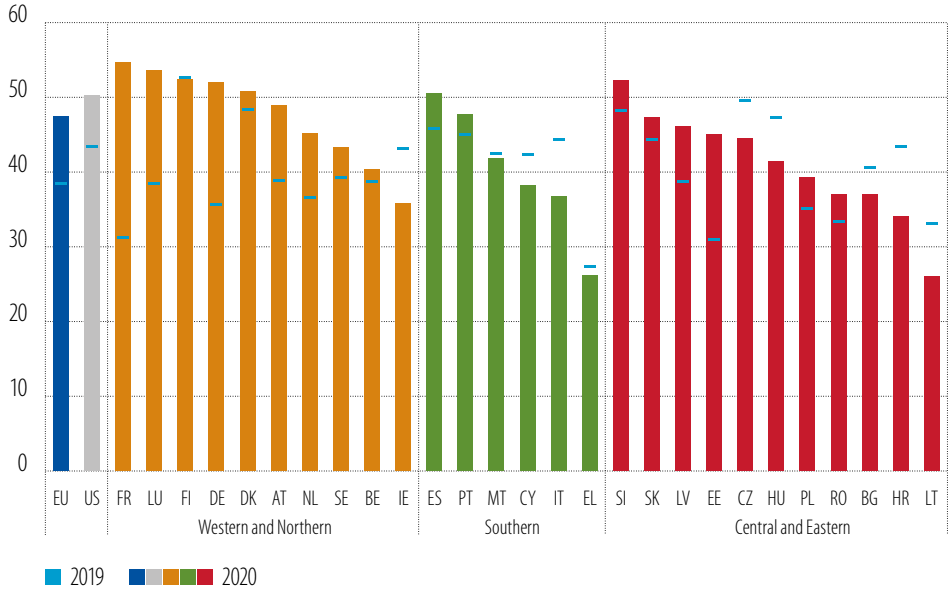
Note: *The predicted probabilities were estimated using a logit model that accounts for clustered error terms. The figure presents coefficients that are significant at a level lower than 10%. The dependent variable takes the value of 1 if firms plan to invest in climate measures in the next three years and zero otherwise. Explanatory variables (other than the impacted predictor) are set at their mean.*

How do firms perceive investment in energy efficiency measures?

Improved energy efficiency is key to limiting climate change. The International Energy Agency (IEA) projects that more than 40% of the reduction in global carbon emissions until 2040, relative to baseline, could be achieved with higher energy efficiency (IEA, 2018). Furthermore, energy efficiency is one of the cornerstones of EU energy policy (European Commission, 2018), and is closely linked to its three main pillars: security (security of supply, import independence, safe production), sustainability (reducing greenhouse gas emissions) and competitiveness (affordable energy for end users, contribution to growth and jobs).

However, many opportunities for investment in energy efficiency are missed, despite being financially sustainable and requiring limited capital spending. Several financial and non-financial barriers limit the adoption of cost-effective energy efficiency measures, and the limited adoption contributes to the energy efficiency gap. Investment barriers to energy efficiency measures are multi-faceted, diverse and often specific to individual technologies and sectors (Sorrel et al., 2004). In addition to these barriers, existing literature suggests that when assessing an energy efficiency investment, firms tend to focus on the direct energy impacts of the energy efficiency measures and neglect significant non-energy benefits (indirect impacts). The EIBIS provides a number of useful insights on European firms' attitudes towards energy efficiency and potential pathways for greater investment.

Figure 14
Investment in climate-related measures and planned investment in EU members (% of firms)



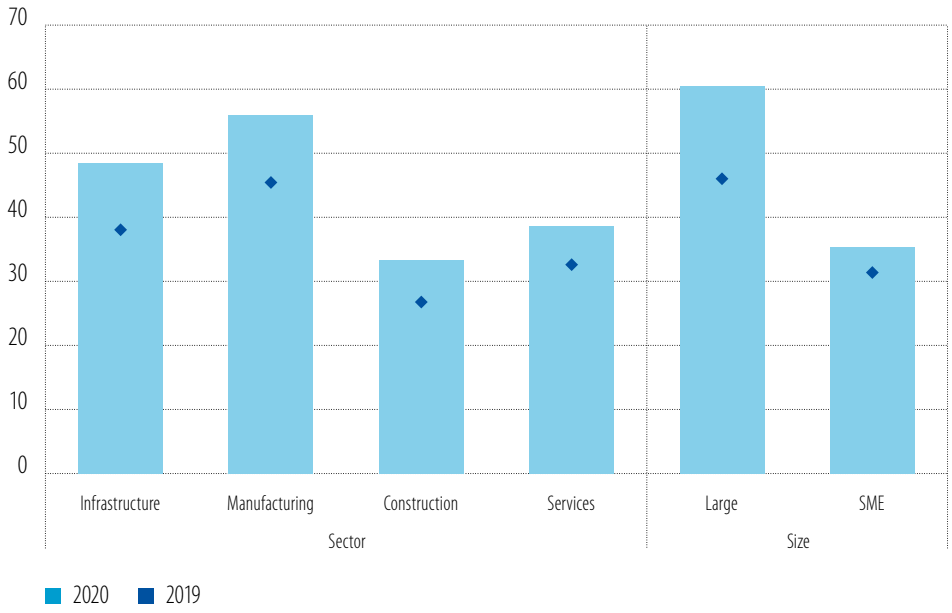
Source: *EIBIS 2020.*
Base: *All firms.*
Question: *What proportion of the total investment was primarily for measures to improve energy efficiency in your organisation?*

Nearly half of EU firms have implemented energy efficiency measures. In 2020, the share of firms investing in energy efficiency increased by almost 10 percentage points to 47% (Figure 14) and came closer to the share observed in the United States (50%). Firms in Western and Northern Europe invest the most (48%), followed by firms from Southern Europe and Central and Eastern Europe (around 40% for both regions). Across the EU countries, France displays the highest percentage of firms that invest in energy efficiency (55%) and is followed closely by Luxembourg (54%), Finland (52%) and Spain (52%). By contrast, Croatia (34%), Greece (26%) and Lithuania (26%) are at the other end of the spectrum.

Large firms and manufacturing and infrastructure firms are the most likely to invest in energy efficiency. While 60% of large firms invest in energy efficiency, only 35% of SMEs do so (Figure 15). Similarly, the manufacturing sector displays the highest share of firms investing in energy efficiency (69%), followed by the infrastructure sector (63%). Construction is the sector with the lowest share of firms that invest in energy efficiency – less than half of construction firms make energy efficiency investments. This is most likely because energy tends to be a core cost component for large firms and energy-intensive sectors. Investment in energy efficiency may significantly reduce their variable costs.

The untapped potential of energy savings is high, as EU firms consider their building stock to be of relatively low quality. In 2019, EU firms reported that slightly more than a third of their commercial building stock is of high or highest energy efficiency standards (EIB, 2020). Moreover, since 2016, their view of the building stock has become more pessimistic. Firms located in Central and Eastern Europe tend to report that their building stock meets lower energy efficiency standards.

Figure 15
Share of firms that invested in energy efficiency by firm characteristic (%)



Source: *EIBIS 2020 and 2019.*
Base: *All firms.*
Question: *What proportion of the total investment was primarily for measures to improve energy efficiency in your organisation?*

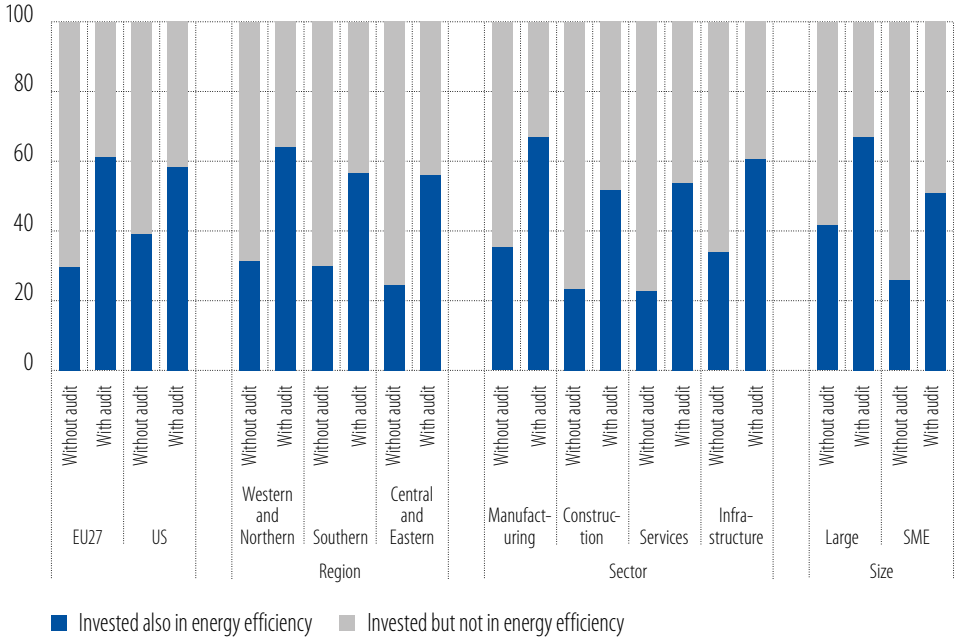
Firms need to be made aware of the benefits of energy efficiency if the uptake of measures is to increase, In 2020, the share of firms investing in energy efficiency measures was considerably higher for firms that had an energy audit (Figure 16). On average, three in five EU firms (61%) that carried out an energy audit also invested in energy efficiency. The relationship between energy efficiency investments and energy audits is more pronounced in large[6] firms (67%), those that operate in the infrastructure and manufacturing sectors (60% and 67%, respectively) and those that are located in Western and Northern Europe.

The crucial role of energy audits also becomes apparent when assessing the investment decisions of firms that did not have an energy audit. Firms that did not have an audit appear to invest substantially in areas other than energy efficiency, possibly because they fail to understand the potential direct and

6 According to Article 8 of the Energy Efficiency Directive (EED 2012/27/EC), energy audits are mandatory for large firms in the European Union. However, various Member States apply different criteria for granting exemptions from the rule, such as annual energy consumption, share of energy costs in sales, level of sales, assets or application of an energy management system.

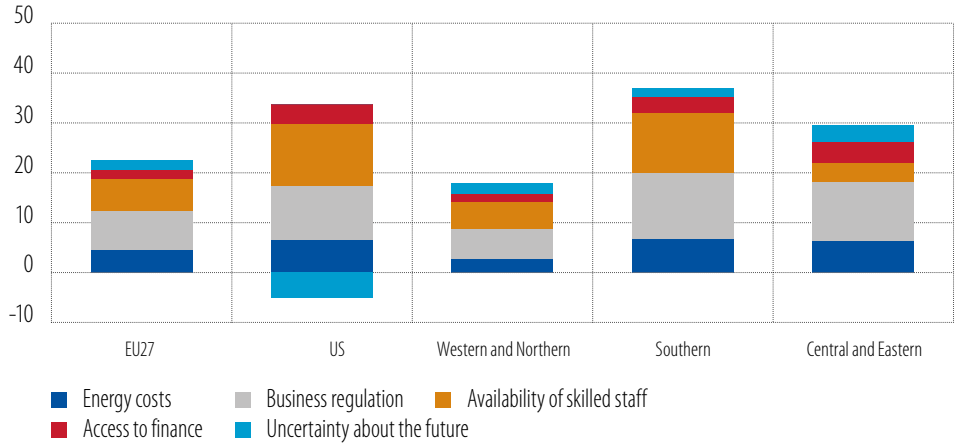
indirect benefits of energy-saving technologies. In other words, audits help firms overcome the information barriers to energy efficiency investments.

Figure 16
Share of firms investing in energy efficiency, with and without an energy audit (%)



Source: *EIBIS 2020.*
Base: *All firms (data not shown for those who said no/don't know/refused to answer).*
Question: *Can I check, in the past four years has your company had an energy audit? By this, I mean an assessment of the energy needs and efficiency of your company's building or buildings.*

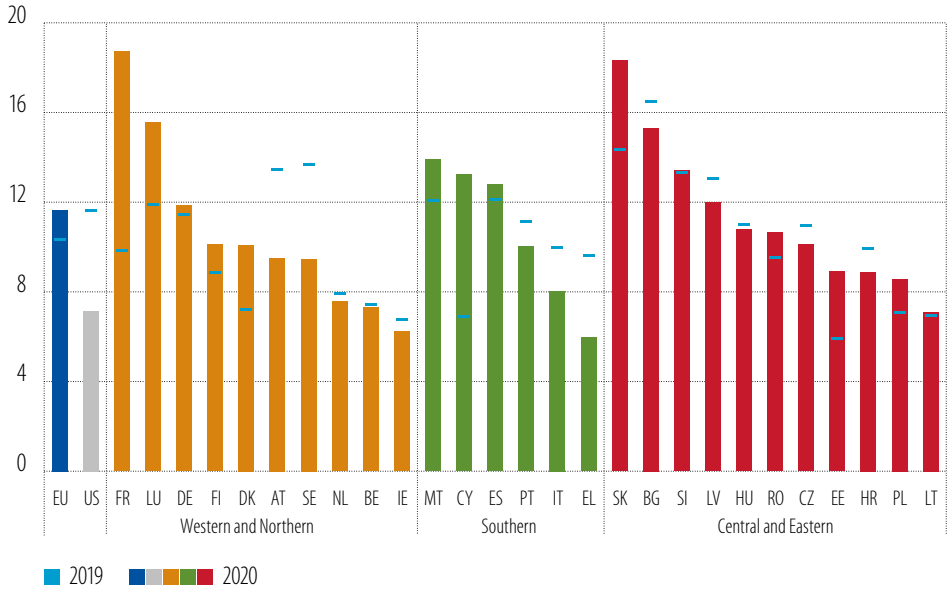
Figure 17
Net balance of various obstacles to investment, between the share of firms that invest in energy efficiency and those that invest but not in energy efficiency (%)



Source: *EIBIS 2020.*
Base: *All firms.*
Question: *Thinking about your investment activities, to what extent is each of the following an obstacle? Is it a major obstacle, minor obstacle or not an obstacle at all?*

Energy costs and uncertainty about business regulation stand out as two long-term obstacles to energy efficiency investment. In the United States, these obstacles weigh more heavily, as does the uncertainty of business regulation in Southern Europe (Figure 17). The remaining long-term barriers, such as access to finance, availability of skilled staff and uncertainty about the future, seem to affect investment decisions in a similar fashion, regardless of the investment area.

Figure 18
Share of firms' total investment in energy efficiency (%)



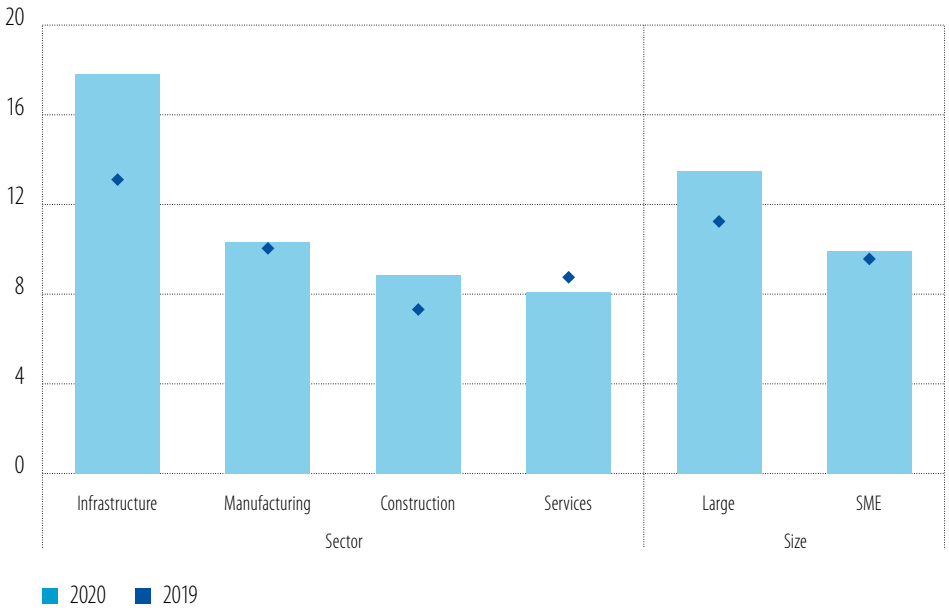
Source: *EIBIS 2019 and 2020.*
Base: *All firms (data not shown for those who said don't know/refused to answer).*
Question: *What proportion of the total investment was primarily for measures to improve energy efficiency in your organisation?*

The share of EU firms that invested in energy efficiency measures, as well as the share of investment spent on such measures, increased from 2019 to 2020. By contrast, in the United States, the proportion of investment spending on efficiency measures fell in 2020. Overall, EU firms spend 12% of their investment budget on energy efficiency measures, whereas US firms spend 7% (Figure 18).

The share of firms' total investment budget that goes to energy efficiency improvements varies widely across EU members. In 2020, firms in France spent more on energy efficiency projects (19%) than firms in any other EU country and especially those in Greece and Ireland, which invested only 6% of their investment budget (Figure 18). Firms in France showed a significant increase in spending (9 percentage points) from the previous year. Firms' spending also varied significantly across most EU countries, possibly because some energy efficiency investments only occur once. The share of investment spending on energy efficiency declined considerably in firms in Southern Europe (such as Greece, Italy and Portugal) and in two countries in Western and Northern Europe (Austria and Sweden).

Spending on energy efficiency improvements is higher in the infrastructure and manufacturing sectors and in larger firms, for which energy is a significant cost. In 2020, firms in the infrastructure and manufacturing sectors spent 18% and 10%, respectively, of their total investment budget on measures to improve their energy savings (Figure 19). By contrast, firms in the services sector and the construction sector spent less, 9% and 8% respectively, of their total investment budget. Similarly, the share of energy efficiency investment is higher for larger firms than for smaller firms. The increase in the share of 2020 investment that went to energy efficiency measures is more pronounced in manufacturing firms and large firms.

Figure 19
Share of firms' total investment in measures to improve energy efficiency (%)



Source: *EIBIS 2020 and 2019.*
Base: *All firms (data not shown for those who said don't know/refused to answer).*
Question: *What proportion of the total investment was primarily for measures to improve energy efficiency in your organisation?*

What concerns do firms have about climate-related investment?

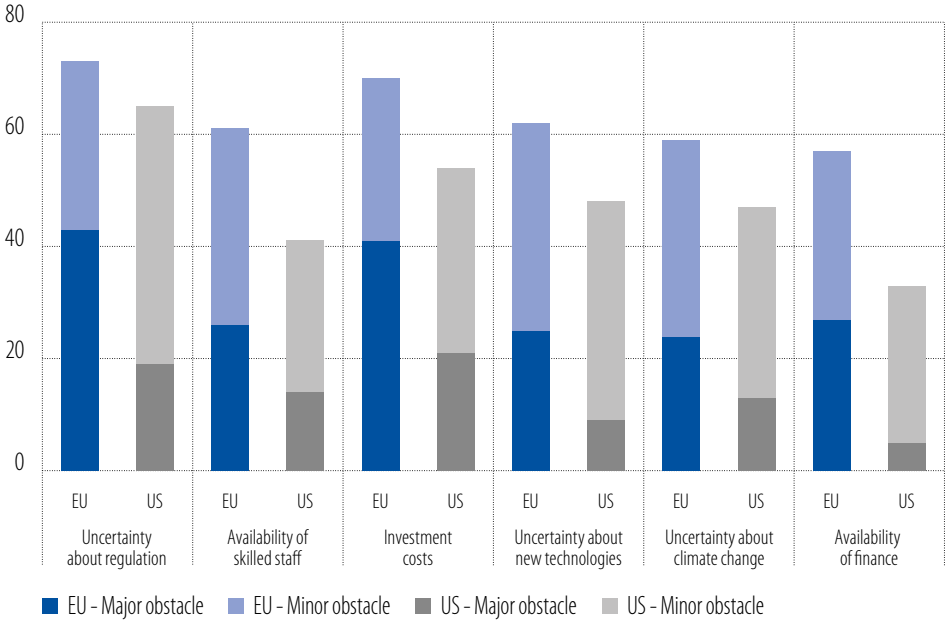
Looking at how firms adapt to climate change is not enough – we must also examine how various factors affect their investment decisions. There are myriad uncertainties and issues that firms confront when making decisions that affect, or are affected by, climate change. Stadelmann and Michaelowa (2011) link these factors to the enabling environment and classify them under three main headings:

- the core business environment, which is relevant for all types of businesses;
- the broader investment climate, including education, financial markets and infrastructure. The investment climate is partially related to the low-carbon transition, through climate change education or investments in electricity grids; and
- targeted policies that encourage the business sector to invest in low-carbon technologies.

Taking the Stadelmann and Michaelowa (2011) methodology into consideration, the EIBIS 2020 asked firms to share their views on the role that six factors play in their climate investment decision-making processes. These factors are: 1) uncertainty about regulation and taxation; 2) uncertainty about future technologies; 3) uncertainty about climate change effects; 4) investment costs; 5) availability of finance; and 6) skilled staff. While the resulting analysis examines only a limited number of variables, it is intended to identify their relative importance in climate investment decision-making.

EU firms are more likely to identify obstacles to climate investments than US firms (Figure 20). For all six different obstacles, the share of EU firms identifying each of them as an obstacle (major and minor) is higher than the corresponding US share. Besides, the severity of these obstacles is much higher for EU firms than in US firms.

Figure 20
Obstacles to climate investment, in the European Union and the United States (% of firms)



Source: *EIBIS 2020.*
Base: *All firms (data not shown for those who said don't know/refused to answer)*
Question: *To what extent is the following an obstacle to investing in activities to tackle weather events and emissions reduction? Is it a major obstacle, minor obstacle or not at obstacle at all?*

Across EU firms, uncertainty about regulation and taxation is the factor most frequently identified (73%) as reducing the likelihood of investment in climate (Figures 20 and 21). Regulations and taxation are important for firms' investment decisions. They affect the cost-benefit analysis of climate investments, and therefore need to be structured to facilitate long-term climate objectives. Stricter environmental regulations tend to encourage firms to cut pollution by making it costly to pollute (for example via a carbon tax or a regulatory standard that mandates the adoption of costly low-carbon equipment). Support schemes do the same by providing economic incentives. Uncertainty about regulation will cause investment decisions to be delayed or abandoned, as firms try to have the full picture of expected cost-benefits before proceeding with the investment.

Tax rates currently have little or no relation to the energy content or externalities (such as carbon emissions or air pollution), while there is great uncertainty about the future development of Emissions Trading System prices in Europe. In parallel, generous support schemes in many EU countries have been revised and are affecting investors' decisions. Taxation has remained unchanged since the beginning of 2000, despite major developments in Europe's climate and energy policies and targets, and the emergence of clean-energy technologies. These are the factors most likely to drive firms to cite uncertainty about regulation and taxation more often than other barriers.

The other issues that EU firms highlight as constraining their investments are the high upfront cost of climate investments (69%) and the availability of skilled staff (60%). Investments in climate cover a broad spectrum of activities and their costs range from hundreds of millions of euros to a couple of thousand. For example, the replacement of machinery can cost several million euros, whereas the cost of changing lighting as part of an energy efficiency strategy is much lower.

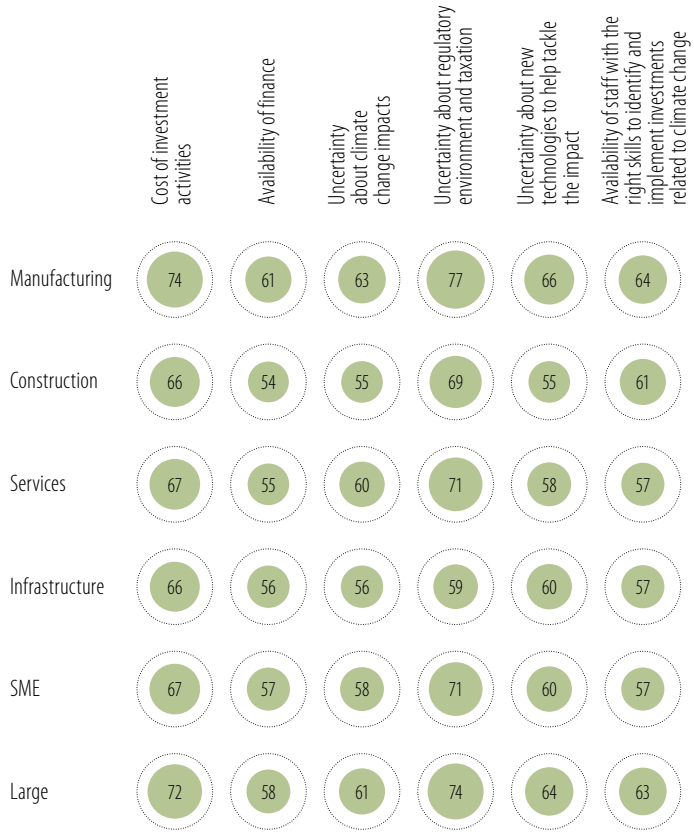
These specific factors lead firms to cite the upfront costs as an obstacle to investment. At the same time, firms often do not consider climate change investment to be a core business investment activity.

In doing so, they neglect low-risk investments that have a predetermined, often short, payback period. To overcome this issue, firms need specific expertise to conduct the necessary due diligence and to successfully identify climate opportunities. EU firms acknowledge this fact. Some 60% of them report that a lack of skilled human resources prevents them from investing in climate measures.

Another type of uncertainty that firms name when assessing climate investments is that of new technologies (62%). This likely reflects firms' concerns about the price, availability and reliability of future clean-energy technologies. These three components are affected by the evolution of learning new technologies, which in turn depends on the policies taken to accelerate that learning. The slower the progress of technological learning, the higher the likelihood firms will adopt a wait-and-see attitude.

Uncertainty surrounding the actual impact of climate change (59%) also weighs on firms' investment decisions. Uncertainty about climate change is a defining characteristic of climate change economics and affects the investment decision-making of firms, but only 59% consider it to be an investment barrier. Although there is a broad consensus that global warming is underway, the lack of widespread information on climate change risks and their complicated nature makes it difficult for firms to react adequately. This explains why uncertainty about climate change is not the most important impediment in their investment decisions.

Figure 21
Obstacles to climate investment in the European Union (% of firms)



Source: *EIBIS 2020.*
Base: *All firms (data not shown for those who said don't know/refused to answer).*
Question: *To what extent is the following an obstacle to investing in activities to tackle weather events and emissions reduction? Is it a major obstacle, minor obstacle or not an obstacle at all?*

Limited availability of finance is a challenge for 57% of EU firms, which highlights the importance of favourable financing conditions. The current period of low-interest rates makes firms more willing to pursue financing. Additional factors that drive their investment decisions could be upfront costs, financial frictions, incentives and their capital structure. The availability of finance remains an important driver

for investment in climate. For example, Kalantzis and Revoltella (2019) suggest that firms tend to use external funds to finance their investment in energy efficiency improvements. Furthermore, as found by Cooremans (2011), investment in climate measures is not considered to be strategic, so internal financial resources are less likely to be used for this purpose. As a result, highly indebted firms that face higher financial constraints will tend to complain more about the limited availability of finance, unless they benefit from financial incentives or a better enabling environment for climate investments.

US firms cite the limited availability of finance less often (33%) as an impediment to climate investment. By contrast, over three-quarters of firms in Southern Europe report limited finance as an impediment to climate investment. In fact, limited availability of finance is reported as a challenge for them more than any other EU country.

Box C

Which firms report investment obstacles?

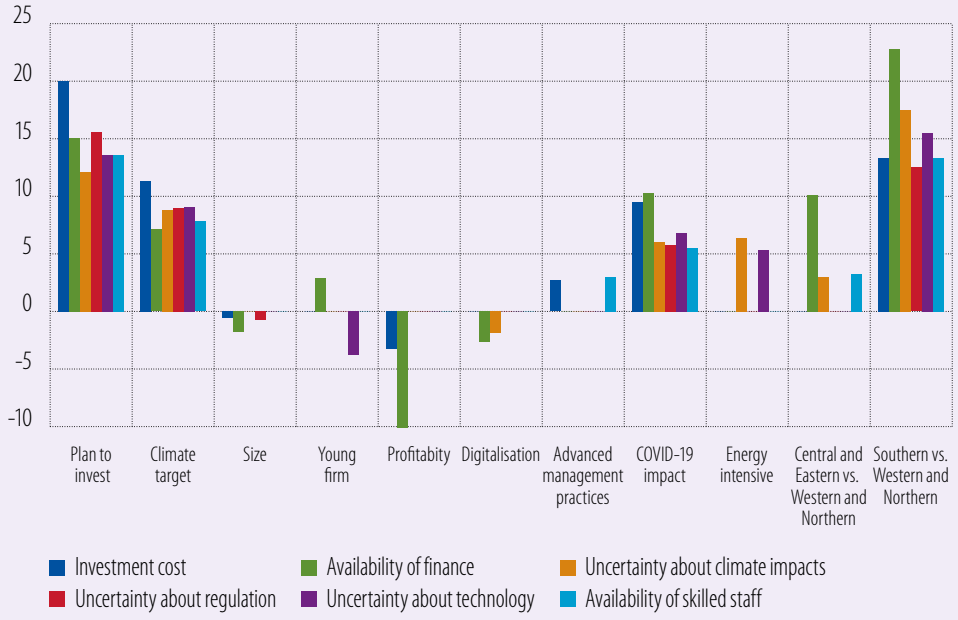
This box presents an econometric analysis aimed at identifying the links between firms' characteristics and the reported investment obstacles. The analysis accounts for six types of investment obstacles: a) investment cost; b) availability of finance; c) uncertainty about climate impacts; d) uncertainty about regulation and taxation; e) uncertainty about the available technology; and f) availability of staff. The analysis followed a similar regression to the one used for the determinants of investment:

$$\text{Investment Obstacle}_{i,k} = \alpha + \beta\ \text{Firm Characteristics}_{i,k} + \gamma\ \text{Geographyr} + \varepsilon_{i,k}, \qquad (1)$$

where $\text{Investment Obstacle}_{i,k}$ indicates one of the aforementioned obstacles. These are reported by firm i in country k. The rest of the model, as well the variables employed, follows the specification used in Boxes A and B.

Figure C.1

Differences in predicted probabilities of firms reporting selected investment obstacles
(percentage points)



Note: *The predicted probabilities were estimated using a logit model that accounts for clustered error terms. The figure presents coefficients that are significant at a level lower than 10%. The dependent variable takes the value of 1 if firms consider the specific investment barrier either as a minor or major barrier and zero otherwise. Explanatory variables (other than the impacted predictor) are set at their means.*

Figure C.1 presents the difference in the estimated probabilities associated with a number of predictors (firms' characteristics). For each of those predictors, it shows how the predicted probability (of firms reporting each of these selected investment obstacles) responds to changes in firm characteristics (from 0 to 1 for discrete variables or by one unit for continuous variables), while holding all other independent variables at their means.

The probability of firms reporting all the selected investment obstacles as either a minor or a major obstacle is greater when firms have plans to invest in the next three years, have set climate targets, say that the coronavirus pandemic has affected their investment plans negatively (reduced investments), and are located in Southern Europe compared to firms located in Western and Northern Europe. Firms in Central and Eastern Europe are less likely to identify obstacles to climate investment than those in Southern Europe, and they mostly focus on a lack of access to finance and to a lesser extent on the uncertainty about the impact of climate change and the availability of skilled staff.

Other firm-specific variables show statistically significant correlations with only some of the obstacles. For instance, younger firms appear to be more concerned about a lack of access to finance and less about the uncertainty about future technologies, while profitable firms are less likely to cite investment costs and a lack of access to finance as investment obstacles. Similarly, digital firms are less likely to consider a lack of access to finance and uncertainty about the impact of climate change as barriers to their investment decisions. Finally, firms in energy-intensive sectors tend to highlight the importance of the uncertainty about future technologies and climate impacts in their investment decisions.

How the COVID-19 crisis is affecting firms' climate-related investments

The measures taken in 2020 to fight the ongoing pandemic have severely affected the functioning of the global economy. Trade and investment channels have been disrupted, the movement of people has been seriously restricted, and businesses have been forced to operate at reduced capacity or to temporarily abandon their activities.

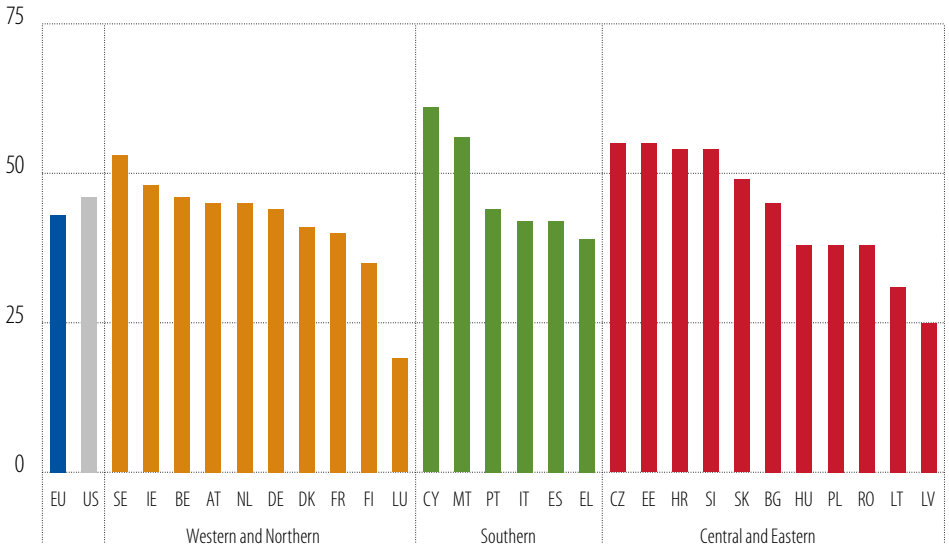
In parallel, confidence levels have fallen markedly and labour markets have been disrupted. Furthermore, the crisis is likely to be felt for a prolonged period. Various institutions (the International Monetary Fund, the European Central Bank and the European Commission) expect the GDP of the European Union to shrink dramatically in 2020, resulting in a significant increase in government debt. The repercussions of the crisis will likely involve a fall in investment, including a fall in investment in climate-related measures. The EIBIS 2020 offers some initial insight into future investment trends (see Chapter 2).

According to EIBIS, the COVID-19 crisis will likely significantly impact firms' plans to invest in climate-related measures (Figure 22). Around 43% of the EU firms that planned climate investment stated that the pandemic will negatively affect their investment plans. However, this number is slightly than in the United States, where 46% of firms that planned climate investment said they will reduce it because of the pandemic.

There are significant differences among EU members on how the COVID-19 crisis will affect the plans of firms that wanted to invest in climate-related measures. The most negative effects are observed in countries whose economies rely to a large extent on tourism, particularly Cyprus, Malta and Croatia. In Cyprus, 61% of firms said they were unlikely to follow through on their investment plans. In Malta the figure was 56%, and in Croatia 54%. On the other end of the spectrum are Luxembourg and Latvia. In Luxembourg, the share of firms that planned climate investment, but whose plans were negatively impacted by the coronavirus, is 19%, while in Latvia it is 25%. In general, the pandemic has taken the greatest toll on climate investment in countries most exposed to sectors, like tourism, that experienced the biggest downturn.

Figure 22

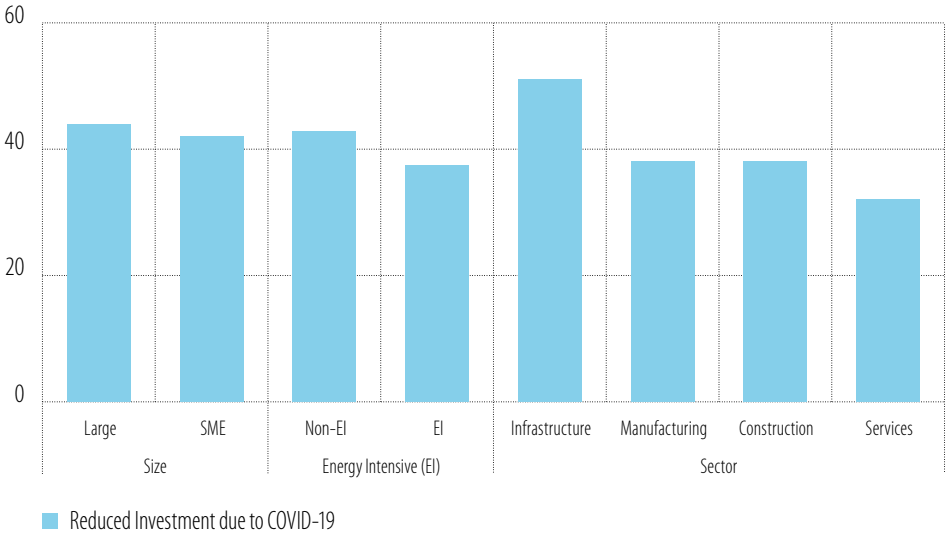
Impact of the pandemic on future investment plans in climate-related measures in the United States, the European Union and its Member States (% of firms)



Source: *EIBIS 2020.*
Base: *All firms (data not shown for those who said don't know/refused to answer).*
Question: *Does your company plan to invest (more) to tackle climate change and related policy impacts in the next three years? Has your company's overall investment expectations for 2020 changed due to coronavirus?*

Figure 23

Impact of COVID-19 on future investment plans in climate-related measures, by sector and firm size (% of firms)



Source: *EIBIS 2020.*
Base: *All firms (data not shown for those who said don't know/refused to answer).*
Question: *Does your company plan to invest (more) to tackle climate change and related policy impacts in the next three years? Has your company's overall investment expectations for 2020 changed due to coronavirus?*

The COVID-19 crisis is expected to affect climate-related investment negatively across all sectors. In the manufacturing sector, for instance, half of firms state that they will reduce their forthcoming investments. In services and infrastructure, a slightly smaller, but still significant, share of firms (38%) are likely to reduce their investments due to the pandemic. These sectors have been hit hardest by the crisis. The impact is felt across different sizes of firms. Around 40% of large firms and SMEs will not go ahead with their investment plans. Overall, the crisis could put the European energy transition at risk. The transition requires extensive investment by firms in climate mitigation and adaptation measures.

While COVID-19 is likely to hurt climate investment, the situation could be turned into an opportunity. Since the scale of the coronavirus crisis began to emerge, the European Union has been leading calls for governments to make the recovery as sustainable and resilient as possible. This means immediately addressing the core issues of the global recession and soaring unemployment, and doing so in a way that also takes into account the key challenge of building cleaner and more secure energy systems.

The European Union has responded to the pledges for a green recovery. On 21 July 2020, the heads of state or government of the 27 European Union Member States, together with the European Council president and the president of the European Commission, reached an agreement on a EUR 1.074 billion long-term budget and a €750 billion COVID-19 recovery fund. The recovery fund, known as NextGenerationEU, is to be allocated among EU members and consists of EUR 360 billion in loans and EUR 390 billion in non-repayable grants. At least 30% of the total expenditure (long-term budget and recovery fund) will be spent on climate objectives. The money will be disbursed only on projects that meet certain green criteria, for example, involvement in sectors important for the energy transition such as green transport and sustainable energy. Furthermore, fossil fuels and nuclear power will be excluded from the funding.

The focus on a green recovery reflects the European Union's commitment to implementing the Paris Agreement and the United Nations Sustainable Development Goals. If implemented properly, the recovery package could be a win-win strategy and a once-in-a-lifetime opportunity to accelerate the fight against climate change. National governments, which have power over spending decisions, should ensure that they step up actions for a green and inclusive recovery, speed up the transition to a low-emissions economy and leverage finance to invest in the green recovery. If they manage to do so, the negative impact of COVID-19 on climate investment is likely to be diminished.

Conclusion and policy implications

As climate change continues and new, more stringent climate policies are being adopted by Europe to meet the Paris Agreement goals, firms will increasingly face a variety of physical and transition risks. However, as the EIBIS shows, only one in five European firms perceive physical risks to be a major risk, and the vast majority do not think the transition to a net-zero economy poses a risk to their business activities. In the United States, the perception of physical risks is even lower, despite the frequent occurrence of extreme weather events in recent years. The same applies to transition risks, but this could be driven by the intention of the United States to withdraw from the Paris Agreement at the time of the survey.

The severity of these risks depends highly on the region and sector that firms operate in. As seen in the EIBIS, firms located in Southern Europe feel more that they are at physical risk from climate change. Their perceptions are likely driven by the frequency of wildfires, floods and heat waves, as well as by the limited ability of their countries to tackle those risks. The dependency of their economies on sectors vulnerable to extreme weather events, such as tourism and agriculture, could be an additional factor. Similarly, carbon and energy-intensive firms perceive transition risks to be higher, especially in Western and Northern Europe. By contrast, the majority of firms in Central and Eastern Europe perceive the impact of the climate change transition to be limited, which is most likely driven by the slower transformation of their energy systems.

Overall, it is evident that most firms do not take into account the already foreseeable physical and transition risks of climate change. Firms may believe that climate change will impact their country or region to a lesser extent than more distant places. In that case, they underestimate the indirect risks to which they are exposed through their global supply chains and markets. Neglecting those risks presumably reduces the motives of firms to invest in adaptation and mitigation measures and puts their long-run prosperity and overall EU climate objectives in jeopardy.

The climate emergency leaves firms with two options: begin planning today and gain a competitive edge, or risk losing ground to more forward-thinking competitors. Prudent steps taken to address climate change now can improve a company's competitive position relative to its national or international peers, and can also help them to earn a seat at the table to influence climate policy. With more climate policies coming from national governments and increasing scientific clarity, now is the time for businesses to craft corporate strategies that address climate change.

Firms with a strong history of reducing emissions, such as those operating in energy-intensive sectors, are already shifting their climate focus from managing risks to exploring new business opportunities. These firms understand better that new markets will be created and that the existing ones will change. This is reflected in the EIBIS, which suggests that energy-intensive firms have invested the most in climate-related measures and are planning to do so in the future. Climate change and the energy transition will create winners and losers, and this is clear to firms in energy-intensive sectors.

The nature of future climate legislation will be the most important factor in shaping the competitive landscape that firms will face. It will determine how the market rewards innovators of climate-friendly products and services, as well as how it punishes laggards. More than ever, integrating climate issues into corporate strategy is a core element of managing risk and seizing the competitive advantage. However many obstacles to climate investment exist, as confirmed by the EIBIS.

According to the EIBIS, the uncertainty about regulation and taxation stands out among the obstacles to climate investment that are cited by both US and EU firms. The other issues that EU firms note as constraining their investments are limited availability of skilled staff and the high upfront cost of climate investments. By contrast, firms overall perceive the uncertainty about climate change, together with a lack of access to finance, as a relatively minor obstacle to climate investment. Lack of finance was mainly identified as an impediment for firms in Central and Eastern Europe, as well as in some crisis-hit countries.

The European Union and national governments have a crucial role to play in minimising obstacles to climate investment. For example, they could minimise regulatory uncertainty, communicate climate policy goals and develop a comprehensive framework that supports these goals as soon as possible. Otherwise, the uncertainty will cause a majority of firms to adopt a wait-and-see strategy by delaying their investments until information is more reliable. Ambiguous government policies prevent firms from committing to long-term climate change mitigation strategies. The European Union must invest massively during the current decade to stay on track with the Paris goals.

At this stage, it is also crucial to improve the awareness of climate change and the impact of related policies among European firms. As seen in the EIBIS, firms that are more aware of these impacts and that also have a climate strategy in place – either by setting climate targets, having designated climate staff, or understanding their energy profile through an energy audit – are those that invest the most. This is why it is necessary to promote informational campaigns to highlight the importance of the climate risks and present them as something that will affect firms in the near future, and not only in the long term.

Although insufficient capital for climate action was not cited as frequently as other climate investment obstacles, it could benefit from appropriate policy measures. Climate finance has been expanding rapidly over the past decade, and EU governments have a crucial role to play in encouraging further growth. Several policies, both market and non-market, could be employed to close the investment gap and reach the climate targets. For instance, governments could directly finance climate action by providing subsidies for renewable energy sources and energy efficiency measures, as well as providing blended finance. They could also take steps to remove environmentally harmful subsidies. Such actions could enhance the cost competitiveness of clean-energy investments. Furthermore, governments could drive capital markets towards greater investment in climate measures. This includes mechanisms that are likely to affect larger, listed firms, such as the introduction of green bond standards, and mechanisms that may increase the capital available for climate projects by SMEs, such as green credit lines.

Governments could also put pressure on firms by influencing third parties, particularly investors. Highlighting to SMEs the importance of environmental, social and governance factors and making climate-related financial risk disclosures obligatory could be important steps in the right direction. The European Commission has already engaged in initiatives that aim to tackle these two issues and has adopted the first key element of the sustainable action plan – the EU taxonomy.

The EU taxonomy and the Task Force on Climate-related Financial Disclosures (TCFD) are two important initiatives aiming to boost sustainable investments. The EU taxonomy increased transparency and provided clear definitions of sustainable investments. The suggestions of the TCFD will increase the climate-related information that investors, lenders, insurers and other stakeholders have about firms. Through appropriate policy measures that support the TCFD implementation, regulators can improve the assessment, pricing and management of climate-related risks. Investors can make informed capital allocation decisions and lenders, insurers and underwriters will be better able to evaluate their risks and exposure over the short, medium and long term.

Finally, climate change is a global challenge that requires collective efforts by countries and sectors. In this context, the European Union as a whole and the individual Member States must continue their efforts to encourage governments and firms in non-EU countries to match the ambitious climate goals of the European Union. This would reduce uncertainty about climate policies worldwide. In parallel, national governments should ensure closer collaboration between the public and private sectors. This collaboration could be achieved through multiple mechanisms, for instance, the involvement of firms from multiple sectors in the development of the national adaptation plans. Moreover, coordination among government agencies for the environment, finance and economic development and with the private sector is key to addressing interconnected climate risks.

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Chapter 6

Leveraging the financial system to green the European economy

World economies have agreed to limit their greenhouse gas emissions to inhibit the growing damage caused by climate change. The European economy has made sizeable progress since the Paris Agreement signed in December 2015. Yet that process needs to speed up if the European Union is to achieve carbon neutrality by 2050, a clear goal set by the European Commission under its new leader, Ursula von der Leyen. While public-sector investments should catalyse much of the investment needed, the private sector will also be key to the policy's success.

Investments in climate mitigation have a specific nature: they are very uncertain, have positive externalities and are dependent on past actions. For these reasons, it is not enough to provide tax incentives, support schemes or guaranteed prices – or even to implement a cap and trade system that provides companies with incentives to reduce their carbons emissions. Greening the economy also depends on a host of individual decisions. Even though green technology is improving rapidly, a wait-and-see attitude explains why investment remains suboptimal and why support from the financial sector is crucial.

In a market-based economy, the financial sector is an efficient system for allocating savings and maximising returns while minimising the overall risk. Investors are already taking into account a firm's broader impact and its overall corporate conduct. Funds focusing on environmental, social and corporate governance (ESG) investing are in demand. Some niche markets, such as green bonds, are developing, but not rapidly enough, and the premium paid for green investments remains tiny. The uncertainty surrounding the true green content of financial assets is preventing investors from being more discerning. Enhanced information, along with the development of simple and transparent standards, should help spur investor demand.

A more market-based system could speed up the greening process, but the European Union is held back by its bank-based financial system. Banks have a major role to play. In fact, central banks and national supervisors are pushing banks to price climate risks more into their loans, while also encouraging the investors that buy up bank liabilities to take greater account of the risk entailed. Enhanced disclosure guidelines and the increased awareness of climate stress is widening the borrowing costs between green and brown loans. Acknowledgement of climate risk will help green the economy.

Introduction

Human activities have contributed to raising the world's temperature by around 1°C compared to pre-industrial times (Intergovernmental Panel on Climate Change (IPCC), 2014 and 2018). Multiple studies show that without changes in the economic system, global warming is likely to push temperatures up more than 4°C, compared to pre-industrial levels, by the end of the century. People are increasingly concerned about this unsustainable path. At the same time, governments are implementing climate policies that are designed to lower the carbon emissions. Government involvement is necessary, because the private sector has little incentive to offset pollution on its own. Moreover, the tragedy of climate change will play out over the long term, while the costs of climate-change policies will be felt over the short term (Carney, 2015).

Against this backdrop, the Paris Agreement, signed in December 2015, aims to limit the rise in average global temperatures to 2°C higher than pre-industrial levels and to pursue efforts to limit the rise to 1.5°C. The agreement has led countries around the world to set carbon-cutting goals. The European Union is taking the lead in the fight against climate change. It has set EU members the ambitious goal of becoming climate neutral by 2050 and of limiting greenhouse gas emissions by at least 55% by 2030 (European Commission, 2020a), a target revised upwards by the European Parliament at the beginning of October 2020.

This chapter analyses the financing of the investment needed to green the EU economy. It explains why, how, and to what extent the financial sector can help, showing that structural shifts in the EU financial system can alleviate some of the transition costs. Changes are afoot in the financial sector, and they are pushing the climate transition. Asset allocation is changing as investors realise that some investments are not viable or not profitable in the long term. The public sector has a key role to play in this changing environment. It needs to structure the new markets while incentivising transparency and new ways of thinking, so that the balance between risk and return can be seen in the context of climate change.

The remainder of the chapter consists of four sections followed by concluding remarks outlining policy implications. In the first section, we analyse the evolution of energy and pollution trends and show the progress already made. We then provide an overview of the European Green Deal. In the second, we look at the main policy levers that can be deployed and show that price-based policies cannot suffice. The specific nature of climate change investment requires the financial sector to be part of the solution. In the third section, we review the main changes that are already taking place, especially with the expansion of sustainable finance. Finally, in the fourth section, we show how the official financial sector (central banks and national supervisors) is moving to strengthen and deepen the changes taking place in the private financial sector.

Investment needed to reach the European Commission's 2030 objective

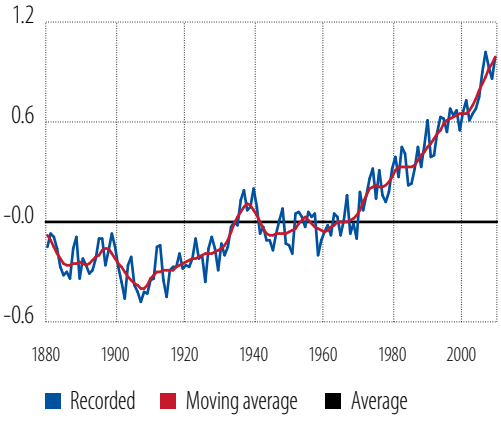
We analyse the official statistics to shed light on the current situation and show how far the European Union is from the 2030 target embodied in European Commission's plans. We then discuss long-term trends in pollution and investments in renewable energy. Finally, we provide a brief overview of the European Commission's green agenda.

EU citizens are majorly concerned by climate change

Global temperatures have already increased by 1.1°C relative to pre-industrial levels (Figure 1). Climate scientists almost unanimously attribute this change to man-made (anthropogenic) greenhouse gas emissions. Based on current mitigation policies, future anthropogenic greenhouse gas emissions are predicted to lead a 3°C increase in warming by the end of the century (IPCC, 2018). However, the future trajectory of global temperatures will largely depend on actions taken to reduce emissions.

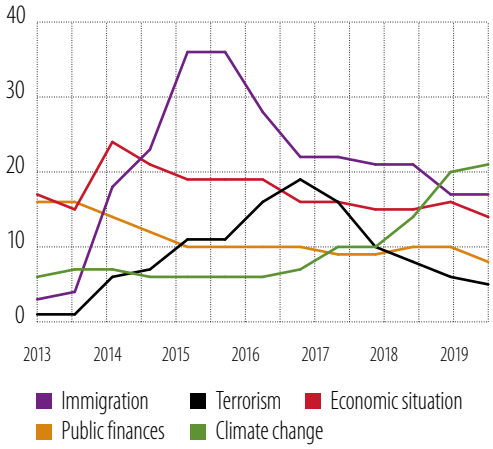
Climate change is increasingly important to voters in the European Union (Figure 2). With the increasing frequency of natural catastrophes and heat waves, European citizens are witnessing global warming's destructive nature. In 2013, voters listed global warming well below immigration, the economy and public finances in the list of challenges faced by the European Union. However, according to the Eurobarometer survey, Europeans have become increasingly concerned about climate change over recent years. Since the beginning of 2019, it has become the European Union's top challenge.

Figure 1
Deviation in land-ocean temperature index (°C)



Source: *National Oceanic and Atmospheric Administration.*

Figure 2
The top EU challenges (% respondents)



Source: *Euobarometer Survey.*
Note: *What do you think are the two most important issues facing the EU at the moment? Two answers maximum. Six-most mentionned items reported. Last record 2019:H2.*

Carbon emissions related to energy needs have risen since the 1960s, and accounted for 35 gigatonnes in 2019 (Figure 3).[1] However, the trend has flattened somewhat recently. The levelling off is mainly the result of a declining carbon emissions from the power sector in advanced economies, thanks to the expanding role of renewable sources (mainly wind and solar photovoltaic), the switch from coal to natural gas, and higher nuclear power output (International Energy Agency (IEA), 2020). The economic slowdown following the 2008 financial crisis also played a role. Currently, China, India and the United States account for about half of the world's carbon emissions, with the share of China and India increasing as their economies develop.

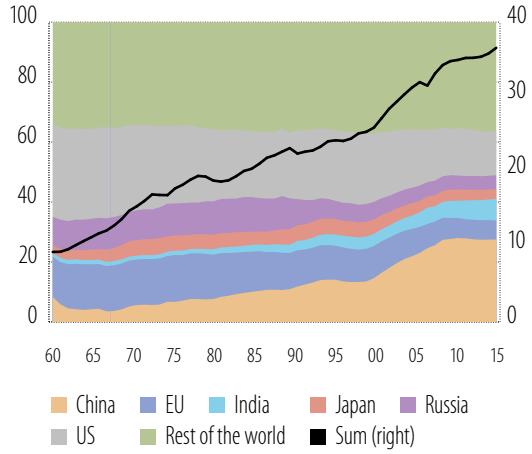
In the European Union, carbon emissions have declined for both primary energy consumption and final energy consumption since 2005, with both dropping to 1995 levels (Figure 4).[2] In 2018, the European Union's primary energy consumption accounted for around 1 400 million tonnes of CO_2 equivalent, a level comparable to 25 years earlier.[3] The decline was stronger in the energy sector as its share in primary energy dropped from 31% to 28%, reflecting the greater efforts made by this sector to reduce its carbon footprint. Despite these favourable trends, primary and final energy consumption are still above the trajectory set by the IEA to monitor progress towards the 2020 energy targets. Those targets are far less stringent than the European Commission's objectives.

1 Carbon dioxide is only one of many greenhouse gases; others include methane, nitrous oxide, and hydrofluorocarbons. To facilitate comparisons, it is conventional to convert costs for reducing non-CO_2 greenhouse gases into CO_2-equivalent units.

2 Final energy consumption is equal to primary energy consumption minus the internal consumption of the energy sector.

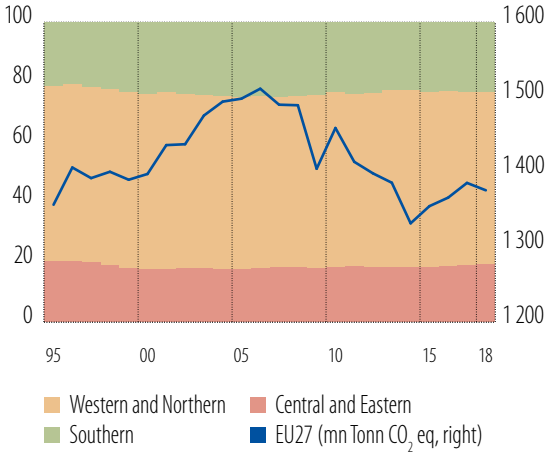
3 Carbon dioxide equivalent or CO_2 equivalent, abbreviated as CO_2-eq, is a metric measure used to compare the emissions from various greenhouse gases on the basis of their global-warming potential, by converting amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential. Carbon dioxide equivalents are commonly expressed as million metric tonnes of carbon dioxide equivalents.

Figure 3
Geographical contribution to world CO_2 emissions (left axis: %; right axis: CO_2 in billions of tonnes)



Source: *EIB Economics Department calculations based on the Carbon Dioxide Information Analysis Centre.*
Note: *Last record 2019.*

Figure 4
Primary energy consumption in the European Union (millions of tonnes of CO_2 equivalent, share (left) and EU level (right))



Source: *EIB Economics Department calculations based on Eurostat.*
Note: *Last record 2019.*

EU progress falls short of meeting the looming challenge

The Kaya identity helps us better understand the forces driving emission trends. As shown in equation 1, the Kaya identity states that the emission level of greenhouse gas carbon dioxide can be expressed as the product of four factors: human population, gross domestic product (GDP) per capita, energy intensity (per unit of GDP), and carbon intensity (emissions per unit of energy consumed).

$$CO_2 = N * GDPN * E/GDP * CO_2/E$$

N is the population, GDPN is per capita GDP, E over GDP is the energy intensity of GDP and CO_2 over E is the carbon intensity of energy. Three components, driven by different factors, account for carbon emission trends: GDP, the energy intensity of GDP and the carbon intensity of energy.

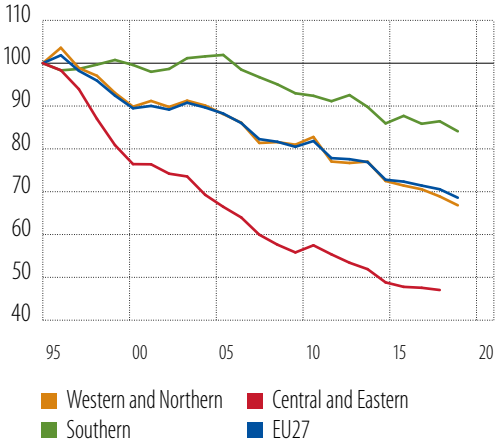
Recent history and official estimates suggest that, over the long term, EU growth is about 1 to 1.5% a year. It is well known that Europe has an ageing population, so labour's contribution to GDP should decline. Productivity growth has also declined since the financial crisis, a phenomenon affecting most advanced economies. Overall, long-term growth fell from around 2% in the 1990s to less than 1.5% before the COVID-19 crisis. With the pandemic, uncertainty has increased. We cannot rule out the possibility that beyond the output lost during the lockdowns, the crisis may leave some scars that further reduce long-term growth. Moreover, we don't know how long it will take to return to pre-crisis levels of economic activity. At the same time, the pandemic isn't over, and further waves cannot be ruled out.

Over the last 25 years, the energy intensity, the amount of energy required per unit of GDP, has declined by around 30%. Figure 5 plots the energy intensity in the European Union and the three regions since 1995. The ratio is based to 100 at the beginning of the sample. In the three regions, the ratio has been declining since 1995, with a stronger drop in the economies of Central and Eastern Europe. This decrease can be explained by greater production efficiency as well as growth in services, which are less energy intensive.

The carbon intensity of primary energy consumed has also been falling. Figure 6 plots the carbon intensity in the European Union and the three regions from 1995 to 2018, using a ratio based to 100 at the

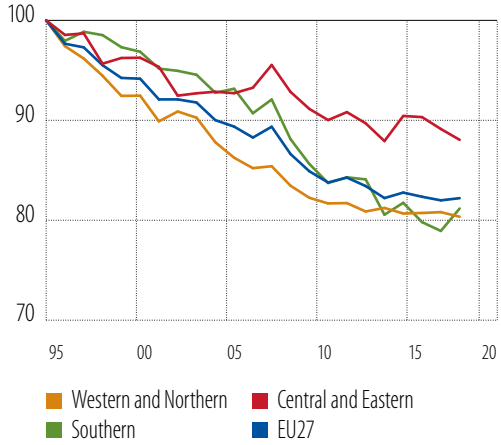
beginning of the sample. The ratio illustrates an almost 20% reduction in carbon intensity in the European Union, with a similar decrease in the economies of Northern and Western Europe and Southern Europe. The decrease for Central and Eastern Europe, however, is less pronounced, by about one-half. In addition to progress made in the traditional energy sector, the decline in the carbon intensity of primary energy consumption also reflects the increased share of renewable energy, which is carbon-free.

Figure 5
Energy intensity of GDP (1995 = 100)



Source: *EIB Economics Department calculations based on Eurostat.*
Note: *Last record 2018.*

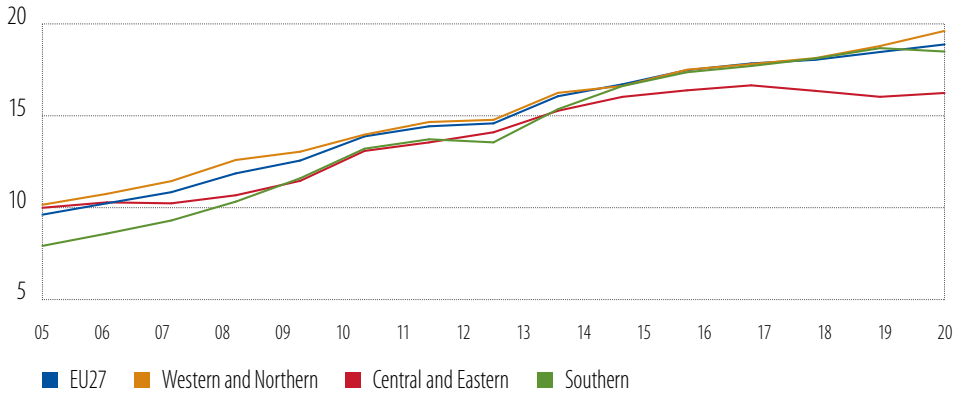
Figure 6
Carbon intensity of primary energy consumed (1995 = 100)



Source: *EIB Economics Department calculations based on Eurostat.*
Note: *Last record 2018.*

Renewable energy's share in final energy consumption has doubled in the last 15 years (Figure 7), from around 9% in 2003 to 18% in 2018. EU economies all made headway, with Southern Europe making the most progress, largely because those countries traditionally had less renewable energy production. The growth was more subdued for Central and Eastern Europe, where the energy sector is based more on coal, and therefore more polluting. The regional differences in efforts to move to less carbon-intensive energy, and the urgency of the need to meet the EU target, explain why the European Union created the Just Transition Fund, a EUR 40 billion fund to help countries catch up.

Figure 7
Share of renewable energy (% of final energy consumption)



Source: *Eurostat and EIB calculations.*
Note: *Last record 2018. Country aggregates weighted on the basis of primary energy consumption.*

The nature of renewable energy in the European Union has profoundly changed over the last 25 years. In 1995, solid biofuels represented more than 75% of renewable energy, with wind making up the remainder. From 1995, wind power increased rapidly and accounted for 60% of renewable energy in 2015. Wind power's contribution has remained 60% to 65% since then. Solar energy contributed only 1% of renewable energy in 2005, but increased substantially from 2015 onward, and now hovers at 20% to 22%.

Declines in energy intensity and carbon intensity explain why carbon emissions have remained close to their 1995 levels, despite a rise in real GDP. We can use the Kaya identity to summarise trends in emissions since 1995. From 1995 until 2018, the European Union's real GDP increased by almost 50%, a rise that normally would have pushed up pollution. However, the 30% decline in the energy intensity of GDP, together with the 20% decline in the carbon intensity of energy consumption, have offset the positive impact of GDP growth on emission volumes. The result is that the European Union's carbon emissions have stabilised. Looking ahead, it will be important for GDP growth to continue to be accompanied by declines in energy intensity and carbon intensity to meet the European Union's climate goals.

Quick overview of renewable energy and climate mitigation in the European Green Deal

Greenhouse gases accumulate over time. Emitted carbon dioxide, the primary greenhouse gas, stays in the atmosphere for many years. It continually increases average global temperatures until a peak is reached about 40 years after the carbon dioxide is emitted. Carbon dioxide then dissipates slowly, and has a half-life of above 30 years (Pizer, 2002). Consequently, limiting the damage from climate change requires large reductions in cumulative emissions over time – yearly fluctuations do not matter much.

Given the long-term nature of the problem, it is important to accurately measure the social discount rate, or the present value of the costs and benefits that will be felt in the future. Opinions differ widely as to the appropriate ethical framework for analysing climate policy's impact on welfare. Any such policies will have important distributive effects, both within and across generations. Ethical parameters such as the pure rate of time preference, or how much we value our own welfare relative to the next generation, and the elasticity of marginal utility, or how much we care about inequality in consumption, have been shown to be crucial determinants of the timing and intensity of optimal policy responses (Nordhaus, 2008 and 2020).

The ultimate policy mix is multifaceted and difficult to design. Carbon reduction can generate significant environmental benefits – for example, increased life expectancy in urban areas. However, decarbonisation will also incur costs, change the value of certain assets and contribute to unemployment in different sectors. A democratic approach requires understanding the social trade-offs when analysing the impact on society's welfare. It is not easy to account for the ethical preferences of diverse groups of individuals.

The huge uncertainty regarding the climate should not be an excuse for maintaining the status quo. Increases in concentrations of greenhouse gases are causing shifts in the climate. We don't know precisely how large these changes will be, or when and where they will occur. We also do not fully understand the social and economic consequences of these changes, or how we will be able to deal with them in the future. We do have an enormous amount of useful information about the perils of climate change, certainly more than enough to recognise that it is an issue requiring immediate policy attention. The downside risk from ignoring climate change is likely to be far worse than the downside risk of aggressive policies to mitigate it. That in itself supports aggressive policy action (Millner et al., 2013).

To reach the European Commission's objective, renewable energy must account for more than one-third of primary energy consumption by 2030. Good policies are based on clear targets and in transparent monitoring of those targets. To reach climate neutrality by 2050 and limit global warming to 1.5°C,[4] the new European Green Deal sets a target to reduce greenhouse gas emissions by 55% of their

4 This requires net-zero greenhouse gas emissions.

1990 levels (European Commission, 2020a) by 2030, a target revised upwards by the European Parliament in the beginning of October 2020.

The energy sector should contribute majorly to reducing emissions. The European Commission's Clean Energy package calls for 32% of final energy consumption to come from renewables in 2030. If that goal is met, electricity generation should cut emissions by half from 2015 to 2030, more than any other sector.[5] Almost all capital expenditure will go towards the rollout of wind and solar energy, and almost none to new fossil fuel capacity. Exposure to coal, gas and carbon prices will be reduced as well as the investments needed to maintain existing fossil fuel plants. The savings will help finance the shift towards renewable energy.

Large increases in energy related investment and low-carbon capital investment are needed. The European Commission's latest impact assessment analysis (2020) indicates that annual energy-related investment should increase considerably over the next decade. In total, around EUR 550 billion is needed to achieve the new proposed greenhouse gas emissions target of 55% by 2030. This means almost EUR 350 billion (including transport) of investment above historic levels from 2011 to 2020, and around EUR 80 billion (or EUR 200 billion including transport) above the baseline scenario, which was targeting a 40% reduction in greenhouse gas emissions by 2030. For companies, low-carbon capital investments would also need to more than double from EUR 59 billion in 2019 to around EUR 122 billion a year (Carbon Disclosure Project (CDP) and Oliver Wyman, 2020). While this is a significant increase, low-carbon investment would still represent a modest share of corporate capital expenditure, growing from 12% to 25% of the total.

The new European Union budget, known as the Multiannual Financing Framework, and the coronavirus recovery fund will help pay for the European Green Deal. Over the next few years, 30% of both the European Union's budget and the recovery fund will be dedicated to climate action and clean energy, representing more than EUR 500 billion. Painful adjustments in carbon-intense sectors and regions will be addressed by the Just Transition Mechanism, which will tap the Just Transition Fund budget proposed to amount to EUR 40 billion.

Contours of a climate policy

Various policy tools can be deployed to shift investment towards low-emission and climate-resilient options (Figure 8). The greening of the economy is too slow under current policies and regulations. Policies need to be overhauled to push the private sector to adequately account for the social and environmental impact of climate change. As shown in Figure 8, these policies should address carbon pricing, fossil fuel subsidies, support for renewable energy,[6] regulations (overcoming barriers or shortening the administrative steps needed for energy efficiency investments or to limit the use of fossil fuels), targeted investment incentives (such as feed-in tariffs or tenders for renewable energy), providing reliable quantitative information to facilitate the computation of economic returns, and support for innovation, among other things (Gillinham and Stock, 2018).

In addition to regulation, altering prices and/or the finance cost of investments are two ways to green the economy faster. Figure 9 is based on a simplified representation of a closed economy comprising four sectors: households, non-financial corporations, the government and banks. Consumers consume two goods: a brown and a green good, each produced by two different technologies, one green and one brown. The brown good is produced combining labour and brown capital and the green good is produced using green capital and labour. Production and consumption result in greenhouse gas emissions which, by definition, are lower for the green good and technology. While capital is sector-specific and renewed each period, labour is free to move across sectors.

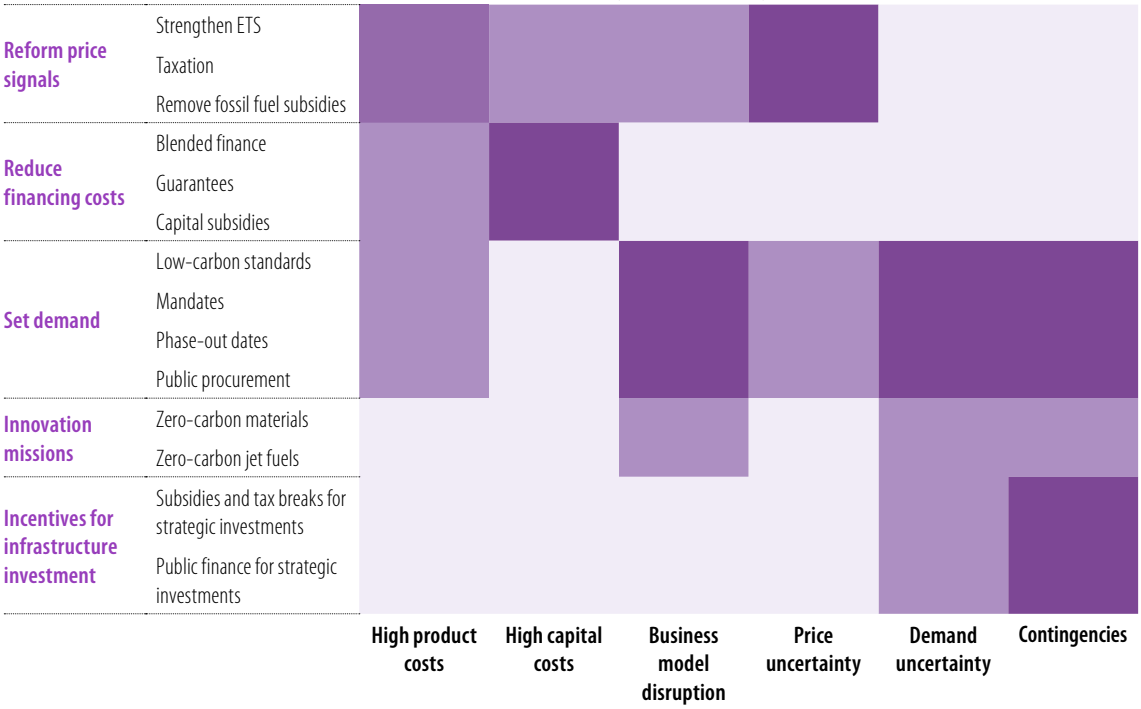
5 The European Commission's Clean Energy Package that set different targets across sectors. Over 2015-2030, it requires the energy sector to reduce emissions by 46%. The target for the transport sector is for 14% of energy to come from renewables.

6 According to the Carbon Disclosure Project, estimates for fossil fuel subsidies in the European Union range from EUR 55 billion to EUR 112 billion a year, comparable to corporate low-carbon capital investment.

Greening requires changing the relative prices of brown vs. green goods and technologies. Greening the economy requires reducing the consumption of brown goods and/or technologies and/or increasing the use of green goods or technologies. To achieve this, the price of brown goods relative to green goods has to increase and/or the relative price of brown capital relative to green capital has to increase. The representation depicted in Figure 9 emphasises the two main policies for changing relative prices: taxing capital or consumption, or altering the relative cost of finance.

Given its pivotal role in the allocation of savings, the financial sector can become a cornerstone of greening policies. The financial sector collects the household savings invested in green and brown capital (Figure 9, left-hand side). When financed by bank loans, an investment's financing cost is calculated as a mark-up on the risk-free rate of funds plus the capital cost. The capital cost is the cost of the equity required to cover the risk of the bank loan. Since the cost of equity is well above the risk-free rate (EIB, 2019), an increase in the share of equity required to back the loan increases the finance cost and reduces the amount that can be invested. More generally, for non-bank finance, investors' expectations or preferences help decide where they put their money, and changes in those preferences can impact the relative costs of brown and green investments.

Figure 8
Barriers to low-carbon instrument (x-axis) **and policy solutions** (y-axis)



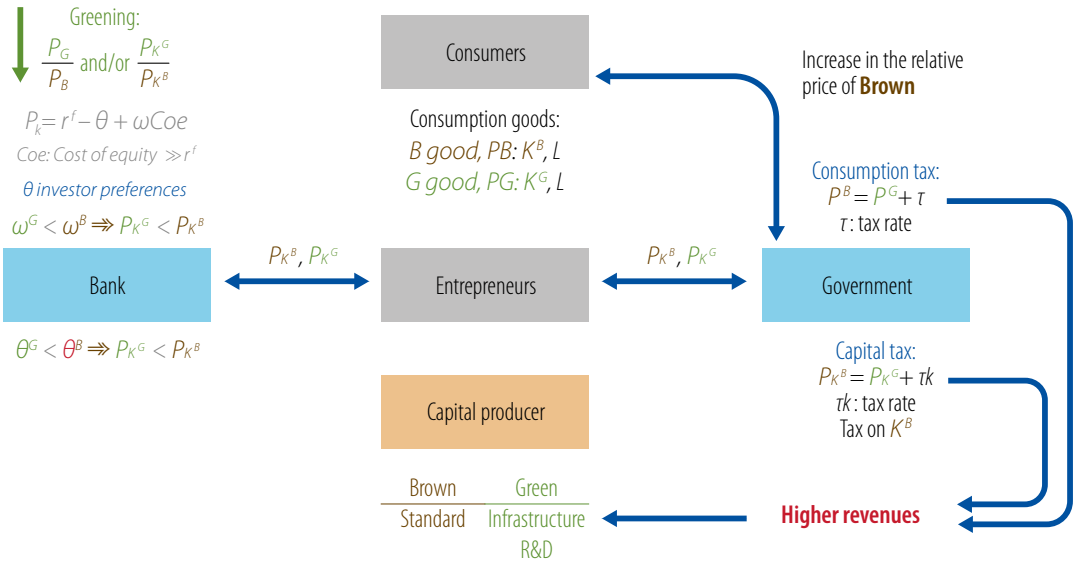
Source: *O. Wyman analysis.*
Note: *The darker the green the higher the impact of the policy implemented.*

The European Union is a large open economy, but not large enough to influence prices worldwide. If major economies were to combine their efforts, they could leverage their market power to foster the development of carbon-efficient utilities, production processes and services. By aligning incentives, standards and penalties, they could push greater economies of scale and reduce production and transaction costs for green products and technologies. Aligned policy action would accelerate a shift in consumption and production patterns, which, given the market share involved, would spill over to the rest of the world. Coordinated policy action is therefore paramount to tackling climate change.

Trade policies can also favour a greener economy. Goods and capital are almost entirely mobile across borders. In the absence of international agreements regarding environmental standards, international

investors can relocate investment and production to less stringent areas and export back to consumers. Shapiro (2019) shows that in most countries, import tariffs and non-tariff barriers are substantially lower for dirty than for clean industries. The differences in trade policy effectively subsidises carbon emissions. New policies that correct this bias would decrease carbon emissions substantially without affecting global real income.

Figure 9
The macroeconomic channels of the main climate mitigation policies



Source: *EIB Economics Department.*

A level playing field must be guaranteed globally, despite insufficient international coordination. By nature, agreements reached at the international level distort trade flows less. By raising the cost of energy, climate policies can increase competitive pressures. The European Union needs to avoid a race to the bottom that would harm production without altering global pollution trends. For that reason, the European Union is discussing a Carbon Border Adjustment Mechanism to be implemented by 2023. Such mechanism should incentivise foreign producers to reduce their carbon emissions and therefore contribute to raise standards globally.

Why the carbon pricing and trading system must be supplemented

Implementing a price for greenhouse gas emissions is crucial to climate mitigation. As shown in Figure 9, pricing emissions encourages users to reduce their energy consumption and emitters to switch to cleaner production alternatives. Pricing policies are a cost-effective way to reduce emissions. They provide emitters with an incentive to cut emissions, as long as cutting emissions is cheaper than paying the carbon price. Pricing policies tend to have a neutral economic impact. Because the policies do not stipulate which emissions should be reduced and/or which technology should be favoured, they overcome the information asymmetry between governments and polluters. Pricing emissions can be achieved through taxes or tradable permits. Incidentally, pricing policies stimulate innovation (Organisation for Economic Co-operation and Development (OECD), 2016a) that will develop new technologies.

Setting a clear and credible path for carbon pricing fosters investment as it enables investors to better calculate returns. Tax-based policy sends market signals that affect expectations. The introduction and strengthening of carbon prices signal a strong policy commitment, which can indirectly impact behaviours

and activities not directly subject to the carbon price. Moreover, the expectation of a permanent increase in prices modifies the technological trajectory of the economy (Fried, 2019). The longer-term effects of higher prices are important for the pricing of financial assets, particularly since the financial sector tends to be forward-looking. Fried et al. (2019) shows that US firms are making investments choices in less polluting processes, despite the uncertainty surrounding if and when a carbon price will be imposed, that reflects an implicit carbon tax of more than USD 3 per tonne.

However, there is wide uncertainty regarding the price of carbon. In principle, carbon prices can be set to reflect the societal or other external costs of carbon emissions or to meet abatement targets. The US government estimated the social cost of carbon at approximately USD 46 per tonne of emissions in 2017 (Interagency Working Group on Social Cost of Greenhouse Gases, 2016). In one scenario for greening the economy, a French study came up with a price as high as EUR 775/tCO_2 in 2050 (Quinet, 2019). The European Commission's studies to achieve net-zero greenhouse gas emissions by 2050 calculate a carbon price of EUR 350/tCO_2 by 2050 (European Commission, 2018).

It is possible to raise taxes without damaging the economy. Some case studies show that it is possible to raise carbon taxes and reduce carbon emissions without damaging economic activity. Sweden, for example, has raised its carbon tax since the middle of the 1990s, reaching USD 127 per tonne by 2018. Over the period, emissions were cut 25% while real GDP grew by 75%, above the European Union's level of 50%. A well-designed package, with more extensive carbon pricing across EU countries and sectors, combined with cuts in distortionary taxes and targeted support for green investment, would allow the European Union to reach its emission goals with practically no effects on aggregate income (Chen et al., 2020). The EU recovery plan brims with this possibility. It expects climate-related investments to account for at least 30% of recovery spending.

Abrupt increases in carbon prices can have elevated social costs. Increasing the price of carbon sharply would have a major impact on production costs, and therefore prices in many sectors. According to Nordhaus (2017), for temperature increases to remain below 2.5°C by the end of the century, the carbon price would need to increase from USD 15 to USD 30 per tonne of carbon to USD 60 to USD 200. At global level, a USD 25 tax per tonne of carbon would increase transcontinental air fares by 6%, the cost of driving a car by 8% and overall consumer price inflation by 1%. The required increase in prices would exacerbate social tensions. An obvious example is the "Gilets Jaunes" (yellow vests) movement initiated in France late 2018.

Carbon taxes can also generate substantial fiscal windfalls. Pricing all emissions at EUR 30 per tonne would generate revenues averaging 1% of GDP across the G20 countries, at current emission levels (OECD, 2017). Most estimates suggest that a USD 35 per tonne tax in 2030 would generate revenues of 1% to 2% of GDP.[7]

To ensure the public's support, environmental tax revenues could be used to finance environmental spending or offset adverse effects. The "Gilets Jaunes" experience in France emphasises the need to gain public support before embarking on sharp increases in the carbon tax. In general, government revenues are used to finance social spending, public services, technology and infrastructure. To boost the carbon tax's legitimacy, the spending breakdown of the resulting revenues could be adjusted.

Public political support could be shored up at minimal cost, especially in the case of housing renovation. Housing is an important contributor to carbon emissions, as insulation and heating system have not kept up with technological progress for most old buildings. Box A elaborates on the on-bill financing scheme, which provides financing for households to invest in energy efficiency. Basically, the investment costs are backed by the savings resulting from the investment meaning that households do not see major changes on their energy bill.

7 The range of estimates is consistent with Nordhaus (2017) which suggests that a USD 25 tax would generate a windfall of USD 168 billion in revenues.

There is mild evidence that governments collecting more revenues from environmental taxes develop greener policies. Across European countries, environmental tax revenues collected by governments amount to 1.5% to 4% of GDP (Figure 10). Nominal spending on environmental protection is well below, from 0.5% to 1.5%. More importantly, the correlation revenues and environmental spending is very weak (R-squared of only 3%). Dedicating carbon taxes to spending for the green transition would have benefits, but it would also constrain governments, which prefer to have more leeway in dedicating tax revenues.

Box A

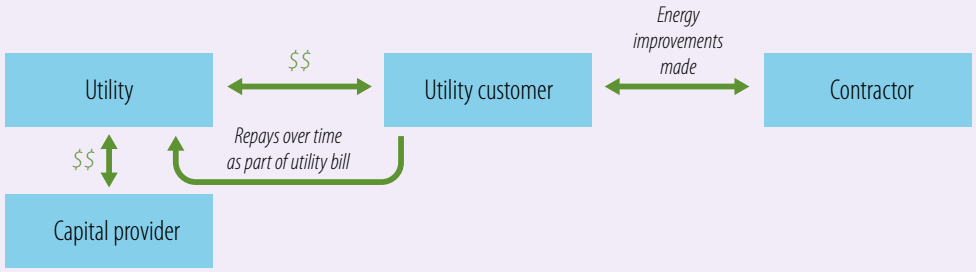
On-bill financing – an innovative financial instrument to support residential energy efficiency

High initial investment costs are a key barrier to investing in energy efficiency improvements in residential buildings, even if in many cases such investments would otherwise have a positive return. The upfront cash flow needs – together with the lack of eligibility for financing that could bridge the cash flow gap – are preventing improvements in large segments of the residential sector.

On-bill financing is a special method of funding energy efficiency or renewable energy investments for households. The unique feature of these programmes is that utility bills are used as the vehicle for repayment. In a typical on-bill programme, the utility company or a third-party lender provides a loan for a customer's energy efficiency projects. The customer then repays the loan through additional charges on their regular utility (gas, electricity) bills (Figure A1).

Figure A.1

The structure of an on-bill financing scheme



Source: *EIB Investment Survey (EIBIS), SAFE, Enterprise Surveys, EIB calculations.*

On-bill programmes generally attempt to achieve bill neutrality, meaning that the savings from the efficiency improvements are expected to equal or exceed the new on-bill loan payments. To achieve this, an energy auditor reviews the efficiency improvements and estimates the reduction in utility expenses expected after the project. On-bill financing schemes can also be combined with grant elements, which can significantly increase the scale of feasible investment, reduce the repayment period and can help to ensure bill neutrality.

The advantages of on-bill financing compared to a simple housing renovation loan are manifold. Most importantly, it can provide access to funding to households that otherwise would not be eligible for a conventional loan or may find a loan too expensive. Many such households with limited or no bank contacts would be able to take out an on-bill loan if their monthly payments are not expected to increase. On-bill agreements are typically very simple, and making repayments directly on a utility bill is convenient. In addition, most of these households have good track records for utility payments, and past bill repayment can be used as a convenient proxy for evaluating the loan applications. In

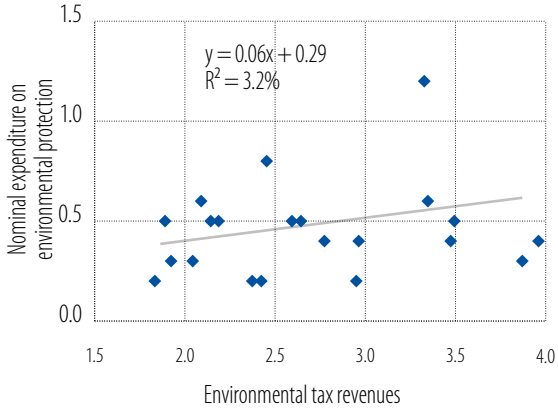
addition, on-bill financing schemes can better align the incentives to carry out energy efficiency renovations in tenant-occupied properties, where landlords are often reluctant to finance the upfront costs of energy-efficient renovations as they do not directly benefit from the subsequent financial and other advantages.

However, on-bill financing schemes often pose significant legal and organisational challenges. Coordination among the various stakeholders – such as the utility company, the lender, the grant provider, the eligible contractors and the beneficiaries – is often difficult. Furthermore, in many jurisdictions it is difficult to find solutions that are compatible with banking regulations, the legal framework governing utility service provision, and consumer protection regulations. These obstacles hinder the more widespread use of on-bill financing in many countries.

In the United States and Canada, on-bill schemes have become widespread in the last 30 years, and they are a key driver of the building renovation market. Most programmes are implemented by rural utility co-operatives and municipality-owned utility service providers. In Europe, only a handful of attempts have been made so far. These include the UK Green Deal programme and the Horizon 2020-funded SUNShINE (Save your bUildiNg by SavINg Energy) project in Latvia, which aimed to carry out the in-depth retrofit of multi-family buildings. A pilot initiative to scale up energy efficiency investments by promoting the implementation of on-bill schemes and focusing on Germany, Italy, Lithuania and Spain is ongoing under the umbrella of the RenOnBill consortium.

The Emission Trading System (ETS) provides an alternative to taxation. ETS provides some flexibility, balancing the uncertainty of the benefits gained by emission reductions and the political risks of high carbon prices. In the European Union, the ETS is based on emission caps. When companies exceed their cap, they buy extra allowances in an open auction. That market is in turn fed by companies selling their unused allowances. The empirical literature shows that the cost increases resulting from the requirement to purchase carbon allowances are passed on to the consumer, producing similar effects to a tax (Dinan, 2009).

Figure 10
Environmental revenues and spending across EU members (% GDP)



Source: *EIB Economics Department calculations based on Eurostat.*
Note: *Average over 2014-2016, the latest period with full coverage of EU countries. Non-profit organisations also included.*

Figure 11
Emissions Trading System carbon price (euros)

Source: *EIB Economics Department calculations based on EMBER.*
Note: *Weekly data ending 1 August.*

The ETS has succeeded in reducing EU emissions in the sectors covered. Firstly, the cap can be adjusted over time to enable a smooth transition of the economy. Secondly, the range of sectors subject to the ETS can be enlarged. While increasing over time, the range of sector remains low, covering around 40%

of total EU emissions, excluding transport and housing (International Monetary Fund (IMF), 2020b). In the European Union's case, the policy has been instrumental in reducing carbon emissions (Martin et al., 2018). For the industrial sectors covered by the scheme, the share of auctioned allowances (or the extra allowances companies pay for) reached 57% of total allowances in 2019.

However, highly uncertain ETS prices may cloud investment returns. After remaining relatively stable at about EUR 6 per tonne of carbon from 2012 to 2017, the price of carbon traded on the ETS rose significantly in 2018 and 2019, hitting EUR 25 per tonne (Figure 11) at the end of 2019. Prices dropped again during the first coronavirus lockdown, dipping to a low of EUR 16 per metric tonne, in line with the 10% to 20% decline in electricity demand in several major European economies (International Economic Agency, 2020). Changes in demand majorly affect ETS prices (Osterloh, 2020; Hale and Leduc, 2020). This price volatility complicates the task of evaluating returns on investments for alternative or less-polluting technologies.

Renewable energy investment and the associated financing

Following years of investment, the cost producing renewable energy has fallen substantially. Figure 12 shows the decline in the cost of energy for onshore wind in the European Union and selected economies. On average, costs have declined more than 50% over the last 25 years. Costs have also fallen for many other sources of renewable energy. These technologies are relatively new and gain in efficiency as their development progresses, benefiting from quick gains in knowledge and large economies of scale.

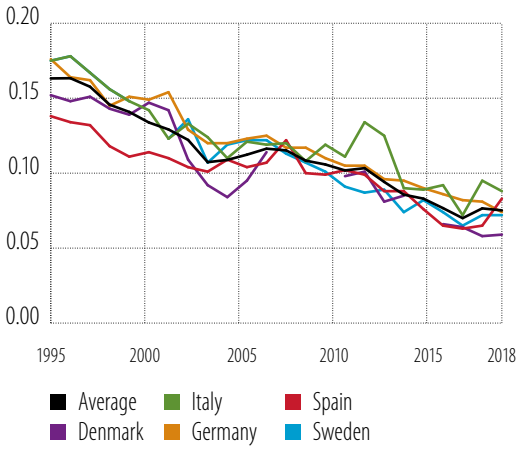
It was relatively unexpected that many sources of renewable energy would become less expensive than fossil energy (Figure 13). Quantifying current costs is necessary when designing climate policy, but it is not enough. Climate change is a long-term problem that can be addressed through a range of technologies whose cost is path-dependent. The optimal mitigation policy is the one that minimises the longer-term costs of adaptation, bearing in mind that actions taken today can influence future costs. Spending on certain technologies today influences the options that will be available to others in the future. By conveying information, the financial markets, decentralised and forward-looking by nature, reduce the risk of locking the economy into a poor technological choice.

A wait-and-see attitude and the irreversible aspects of certain decisions help explain why renewable energy investments are not higher. Investments made by others today tend to bring down overall costs tomorrow. Today's spending also affects investment in infrastructure. The purchase of electric or hydrogen cars, for example, will lead to varying demand for charging stations. Given that substantial parts of the investments are irreversible, there is an incentive for investors to wait and see how things will play out (Vogt-Schilb, Meunier and Hallegatte, 2018). Gerarden et al. (2015) review the factors explaining the energy efficiency gap. The authors show that renewable energy investments do not appear to be adopted by consumers and businesses to the degree that might seem justified, even on a purely financial basis.

Green investments are specific in nature. They enhance welfare but are risky for investors. While regulatory uncertainty can be reduced by long-term commitments from policymakers, technological changes and shifts in consumer preferences remain flux. Hence, the transition is likelier to be financed by risk-taking and risk-absorbing instruments such as equity. Longer-term investors also need to be attracted.

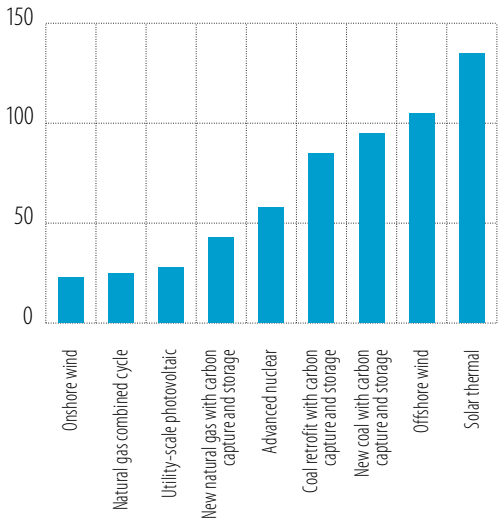
Financed-constrained firms tends to invest less in energy efficiency. In the European Union, energy efficiency investment by non-financial firms is unevenly distributed across the Member States, sectors and size classes. Across EU regions, however, the share of this kind of investment is very similar. It varies in a narrow range of around 10%, but overall a high proportion of firms do not invest in energy efficiency. Figure 14 shows separately the proportion of finance-constrained firms investing in energy efficiency and those which do not. In the European Union, particularly in Southern, Central and Eastern Europe, firms not investing in energy efficiency tend to have less access to finance. This relationship suggests adverse conditions for accessing external finance help explain why firms aren't investing in energy efficiency.

Figure 12
Global weighted levelized cost of energy of onshore wind (2018 USD/KWh)



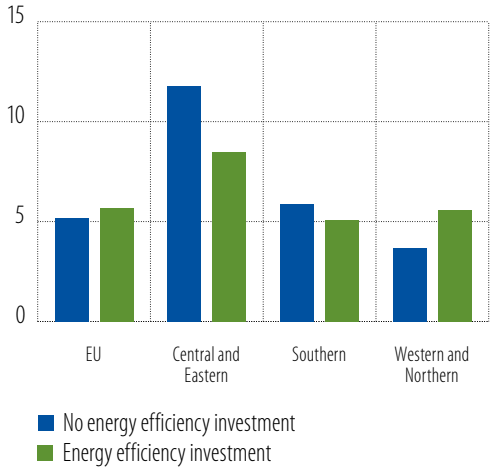
Source: *International Renewable Energy Agency (Irena).*

Figure 13
Comparing costs (USD per tonne of CO_2 in 2017 dollars)



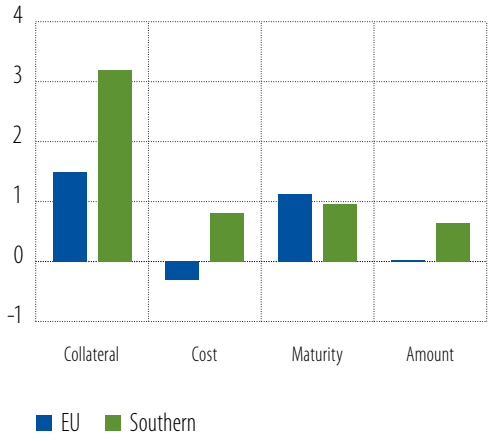
Source: *K. Gillingham and J.S. Stock (2018).*
Note: *Estimates are derived from the US Energy Information Administration's Annual Energy Outlook 2018. Costs are projected for facilities that are due to come online in 2022 and do not include federal renewable energy tax credits or other subsidies.*

Figure 14
Proportion of finance-constrained firms (%)



Source: *EIBIS 2020.*

Figure 15
Difference in dissatisfaction between firms not investing in efficiency investment and those investing (percentage points)



Source: *EIBIS 2020.*

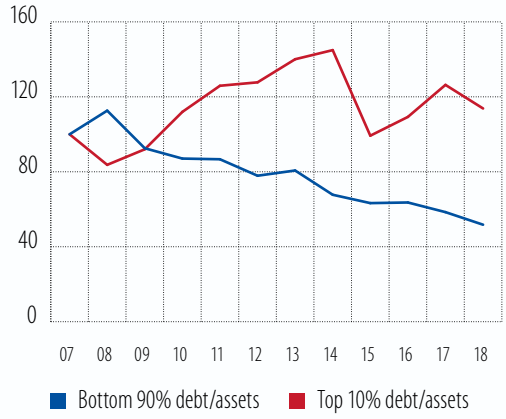
Firms not investing in energy efficiency tend to be more dissatisfied with financing offers they receive. Figure 15 compares the levels of this dissatisfaction. It depicts the difference between firms not investing and firms investing in energy efficiency according to various characteristics of the financing offer. For most of these features, the firms not investing in energy tend to be more dissatisfied. Hence, dissatisfaction

with the financing offer may be a factor limiting a firm's capacity to invest in energy efficiency. The difference in finance costs and collateral requirements is especially pronounced in Southern Europe.[8]

More indebted firms are showing hardly any progress in reducing carbon emissions. A sample of publicly listed firms in 28 EU members (including the United Kingdom) shows the average ratio of greenhouse gas emissions to sales halved from 2007 to 2017. Large differences exist between firms, however, on their ability to make their production greener. In particular, the most highly leveraged firms do not follow the EU-wide patterns (Figure 16). For highly indebted firms, emission ratios are not declining, and varied from 80 to 140 during 2007-2017. This suggests that excessive leverage reduces a firm's ability to shift production towards greener processes.

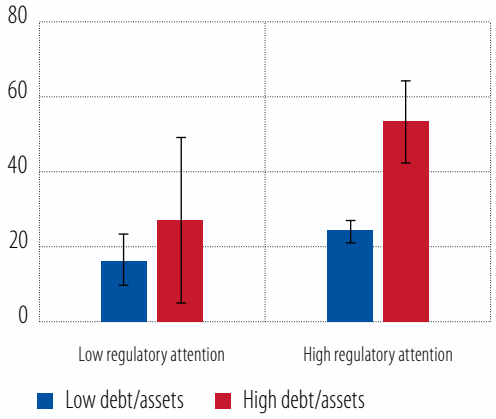
In sectors with the most stringent environmental regulations, highly indebted firms emit more carbon than their less-indebted peers (Figure 17). We have estimated how carbon emissions respond relative to legislative constraints, depending on the level of corporate indebtedness.[9] The results shown in Figure 17 confirm that higher debt financing reduces the responsiveness of firms to the regulatory environment, impeding the green transition. Looking more closely at the type of debt and the breakdown between short- and long-term debt, the debt-to-carbon relationship seems to be mostly driven by short-term debt, with no visible effects observed for long-term debt. Overall, the results suggest that there is no significant difference between high- and low-debt firms in sectors with little regulation. However, in the more environmentally regulated sectors, highly indebted firms seem to be less able to lower their carbon emissions than their less-indebted peers.

Figure 16
Carbon-to sales ratio (2007=100)



Source: *EIB analysis in Tueske and Wolski (2020) based on Refinitive and Orbis.*
Note: *Sample of 602 publicly listed firms in the EU28. A debt to asset ratio of 80% is the threshold for the top 10% indebted firms.*

Figure 17
Carbon emissions of firms determined by debt and regulatory attention



Source: *EIB analysis in Tueske and Wolski (2020).*
Note: *The figure reports the predictive margins for an average firm operating in low/high regulatory attention sectors (LEX variable 10 or 50) with low/high debt (debt/assets at 30 or 80). Low debt/assets is set at 30% and high debt/assets at 80%.*

8 The population of firms represented differs across Figure 14 and Figure 15. Those dissatisfied received bank finance while those financially constrained did not.

9 We built LEX, a legislative index based on the number of environment-related legal documents published in the EU Lex database in a given year in a given sector. We then drew up estimates based on the following equation:

$$\log (CO_2)_{icst} = \beta_0 + \beta_1 LEX_{st} \times DEBT_{icst-1} + \beta_2 DEBT_{icst-1} + \beta_3 X_{icst-1} + \mu_{cst} + \varepsilon_{ict}$$

where I is the firm, c is the location country, s is the sector and t is the year. CO_2 is the CO_2 emission (in million tonnes) and DEBT is the firm's total debt divided by total assets, X denotes a vector of lagged control variables including the logarithm of total assets, the ratio of cash flow to total assets, and the ratio of sales to total assets. Its inclusion allows us to capture the independent impact of various firm-specific characteristics.

A call for a more equity-based financial system

It is well known that the European Union's financial system is bank-based (Figure 18). The financial sector has exploded in recent years and is now more than twice the size it was in the 1990s. Since the financial crisis, growth in bank finance has trailed market sources of finance. Despite this, bank-based finance continues to dominate in the European Union (EIB, 2019). This picture is relatively unusual as financial markets develop more at later stages of economic development (Beck and Levine, 2002; Hsu et al., 2014).

Empirical literature suggests a link between the nature of the financial system and the ability of an economy to go green. This is consistent with the nature of green investment, which is longer-term and riskier. For example, De Haas and Popov (2019) show that stock markets are superior to banks in decarbonising the economy. The authors consider a hypothetical increase in the share of market finance of 20 percentage points on average for 80% of the world economies (from an average of 30%). This would align the financing structure of these economies with that of Australia, Canada, Finland and the Netherlands. According to the authors' estimates, this structural change would likely result in an 11% reduction in aggregate carbon emissions.

We have looked at whether the European Union's financial system is affecting the level of carbon emissions, or the economy's capacity to invest in renewable energies. We focused on the EU economies, where the differences in economic development are much less pronounced than at global level. The sample covers all EU economies from 2000 to 2018.[10] However, because some records are missing, the equations are estimated using fewer observations – 399 to 484 – than what would normally be available over the period. We defined the ratio of market-based finance as equity over equity and bank assets. These definitions are in line with prior studies on the link between financial development, financial structure, and growth (such as Beck and Levine, 2002; Hsu et al., 2014). Note that we did not include funding through corporate bond markets, for two practical reasons. First, comprehensive data on corporate bond financing are missing for many of the countries in the dataset. Second, in the vast majority of countries for which we have data, corporate bonds account for a negligible share of overall financial intermediation compared with credit markets and stock markets. We controlled for a given level of economic development by incorporating the level of real GDP at the beginning of the sample in 2000. We assessed the link between various brown intensity indicators and the financial structure.

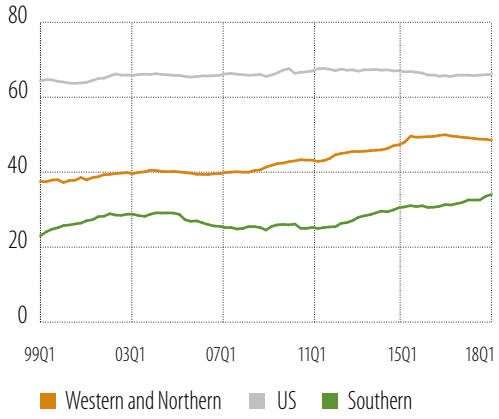
We found evidence that EU economies generate fewer carbon emissions per capita if they receive more market-based finance. Our results are indicated in Figure 19. They suggest that a 1 percentage point increase in the share of market finance is accompanied by a reduction of 6.9 to 9.1 in the carbon intensity of primary energy consumption. The effect is statistically significant at a level of at least 5%. An increase in the size of the insurance sector also has a positive but not effect. A 1 percentage point increase in the share of insurance assets in GDP is also accompanied by a reduction of 0.1 percentage point of greenhouse gas emissions per capita. Overall, these results suggest that more developed financial markets or larger long-term investors facilitate the financing of renewable energy investment and are therefore associated with a greener economy.

Innovation and the level of tangible assets partly explain why equity investments reduce the carbon footprint more than debt. Energy-efficient sectors – sectors that have lower carbon emissions per sales – tend to be more innovative but poorer in tangible assets than carbon-intensive sectors. At the same time, equity is known to be supportive of innovation and intangible investment (EIB, 2019). As shown by Kim and Weisbach (2008) or Brown et al. (2017), sectors rich in tangible assets expand faster in bank-based economies while innovative sectors grow faster in economies with deeper stock markets. Economies with deeper stock markets are also associated with more "green patenting" in traditionally carbon-intensive industries. Private equity is also important in energy efficiency, confirming the important role that

10 Data related to emissions come from the OECD. Data related to financial structure come from the World Bank Financial Structure Indicators. GDP is taken from Eurostat.

investors such as venture capitalists play in innovation and technological adoption (Kortum and Lerner, 2000). More developed financial markets tend to have higher governance standards, and the quality of those markets' institutions can limit the environmental impact of economic growth (Dees, 2020).

Figure 18
Share of market-based finance in Europe (%)



Source: *EIB calculations based on Bank for International Settlements.*
Note: *Computed as market debt over market debt and bank credit for non-financial corporates. Central and Eastern European countries are not populated enough to produce a representative aggregate.*

Figure 19
Impact of financial structure on carbon emissions

	Market over banks		Insurance premia over GDP		
	current	lagged	current	lagged	Obs.
Carbon intensity of primary energy consumption	-6.9** (3.06)				431
		-9.1*** (3.05)			399
			-5.5 (24.03)		482
				-13.7 (24.50)	432
Relative change in greenhouse gas emissions per capita	-0.03 (0.04)				431
		-0.1** (0.04)			399
			-0.8*** (0.26)		482
				-0.9*** (0.26)	432

Source: *EIB calculations based on Eurostat and the IMF.*
Note: **,**,*** denote significance at the 1, 5 and 1% level.*

The analysis points to existing synergies between two major policy agendas in the European Union, namely the European Green Deal and the Capital Markets Union. With the Capital Markets Union, Europe is trying to foster financial markets and integrate them across different countries. On the one hand, supporting equity investment is one way policymakers can accelerate the transition to a low-carbon economy. On the other, banks that largely finance carbon-intensive sectors could be encouraged to reduce the carbon emissions generated by their loans. As a first step, policymakers could push for more public disclosure, which could result in banks' lending more to firms active in the low-carbon economy.

How the financial sector supports the green transition

In this section, we review the investors most likely to be interested in long-term assets and the development of sustainable finance, looking at environmental, social and corporate governance funds (ESG) as an asset class. We then analyse the various hurdles standing in the way of long-term investment in the green economy, as well as the ways policymakers could remove those hurdles. Finally, we provide evidence that more transparent or greener companies enjoy lower costs of capital.

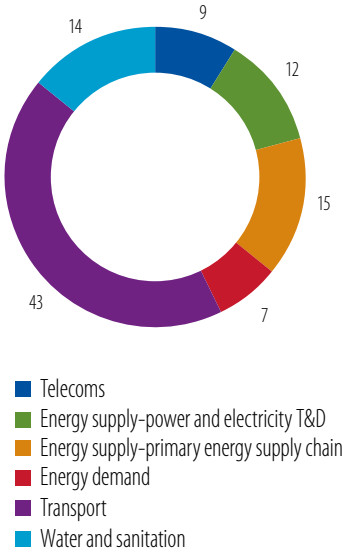
The need for more involvement from long-term investors

According to the Global Infrastructure Hub, EUR 94 trillion is needed to meet the world's infrastructure requirements by 2040, a large part of which could support the green transition. The needs are

multifaceted, with transport and energy accounting for more than three-quarters of investment (Figure 20). These sectors are prime candidates for climate change mitigation. Infrastructure investments therefore offer important opportunities for decarbonising the economy, in addition to providing returns and diversifying portfolios.

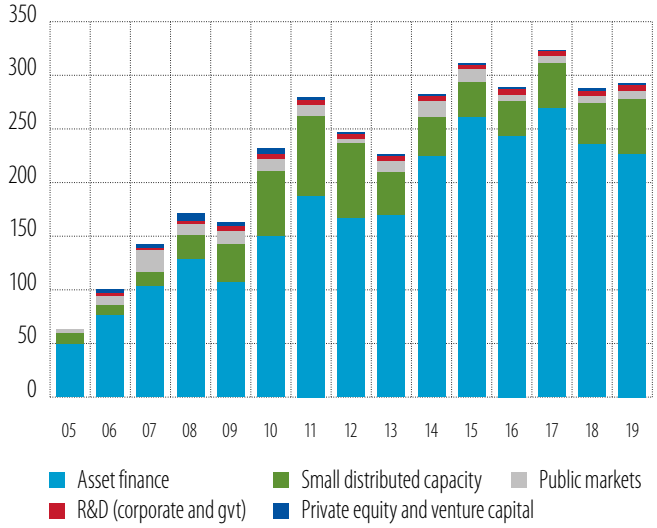
Compared to other investments, infrastructure generates less volatile and more predictable cash flow over a longer horizon. Infrastructure contracts are long, reflecting the length of the construction itself and the significant period over which services are expected to be delivered. The demand addressed tends to be inelastic, or less dependent on price. At the same time, the price of the service provided, which is sometimes subsidised by public authorities, can be pegged to inflation. Infrastructure investments therefore protect revenue streams from fluctuating price levels and provide predictable cash flow. As the associated goods or services tend to be delivered as part of a monopoly, they also often bring elevated returns.

Figure 20
Global infrastructure investments needs by sector (2016-2030, in %)



Source: *OECD.*

Figure 21
Global trends in renewable energy investment by asset class (USD bn)

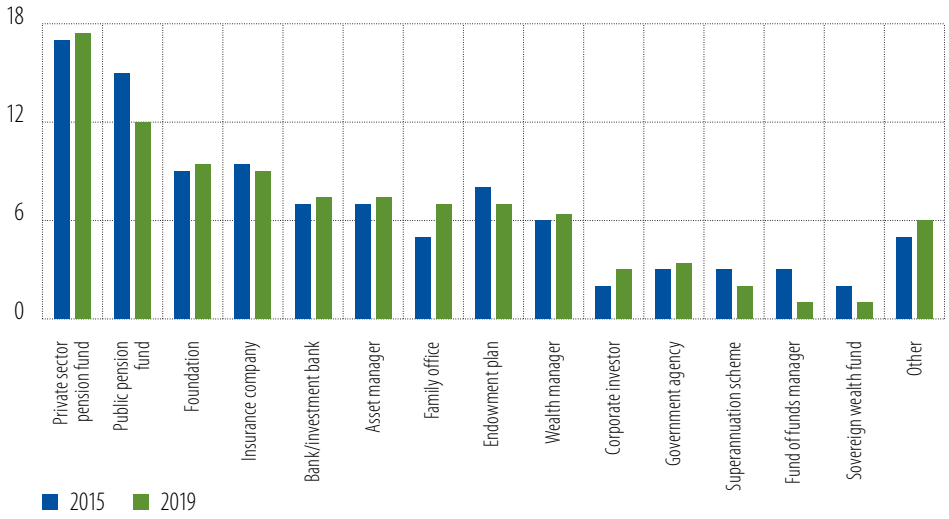


Source: *Irena.*
Note: *New investments.*

About USD 300 billion is invested globally in renewable energy a year. The flow has remained almost constant since 2015 (Figure 21), falling short of what is needed in the years to come. The bulk of the investment is financed through assets, with very little money coming from public markets. Pension funds and insurance companies are the likeliest to invest in infrastructure. Figure 22 provides a breakdown of infrastructure investors for 2015 and 2019, the latest record available. Nearly one in five private sector pension funds invests in infrastructure, making pension funds the biggest category of investor. Next, more than one in ten public sector pension funds and insurance companies also invest in infrastructure.

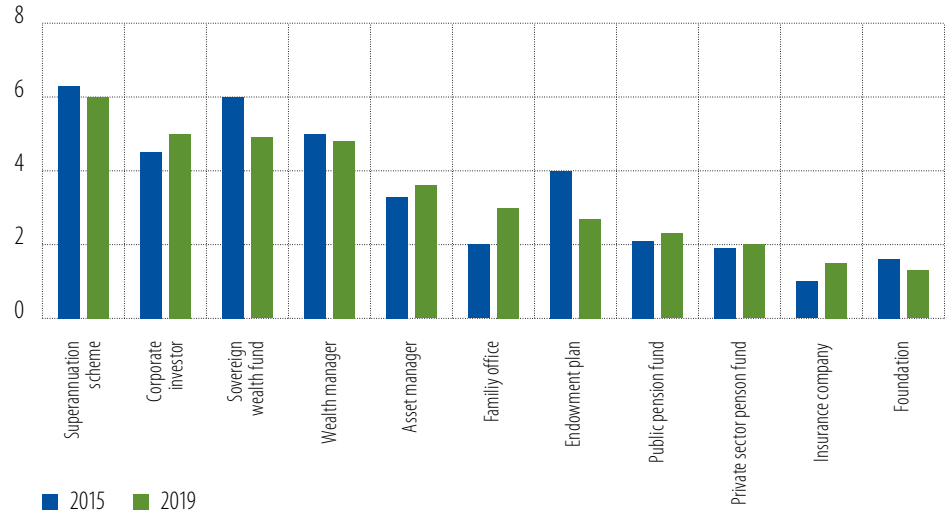
Although pension funds and insurance companies traditionally invest in infrastructure, their sizeable assets under management mean that infrastructure only accounts for a small portion of their balance sheet (Figure 23). Sovereign wealth funds tend to invest the most in infrastructure (EUR 153 million mean commitment). They are followed by asset managers (EUR 79 million), public pension funds (EUR 60 million), and insurance companies (EUR 43 million). With average investment of EUR 6 million, corporate investors lag far behind. Some of this is caused by regulatory hurdles for private investors. Removing those hurdles could increase private investors' participation.

Figure 22
Infrastructure investors by type (proportion of investors, %)



Source: *EIB Economics Department calculations based on Prequin Pro.*

Figure 23
Median current allocation to infrastructure by type (% of assets under management)



Source: *EIB Economics Department calculations based on Prequin Pro.*

Long-term investors could be brought into infrastructure projects in larger numbers. In the Official Monetary and Financial Institutions Forum (OMFIF) GPI Survey 2019, respondents from central banks, sovereign funds and public pension funds were asked whether they were allowed to invest in real assets, which includes infrastructure. 60% of respondents said that they were not permitted to, either by the laws and regulations in force, or by their fund mandate (OMFIF, 2020).

While publicly listed infrastructure firms give investors a way to participate, unlisted infrastructure projects also provide opportunities. A common but indirect manner of investing in infrastructure is through publicly listed infrastructure projects. Becoming a shareholder of a publicly listed infrastructure company or buying corporate or project bonds allows investors to diversify and gain exposure to the sector, possibly with small investments that reduce risk. Infrastructure funds allow institutional investors without specific expertise or resources to buy into projects and to diversify their investments at relatively low cost. Because these infrastructure assets are traded on public stock exchanges, more transparency can be expected on the project itself and on pricing. However, a large number of infrastructure projects are unlisted. These make it possible to reduce risk by increasing diversification.

By nature, infrastructure investments have to be sustainable and should therefore meet ESG criteria. The long-term nature of infrastructure investment makes sustainability critical, as only sustainable assets can increase in value over the long term. For this reason, infrastructure investors increasingly factor in sustainability considerations measured by ESG criteria when making investment decisions. Investors have aligned investment practices more broadly with the United Nations' Sustainable Development Goals or the G20 Principles for Quality Infrastructure Investment (OECD, 2019). Many pension funds, insurers and asset managers are now required to allocate a portion of their investments to ESG projects.

Measuring and comparing ESG performance is cumbersome. A variety of market-driven strategies and approaches are used to take sustainability into account in investment decisions, including numerous private sector initiatives and platforms. However, a lack of standardisation in ESG data and information make it difficult to measure a project's sustainability. Many different sustainability reporting standards exist, each with their own objectives and set of stakeholders. Asset managers and asset owners face a fragmented, increasingly burdensome system.

The European Union's green taxonomy is an important step towards investor and corporate disclosure. In June, the European Parliament adopted a regulation that established a European Union-wide classification system, or "taxonomy," with the aim of setting a common language for determining the economic activities that may be considered sustainable from an environmental point of view. The taxonomy complements the European Commission's proposals on improved disclosures on sustainable investments and risks, and benchmarks for low-carbon measures and efforts to improve the carbon footprint.[11] The proposed regulation provides guidance for companies on how to report climate-related information in line with the Task Force on Climate-related Financial Disclosures (TCFD) recommendations. The EU taxonomy will be further developed through a new platform on sustainable finance. The first company reports and investor disclosures using the EU taxonomy are due at the start of 2022.[12]

The new EU taxonomy helps standardise data, information and criteria. Project data disclosure remains very scarce and the correlation between various ESG metrics is very weak (European Central Bank (ECB), 2019). The inconsistent measurement of ESG criteria is a major impediment to the development of ESG assets. The EU taxonomy covers several infrastructure assets, such as transport and electricity, bringing clarity on the environmental impact (especially for the climate), while also considering social and governance aspects. As such, the new taxonomy can help to label financial products as ESG-compliant. The EU green taxonomy and green bond standard provide a very good starting point. Later, projects can be further broken down into assets that are neither brown nor green, but lie on a spectrum between the two.

Growing sustainable finance

ESG investing is growing fast and new securities are being developed. The Global Sustainable Investment Alliance estimates that at the beginning of 2018, more than USD 30 trillion in institutional assets worldwide

11 For a detailed presentation of the EU taxonomy, see the section "The EU taxonomy and climate investments" in Chapter 4.

12 Spain has already issued a draft Climate Change and Energy Transition bill requiring entities with securities admitted to trading, credit institutions, insurance and reinsurance companies, and other companies (for reasons of size) to publish an annual assessment of the financial impact on society of the climate change risks generated by their activity, as well as the measures taken to address those risks from 2023 (Delgado, 2020).

were invested in products that were sustainable, environmental, social and governance-focused, or green.[13] New ESG bonds labelled "blue bonds," as defined by the World Bank, fund coastal restoration, marine biodiversity, sustainable fisheries and pollution control. "Humanitarian bonds" target pandemic disease and migration. Specialised issuers have emerged and several organisations track green finance and follow the broader set of so-called impact bonds.

The capital reallocation prompted by the expansion of ESG investing could trigger "carbon correction" in asset prices. Figure 9 shows that lower financing costs or a stronger investor preference for greener production processes help accelerate the green transition. Some investors refuse to support management teams of companies that do not properly disclose their environmental footprint.[14] Following this policy, "brown" companies might face slumps in their valuations because of their poor carbon footprints or because investors steer clear.

Reputational and litigation risks can help explain investor aversion to non-green assets. The greening of carbon-intensive sectors is, to a large degree, explained by equity investors pushing these sectors to adopt and develop greener technologies because they are concerned about future litigation costs. Investors see green firms as less likely to suffer from environmental disasters – and therefore less likely to be involved in litigation (Klassen and McLaughlin, 1996; Hong Kacperczyk, 2009).[15]

Shifts in investor preferences can be accompanied by efforts to clean up companies. For example, Gollier and Pouget (2014) show that large activist investors can generate outsized returns by investing in non-responsible companies and turning them into responsible ones.

Green bonds are continuing to develop rapidly but still represent a small portion of the market. "Green bonds" are debt securities whose proceeds are used to finance investment projects with an environmental benefit (Ehlers and Parkers, 2017). The first green bond was issued in 2007 by the European Investment Bank. From 2008 to 2017, global annual issuance rose from less than EUR 1 billion to more than EUR 120 billion (ECB, 2019). Since 2013, the average net issuance of euro-denominated investment grade green bonds represented around a quarter of the global net green total. However, despite strong growth, green bonds accounted for only 1% of the overall supply of euro-denominated bonds over the same period. Green bonds represented 3% of global bond issuance in 2018 and, despite their dynamism, they appear insufficient in their current setup to finance the greening of the economy.

Green bonds are not unlike other bonds in that they tend to be priced closer to the initial guidance and are often oversubscribed. They generally offer similar yields to comparable conventional bonds, but there is evidence that in some markets, issuers can borrow at lower rates than through conventional bonds. These lower rates are consistent with the idea that investors are prepared to forgo some income in the pursuit of sustainable investments (Baker et al., 2018).

The absence of a properly recognised and harmonised classification makes greenwashing a risk for some assets. New securities and investment structures are emerging in a market where the risks and rates of return are not fully transparent, comparable or accessible in ways that can be consistently monetised. Green issuers can expect lower financing costs and a possible premium created by attracting investors willing to accept a lower return. But the growing scale, complexity and diversity of green bonds may yet pose the most significant challenge for sustainable finance. Credibility must be safeguarded.

13 The aggregate comprises six major markets: Australia, Canada, Europe, Japan, New Zealand and the United States.

14 In January 2020, BlackRock, the world's largest investment manager, announced that it would divest from companies that made 25% or more of their revenues from coal, and that it would start using its voting power to force companies to disclose climate risks. According to InfluenceMap, in late 2019, BlackRock controlled shares in fossil fuel companies worth USD 87.3 billion. It was a top-three investor in all eight of the world's largest oil companies, and a top-ten investor in the 12 most systemically important banks in the world.

15 Salinger (1992) shows that large-scale ecological accidents, such as the Bhopal gas tragedy or the Exxon Valdez oil spill, are associated with extremely high litigation costs. In recent history, several major US equity funds have divested from tobacco companies when it became clear that litigation risks could become prominent.

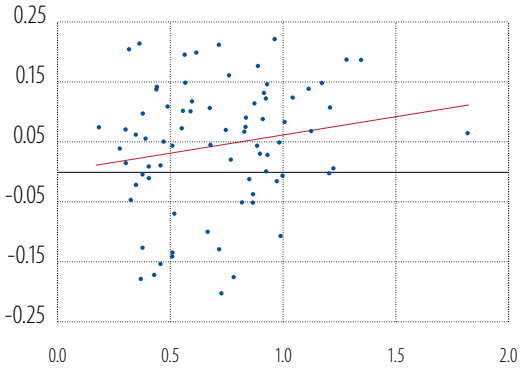
Harmonising the taxonomy limits the incentive to "greenwash" assets. For sustainable investment to go truly mainstream, it needs to do more than exclude irredeemably brown industries and finance new, deep-green technologies. Sustainable investing must catalyse and support all companies that are working to shift from brown to green. It is very important that the temptation to "greenwash" existing spending be avoided.

The EU taxonomy and the green bond standard initiative are very important steps. The proposed EU taxonomy regulation aims at clarifying green definitions and putting in place a verification and accreditation process to enhance credibility. Green bond principles have been developed by the private sector (International Capital Market Association (ICMA), 2014) and the European Commission is building on these and the taxonomy regulation to establish an EU Green Bond Standard. As part of this initiative, banks, corporate issuers, multilateral development banks, regulators and governments are working together to improve standards further (Ehlers and Packers, 2017).

Some evidence of a green premium

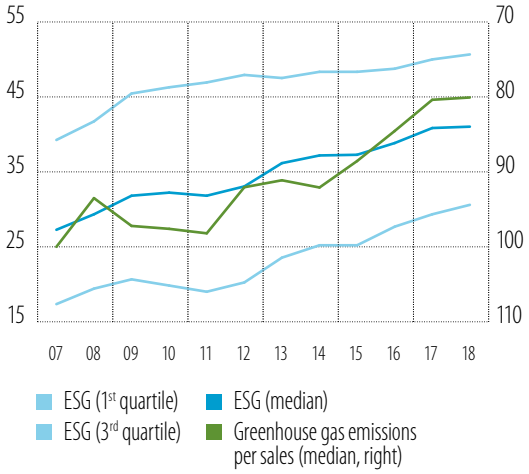
Evidence suggests that more transparent companies are increasingly seeing valuation gains. Four-fifths of the largest 1 100 companies worldwide now disclose climate-related financial risks, as some recommendations from the Task Force on Climate-related Financial Disclosures (TCFD) advise.[16] Three-quarters of investors who use this information have seen an improvement in the quality of climate disclosure. Figure 24 plots the change in TCFD disclosure and the variation in stock prices for a set of EU manufacturing companies covered in the dataset. While the change is computed over a short period of time, from 2015 to 2019, it appears that more compelling corporations with increased TCFD disclosure are enjoying premiums in their share prices.

Figure 24
Change in TCFD disclosure (x-axis, 2015-2019, %) **and in stock prices** (y-axis, 2015-2019, %)



Source: *EIB Economics Department calculations based on Bloomberg*
Note: *Manufacturing sector only. Sample of 76 EU companies.*

Figure 25
ESG performance and greenhouse gas emissions per sales across time (index, 100=2008)



Source: *EIB calculations based on Bloomberg.*
Note: *Sample of listed companies from all economic sectors in advanced economies. Greenhouse gas emissions per sales is based on 100 in 2008 and reported on an inverted axis.*

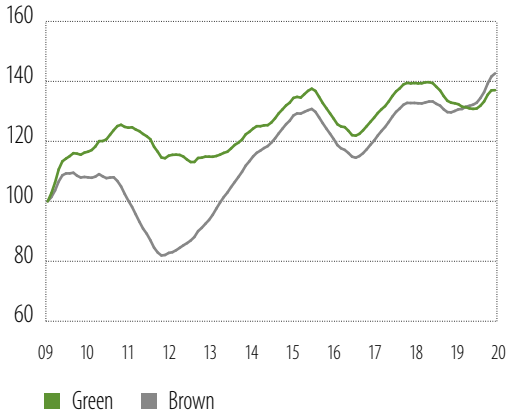
16 In 2017, the Financial Stability Board's Task Force on Climate-related Financial Disclosures highlighted the need for comparable and consistent disclosures about the risks and opportunities of climate change, and issued recommendations to this end. The supporters of the Task Force on Climate-related Financial Disclosures (TCFD) have balance sheets totalling USD 120 trillion and include the world's top banks, asset managers, pension funds, insurers, credit-rating agencies, accounting firms, and shareholder advisory services.

We have analysed the existence of a relative equity premium for green corporations. We built a granular database merging balance sheet information from Orbis with Datastream data on equity prices and the Bloomberg database on environmental, social and corporate governance scoring for more than 500 corporations. The dataset covers several economic sectors with almost half of the companies operating in the manufacturing sector and more than 35% in the electricity, mining, finance and insurance and communication sectors.

Over time, the companies report increased performance. Figure 25 shows the median greenhouse emissions to sales ratio and ESG score. The ESG score goes up, while greenhouse gas emissions trend downward (on an inverted scale in the figure), reflecting better ESG and emission performances. The findings may be influenced by the survey's composition as public awareness has increased pressure on top companies. However, the relationship was similar at the upper and lower end of the sample.

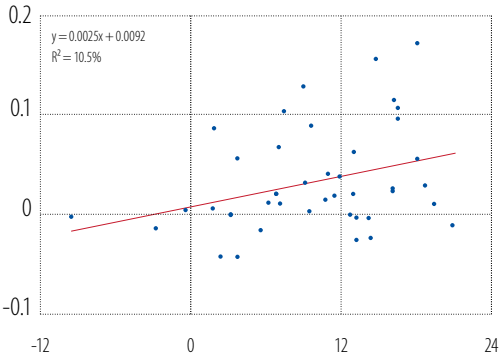
Since the global financial crisis, a portfolio of green equities has typically outperformed a portfolio of brown equities. We split the companies from the sample above into two groups, green and brown, depending on their average greenhouse emissions over the period. Companies with a ratio below the median are in the green portfolio and those with a ratio above are included in the brown portfolio. We computed the return on each portfolio, using each company's share of the pool's average capitalisation, its stock price trends and dividend ratio. The results in Figure 26 suggest that green portfolios have mainly outperformed since the financial crisis and are less volatile. The volatility may reflect the sector composition of the portfolios, with the green equities being more service-based and brown more manufacturing-oriented, and therefore more cyclical.

Figure 26
Total portfolio return (2009=100, 12-month moving average)



Source: *EIB Economics Department calculations based on Bloomberg.*
Note: *EU companies.*

Figure 27
Change in ESG (x-axis) **and deviation from the market return** (y-axis)



Source: *EIB calculations based on Bloomberg.*
Note: *European firms only. Change over 2014-2017 and 2006-2009.*

A simple analysis suggests that as a company's ESG standards rise, its shares tend to outperform the market. For the sample of EU firms, Figure 27 shows the relationship between the change in ESG disclosure from 2006 to 2009 and from 2014 to 2017, and the stock's deviation from the market return. The positive relationship suggests the market returns on two companies for which the ESG index differs by 4 percentage points – other things else being equal – differ by 1%. The simple relationship has a relatively weak explanatory power however and more factors should be taken in consideration to better explain differences in market returns.

After accounting for a firm's overall performance, returns significantly increase with the ESG rating. We then looked at estimates based on more sophisticated equations run on the whole dataset of around 1 075 corporations.[17] The equations incorporate sectoral dummies and variables for the firm's economic performance (asset turnover, profit margin, price to book ratio) to explain the market return and total return. Each indicator was entered separately in different equations. The coefficients are fairly similar across the estimates. They are statistically significant at the 5% level at least. Moreover, they are around twice as high as the elasticity obtained from the scatter plot, suggesting that a 2 point increase in ESG raises returns by 1%. The conclusion that ESG bonds lower the cost of finance for corporates is broadly supported by the literature: Friede et al. (2015) combines the findings of about 2 200 studies published in academic journals and reaches a favourable conclusion.

Given limited data availability, simple linear models must be handled with caution. It may well be that the effect is not linear and will increase over time. From a long-term perspective, climate change awareness is in its infancy. As it gains momentum, it will likely have an effect on the equity premium of green versus not green companies, with the equity premium likely widening over time. The relationship may also evolve with new, major policy announcements, causing the economy to adjust and prices to be revised. Finally, there is a danger that markets could suddenly overreact, with the prices of brown assets falling off a cliff. However, limited data makes it difficult to test these hypotheses.

Why and how institutions and financial supervisors can accelerate and deepen the transition

As explained above, several changes suggest that the financial sector is becoming increasingly concerned with environmental issues. However, the change is relatively slow – or at least too slow to meet the looming challenges. In this section, we review the actions undertaken by the financial sector, central banks and bank supervisors to accompany and strengthen this change.

Improved transparency is necessary to assess climate risks

The financial sector is becoming increasingly affected by two types of climate-related risk. We can make a distinction between very different types of climate risk: physical risks, resulting from global warming, and transition risks, resulting from shifts in investors' expectations/preferences. When physical risks materialise, they erode asset values, reducing collateral value for banks' loans. They also increase the payments made to insurance companies. Transition risks materialise when mitigation policies, technological advances or changes in public sentiment lead to a repricing of assets.

Physical risks are becoming more prominent, with potential losses increasing. There is evidence of an increase in the scope and frequency of the losses resulting from natural disasters: extreme weather events are more severe, more frequent and last longer. The share of weather-related losses has increased steadily, accounting for over 80% of insured natural catastrophe losses in 2018 (Giuzio et al., 2019). Besides, rising sea levels, droughts and floods and a higher incidence of extreme weather events can cause losses for homeowners and diminish property values. The risk in banks' mortgage portfolios is increasing, mirroring the rise in the likelihood and concentration of adverse events that were previously considered unrelated.

Credit ratings agencies are starting to incorporate climate change into their models. As a result, physical risks are beginning to be priced into these models, but at a fairly slow pace. As climate change intensifies, the risk of significant losses – through damage to property, infrastructure and land – is rising in high-risk regions. This risk is eroding asset values, which in turn is affecting their value as collateral,

17 See Davradakis and Maurin (2020) for more details. Regressions estimated with random effects estimator, sector fixed-effects are used as control, standard errors clustered at the sector level.

for a large number of financial institutions. Insurance liabilities are particularly exposed, and properties in areas vulnerable to floods, fires and hurricanes have become more expensive to insure. While new models have improved insurers' ability to forecast and measure risk for insurance coverage and pricing, climate change is so strong and rapid that the historical data needed to build accurate models are lagging.

So far at least, climate disasters have had a negative but limited impact on stock prices. The IMF (2020a) finds that, on average, climate disasters have resulted in a drop of 2% for banking stocks and 1% for the overall stock market.[18] In one out of ten cases, the impact on the aggregate market is greater than 14%, indicating that some climate disasters can have a material effect on financial stability. Hong et al. (2018) investigated the impact of drought on food companies' cash-flows. They show that a portfolio which shorted food stocks in countries experiencing a drought and went long on those in countries not experiencing a drought generated a 9.2% annualised return from 1985 to 2015. This excess return is larger in countries with little history of droughts prior to the 1980s, suggesting that markets inexperienced with climate change underreact to such risks.

Transition risks materialise when mitigation policies, technological advances or changes in public sentiment lead to a repricing of assets. Changes in climate policy, technology and shifts in consumer and investor preferences exacerbate the risks associated with the climate transition. During the transition, carbon-intensive firms or fossil fuel companies could see their earnings decline. An extreme case is companies focused on fossil fuel extraction, which could find themselves stuck with worthless assets in a new, low-carbon global economy. Funding costs for those companies are increasing because of higher default risks and lower profit expectations. Investors already holding assets from these companies could see their values decline.

Assessing whether the transition risk is priced correctly is even more challenging because transition risk plays out over the long-term and is contingent on many other factors. While physical risk can be measured objectively, transition risks are very much forward-looking and more difficult to price. Transition risks depend the policies crafted and policymakers ability to deliver on those new policies, the impact of emerging technologies, social preferences and a company's capacity to adapt its business model. The literature shows that transition risk pricing is not straightforward (Delis et al., 2018; Friede et al., 2015).

Policies to curb or prevent climate change can also strongly affect asset valuations. Policies implemented to try to prevent or curb climate change (climate change mitigation) may also have wide-ranging effects that hit different sectors – the energy, transport, manufacturing and construction sectors in particular. If the mitigation efforts are too timid in the present, the magnitude and pace of the necessary adjustment will be greater in the future, creating the potential for a sudden and general market correction or even an economic recession (Lane, 2019).

Overall, climate change-related risks have the potential to become systemic (ECB, 2020). Banks' could have significant exposure to the largest carbon emitters, making a disorderly transition to a low-carbon economy a systemic risk for the financial sector. Exposures to transition risk, although contained in relative terms, may be significant for some banks in absolute terms. The ECB (2020) shows that banks' exposures to the 20 largest emitters represent 20% of total large exposures, or 1.8% of the total assets of the banks in the sample. Together, these 20 emitting firms are responsible for more than half of the reported aggregate carbon footprint contained in the large asset exposures of euro area banks.[19] Correct pricing reduces the risk of banks' suddenly reassessing the assets' worth, which could result in fire sales or abrupt slumps in the asset prices of specific firms or sectors (European Systemic Risk Board (ESRB), 2016; Bank of England, 2018).

18 The study considers around 350 large climate disasters over the past 50 years, on a sample of 68 economies, representing 95% of global GDP. For example, Hurricane Katrina, in 2005, with the largest damage in absolute terms in our sample (1% of US GDP), had no discernible impact on the US stock market index. The 2011 Thai floods, by contrast, with the largest damage relative to the economy's size, caused a 30% drop in the stock market over 40 days.

19 Efforts to gauge financial institutions' exposures to transition risk have so far mostly concerned investments in certain industrial sectors. Typically, the most climate-sensitive sectors are selected in the NACE classification on the basis of an aggregate environmental metric, such as a metric for carbon emissions for the sector. Battiston et al. (2017) remap all the sectors at NACE2 4-digit level into new climate policy-sensitive sectors, combining criteria including carbon emissions, the role of the sectors' supply chains, and the existence of traditional policy institutions for the sectors.

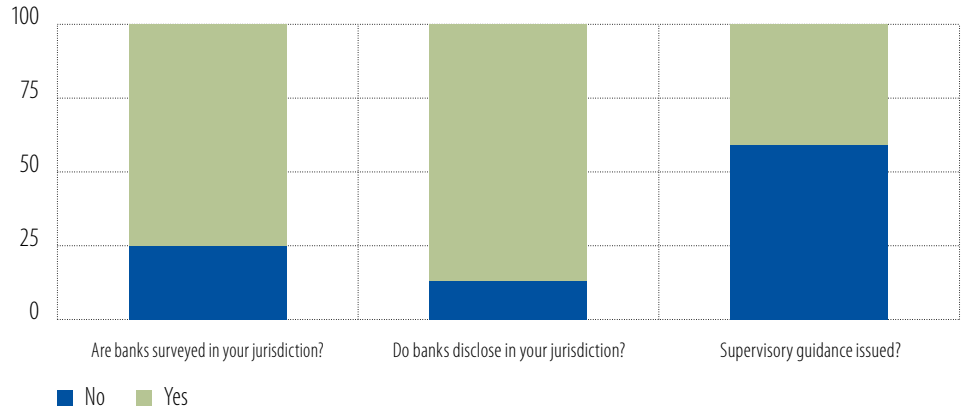
Banks' ability to address climate risks is limited by the available data. A survey by the Institute for International Finance looks at the impediments that prevent financial firms from developing an explicit process for identifying and addressing climate risks and opportunity. A lack of available data is listed by 28% of respondents, followed by a lack of experience (16%) and a lack of regulatory requirements or supervisory expectations (also 16%).

Institutions are developing frameworks to improve the awareness and pricing of climate risks

Climate change affects central banks as guardians of monetary policy role and as bank supervisors. On the monetary policy side, climate risks impact relative prices, expectations, capital stock, balance sheets and financial markets, therefore affecting productivity, potential output, interest rates and the output gap (Blatten et al., 2020). Monetary policy's challenge is to disentangle the temporary and permanent shocks arising from climate change, and to react to the risks that natural disasters represent. On the supervisory side, climate change potentially requires an update of the prudential framework, and in any case careful monitoring based on enforced disclosure.

For the Network on Greening the Financial System (NGFS), ensuring the financial system is resilient to climate-related risks falls within the remit of central banks and supervisors (NGFS, 2020).[20] The network, which consists of around 70 members, aims to analyse, define and promote best practices that contribute to the proper management of climate risk in the financial sector. It has released several reports intended for central banks and supervisors, itemising the necessary measures to foster a greener financial system, focusing on (1) supervisory practices, (2) climate-related stress testing[21], and (3) data gaps and disclosures. The NGFS emphasises the importance of acting in a swift but orderly fashion to incorporate physical and transition risk in prudential frameworks.

Figure 28
Current initiatives related to financial risks



Sources: *Bank for International Settlements (BIS) 2019.*
Note: *Yes and to some extent for Q2, yes and in the process for Q3. The numbers of responses vary by question, from 23 to 27 reporting central banks.*

20 This network, created late 2017, brings together central banks, supervisors and international institutions.

21 The report develops reference climate policy scenarios for central banks and supervisors and gives them guidance on how to integrate climate risk analyses into macroeconomic and financial stability surveillance, capturing the macro financial impact of these risks. Climate-related risks are non-linear, will to a large extent manifest themselves in the future and can therefore not be based on historical data. As such, we need to develop forward-looking risk management techniques.

Changes have already been implemented and climate disclosure is on the rise. A survey from the Bank of International Settlements (BIS) conducted on 27 central banks and supervisory authorities shows that banks disclose in a large number of jurisdictions and that supervisory guidance is issued in around one-third of them (Figure 28). Currently in the European Union, there is a lack of granular public data detailing complex and evolving exposures both within and across economic sectors. For the purposes of their regulatory disclosures, institutions are expected to publish meaningful information and key metrics on climate-related and environmental risks that they deem to be material.[22]

The European Central Bank's Single Supervisory Mechanism has recently published its guide (ECB, 2020), outlining its understanding of the safe and prudent management of climate-related and environmental risks under the current prudential framework. The guide describes how the European Central Bank (ECB) expects institutions to consider climate-related and environmental risks – as drivers of established categories of prudential risks – when formulating and implementing their business model and strategy (in the short, medium or long term), their governance and risk appetite and their risk management framework (identification, quantification, credit-granting process, monitoring, internal reporting, stress testing and liquidity).

While everything does not have to be green or brown, green-supporting factors and brown-penalising factors can be distinguished. The former lowers capital requirements for financial institutions conducting more green investments by assigning lower risk weights to sustainable assets. Given the higher cost of bank equity, lower capital requirements incentivise banks to raise the volume of credit to green investment. Brown-penalising factors assign higher risk-weights to carbon-intensive assets, requiring banks to raise capital requirements to cover for the higher risk and therefore penalises credit allocation to unsustainable investments by raising their cost of finance.

Freeing up capital by lowering the capital charges for climate-friendly investment would jeopardise prudential frameworks. For the integrity of financial institutions and financial stability, it is important that prudential frameworks remain risk-based. In its action plan, the European Commission also proposed exploring the feasibility of including climate-related risks in banks' capital requirements frameworks. While the idea of a green-supporting factor – a risk-weight reduction in the prudential framework for banks' exposures to green assets – has been discussed, providing capital relief or lower capital charges for green investment would blur the objective of risk-weighting.

However, increasing capital charges for loans to brown companies does make sense and is aligned with the principle of prudential capital. On the one hand, the purpose of weighting bank assets is not to estimate their societal impact. Climate investment is welfare-enhancing, but can be exposed to changes in technology. On the other hand, the value of stranded assets, defined as assets affected by unanticipated or premature write-downs, devaluations or converted to liabilities, can affect banks' net worth and therefore their capital buffers. The possibility of stranded assets should be acknowledged when calculating risk-based capital requirements. Climate stress tests are a good way to start.

In Europe, the European Systemic Risk Board highlighted the potential impact of physical and transition risks on the European financial system and recommended that authorities consider developing climate stress-test methodologies (ESRB, 2016; Vermeulen et al., 2018). Stress tests and scenario analyses can be used to gauge the quantitative impacts of various climate mitigation scenarios. While work is ongoing, especially on data and methodologies, stress test methodologies push institutions to look forward and think about climate change. Compared with traditional stress tests, climate stress tests carry greater uncertainty given the long time horizon of the expected impact, the choice of the appropriate discount rate and the timing of new policies and changes in technology.

22 One can isolate three levels of emission disclosure. Scope 1 relates to direct emissions from owned or controlled sources (company facilities, machinery and vehicles), scope 2 relates to indirect emissions from purchased electricity, steam, heating and cooling, scope 3 relates to all other indirect emissions (business travel, employee commuting, purchased paper, waste, office equipment, etc.). An ECB study based on the 12 largest banks and 14 largest insurers in the euro area estimates that more than 80% of institutions disclose business travel and around one-third of them report commuting (ECB, 2019).

What matters for the allocation of capital flows is the spread between brown loans and green loans. As shown in Figure 9, since the cost of equity is much higher, more capital is required to back a bank loan, making it more expensive. This influences the allocation of savings across various investments, which depends on the relative returns. What matters for the allocation of credit is the wedge – the difference between the returns on green and brown investments. Whether the gap widens from the two sides does not really matter. Higher financing costs for brown investment would divert the flow of credit to green investment.

Banks are starting to price in exposure to climate policy. Dellis et al. (2017) compare the loan rate charged to fossil fuel firms – along with their climate policy exposure – with that charged to other firms. The authors find that before 2015, banks did not price in exposure to new climate policies. After 2015, however, the authors find that fossil fuels firms exposed to stricter climate policies saw their credit costs rise, particularly for those holding more fossil fuel reserves. "Green" banks also charge higher loan rates to fossil fuel firms.

Conclusion and policy implications

We have analysed the financing of the investment needed to meet the European Green Deal, emphasising that support is needed from the European Union's financial sector. We show that structural shifts in the European Union's financial system can alleviate some of the costs of the transition toward a cleaner economy.

Changes are already taking place as investors become increasingly aware of the long-term unsustainability of some investments and adjust their preferences accordingly. As shown with green bonds, new products and markets are emerging. But ESG investing still falls short of the challenge, and green investment premiums, when they exist, remain tiny. Green assets are still in their infancy, and are largely in the hands of private initiatives. But to truly take off, fledgling markets have to be structured, and the financial sector could contribute to the building of those markets.

The public sector has a key role to play in structuring a green-friendly financial system. The financial system needs more transparency and new ways of thinking so that risks and returns can be re-evaluated in the light of the greening of the economy. Very recently, European authorities, central banks and bank supervisors have issued recommendations and guidance that will provide companies with the information required, helping to expand these markets.

Transitioning the whole economic system takes time and requires public support as oligopolistic powers shift and the value of assets fluctuate widely. The strategy has to be coordinated and phased in to avoid adjusting too quickly, which could harm economic competitiveness and fuel social unrest. However, the European Union's green agenda can also benefit from synergies with the Capital Markets Union and public support for the coronavirus recovery.

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Chapter 7

Intangible investment, innovation and digitalisation

The coronavirus pandemic crisis has led to wider recognition of the importance of innovation and digital transformation. According to the latest results of the EIB Investment Survey (EIBIS), most firms in the European Union and the United States expect the COVID-19 outbreak to have a long-term impact on the use of digital technologies, with more than a third of firms expecting it to affect their service and product portfolio or supply chain.

With investment collapsing due to the pandemic, many firms may fail to adapt to the new digital reality. At the same time, a sharp drop in sales may drive them to focus on short-term survival strategies. They may delay or cancel investment in innovation activities, which will impede the creation, transfer, and adoption of new technologies. EU firms need to reassess their operating context and proactively invest, innovate and adapt to ensure their sustainability and ability to thrive in the new environment. This will require significant investment across the European Union and a policy framework conducive to innovation and the adoption of innovation.

The global innovation landscape is changing rapidly because of the growing importance of digital technologies and the emergence of China, which has joined the United States and Europe as a global player in research and development (R&D). While remaining at the forefront of technology, the European Union is investing less in R&D as a percentage of gross domestic product (GDP) than other major economies. This lower level of R&D may have negative implications for innovation and long-term growth. Lower business R&D spending is largely behind the R&D gap in the European Union.

The digital transformation is affecting virtually all sectors of the economy. European companies are global leaders in various traditional industries, those without digital origins. But the European Union is less present in fast-growing digital sectors such as software and computer services. Several Chinese companies have joined the ranks of top US firms as important technological players. Meanwhile, the European Union does not appear to be generating many new innovation leaders, especially in the digital sector, potentially jeopardising the long-term competitiveness of Europe. A weak European digital sector also means that EU companies and citizens will lack ownership of their data, leaving it to be controlled outside the European Union.

The European Union is lagging behind not only in digital innovation, but also in digital adoption. Digital adoption rates are lower for EU firms than US firms. Firms that have implemented digital technologies, especially those using multiple technologies, tend to perform better than non-digital firms. They invest more, are more innovative, have better management practices, grow faster and create higher paying jobs. Digital firms are also more likely to invest to meet the challenges of climate change, such as preparing for extreme weather events and reducing their carbon emissions. That being said, EU firms tend to invest much more in these areas than US firms, despite having lower digital adoption rates.

To foster the green recovery and address the long-term impact of COVID-19, the European Union will need to create better conditions for innovation and digitalisation. Intangible investment, such as R&D, software and databases, training of employees and organisational capital, and digital technologies are rising in importance. Public policies should not only focus on supporting R&D activities, but should also consider regulations affecting competition, the environment, data and trade to improve the diffusion of innovation. While governments tend to weigh different policies and their potential impact on innovation activities separately, recognising the complementary nature of policy interventions is key to finding the right mix. Getting the balance right is especially relevant for firms that are not at the cutting-edge of technology, as the COVID-19 crisis is likely to exacerbate the digital divide between them and more technically savvy firms.

Introduction

The COVID-19 crisis has led to wider recognition of the importance of innovation and digital transformation. According to the latest results of the EIBIS, most firms in the European Union and the United States expect the coronavirus pandemic to have a long-term impact on the use of digital technologies. Businesses will rely on technology to prevent disruptions and to improve communication with customers, suppliers and employees. More than a third of firms expect the pandemic to affect their service and product portfolio or supply chain. With investment collapsing due to the COVID-19 crisis, many firms may fail to adapt to the new digital reality. A falloff in revenue will squeeze their liquidity and may force them to focus on short-term survival strategies (Revoltella, Maurin and Pal, 2020). They may delay or cancel investment in innovation activities, which will impede the creation, transfer, and adoption of new technologies (World Bank, 2020). EU firms therefore need to reassess their operating context and invest, innovate and adapt to ensure their sustainability and ability to thrive in the new environment. This will require significant investment across the European Union and a policy framework conducive to innovation and the adoption of innovation.

This chapter provides an overview of recent trends in global R&D expenditure and the investment activities of innovative companies. It highlights the changes in the global innovation landscape, with China emerging as a new player and digital innovation disrupting many sectors that were not born digital. The chapter discusses the rapid adoption of digital technologies in the European Union and the United States, the impact on the performance of firms and the constraints they face. Firms that have implemented digital technologies, especially those using multiple technologies, tend to perform better than non-digital firms. They invest more, are more innovative, have better management practices, grow faster and create higher paying jobs. Digital firms are also more likely to invest in tackling climate change challenges, an area in which EU firms invest much more often than US firms. The chapter concludes by highlighting the importance of developing effective public policies that incentivise investment in innovation and digitalisation to address the COVID-19 crisis and foster the green transition.

Innovation in advanced economies

Innovation and digital transformation can help limit the negative consequences of the coronavirus outbreak. Investment in innovation – especially in the pharmaceutical and biotechnology sectors, and more generally in the health sector – is critical to finding an effective treatment rapidly and limiting the virus's spread. Digital technologies are also key to adapting to a new environment where people work remotely to respect physical distancing requirements.

The short-term economic recovery can be supported with investments in physical and human capital, but in the long term, economic growth will depend on innovations that make capital more productive. Almost half of firms in the European Union and United States expect to invest less and delay or abandon investment plans in 2020 as a result of the pandemic, according to the latest EIBIS results. Most governments have responded with indirect measures to support investment while protecting employment in the short term. At the same time, the policy response has also tried to incentivise investments in innovation, digital technologies and climate-friendly measures, as illustrated by the European Commission's NextGenerationEU recovery plan. New products, services and processes need to be developed to address the European Union's pressing challenges, such as an ageing population, climate change and numerous environmental and public health issues. Addressing these challenges will create opportunities for firms and jobs for workers. However, for this growth to materialise, governments must create incentives that encourage workers to acquire the new skills necessary to promote innovation.

Innovation is the result of costly and risky processes that require systematic investment in research and experimental development activities. The Frascati Manual (Organisation for Economic Co-operation and Development (OECD), 2015) states that R&D activities must meet five criteria: novel (aimed at new findings), creative (based on original concepts and hypotheses), uncertain (with a high risk of failure),

systematic (planned and budgeted) and transferable (or reproducible). For example, the race to find an effective COVID-19 vaccine illustrates the uncertainty associated with innovative activities. It is difficult to predict whether and when the development of new products or services will be achieved. Even when the innovation is successful, expected returns and market success remain highly uncertain and can be volatile (Arrow, 1962). In addition, R&D investment is typically irreversible, regardless of the outcome of the innovation activities, because R&D investments encompass a large share of irrecoverable costs (Pindyck, 1991; Dixit and Pindyck, 1994). R&D investment, and the human capital and knowledge it entails, can be highly project-specific.

Investment in innovation is notoriously difficult to measure. Statistics on R&D expenditure are typically used to compare investment in innovation across countries and firms. However, R&D may only capture a small part of the actual investments in innovation.[1] One way to better capture the innovation activities of firms in advanced economies is to consider investment in other intangible assets, such as software and databases, training of employees and organisational capital (Haskel and Westlake, 2017). Similarly, intellectual property – such as patents for inventions, trademarks, industrial designs, geographical indications and copyright – are complementary to R&D expenditure (Scherer, 1965). Another example of innovation is the application of digital technologies, such as advanced robotics, artificial intelligence, big data and analytics, and the internet of things (Brynjolfsson and McAfee, 2014).

Both the public and private sectors are engaged in innovation, with complementary roles. In most advanced economies, businesses are the largest contributor to R&D expenditure. However, R&D investment by higher education institutions and research institutes is also essential to generating the new knowledge, human capital and skills needed by the private sector. While most business R&D spending is on applied research and experimental development, governments also make major investments in basic science. These investments share the risk associated with innovation and help to attract funds from the private sector (Mazzucato, 2013; Ahmadpoor and Jones, 2017).[2] For example, a major role played by the public sector is to procure and create demand for innovative products in areas such as cybersecurity, defence and health (Moretti, Steinwender and Van Reenen, 2019). In addition to its direct involvement in R&D activities, the public sector also facilitates the development and use of new ideas, providing supportive conditions for innovative firms.

R&D can suffer from imbalances caused by market failures. An example is when the social returns on R&D are higher than the returns to private firms making the investment. R&D activities are typically affected by several market failures – such as uncertainty, financial constraints and lack of appropriability – that may lead to underinvestment (Nelson, 1959; Arrow, 1962; Stiglitz and Weiss, 1981). For example, the know-how generated by R&D activities could spill over to competitors, preventing the private investors who financed the initial R&D activity from receiving all the returns (Schumpeter, 1942). As a result, public intervention can be justified due to the positive impact R&D spending and innovation can have on the larger society (Griliches, 1992; Hall, Mairesse and Mohnen, 2010; Bloom, Schankerman and Van Reenen, 2013; Jones and Summers, 2020).

Public policy for innovation should go beyond direct support for R&D expenditure. Policies should also consider competition, environmental and trade policies that would help diffuse innovation. Understanding how firms create and adopt innovations is key for the design and implementation of effective public policy. The rising importance of intangible investment and digital technologies means that public policy should not only focus on highly innovative firms in manufacturing or on tax incentives for business R&D investment, but should also improve competition, environmental, data, trade and patent regulations (Furman, Porter and Stern, 2002; Aghion et al., 2005; Bloom, Van Reenen and Williams, 2019).

1 For example, some large US companies, such as Goldman Sachs and Walmart, report zero R&D in their corporate accounts (Jones, 2016). In addition, accounting and fiscal regulations in many EU countries did not require companies to report R&D expenditure until recently, even for publicly listed firms.

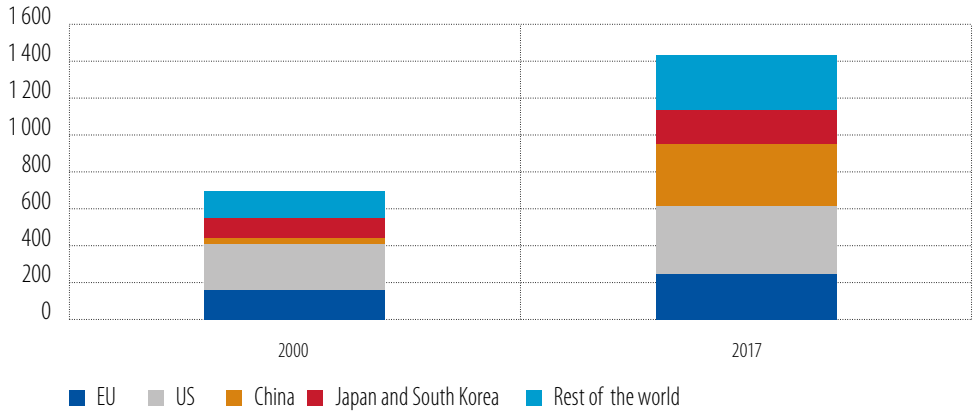
2 There are three broad types of R&D activities defined in the Frascati Manual (OECD, 2015): basic research, applied research and experimental development. Basic and applied research are based on experimental or theoretical work undertaken to acquire new knowledge. Unlike applied research, basic research is not directed towards any particular application or use. Experimental development is directed towards producing new products or processes and to improving existing ones. However, basic research does not necessarily lead to applied research and then to experimental development. Experimental development can support basic research with new findings, and basic research can also lead directly to new products or processes (OECD, 2015).

While different policies supporting innovation are often considered and assessed separately, it is vital to recognise that different policy interventions can complement one another (David, Hall and Toole, 2000; Czarnitzki and Delanote, 2015). Finding the right mix is especially relevant for firms that are not at the forefront of technology, as the COVID-19 crisis is likely to exacerbate the digital divide among companies.

A changing global innovation landscape

Global R&D expenditure has increased rapidly over the past two decades. R&D expenditure reached an estimated EUR 1.4 trillion in 2017, up from EUR 695 billion in 2000 (Figure 1), with China contributing the most to the rise (National Science Board, 2020). From 2000 to 2017, R&D expenditure in China increased tenfold, corresponding to an annual growth rate adjusted for inflation of 16%. In comparison, the yearly increase of domestic R&D expenditure was a modest 2% in the United States and 3% in the European Union.

Figure 1
R&D expenditure in 2000 and 2017
(in EUR billion in purchasing power parity at 2010 prices and exchange rates)



Source: *EIB calculations based on European Commission (2020) and Joint OECD-Eurostat international data collection on resources devoted to R&D.*
Note: *GERD (gross domestic expenditure on R&D), in EUR million expressed as purchasing power parity at 2010 prices and exchange rates.*

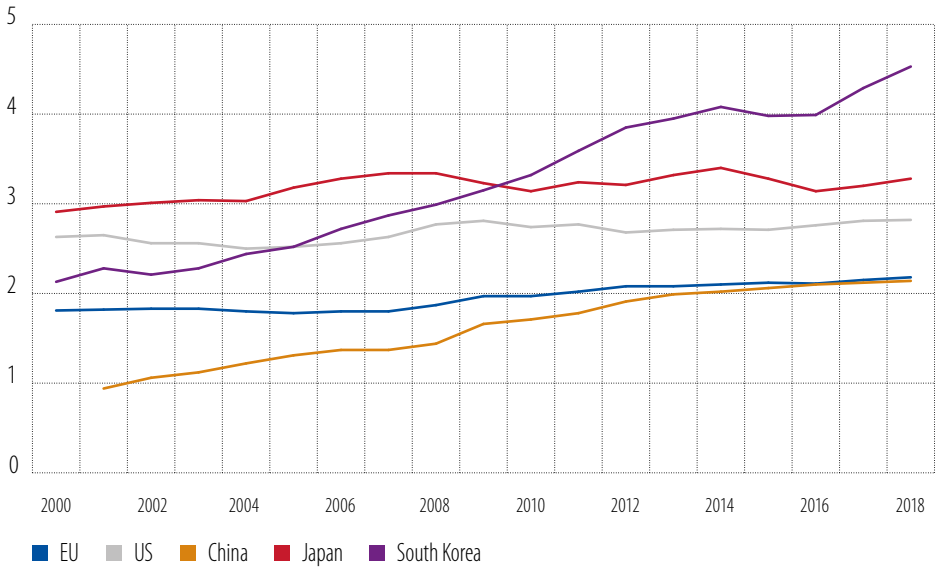
The United States spends the most on R&D, followed by the European Union and China. In 2018, the United States spent more than EUR 492 billion (in current prices) on R&D, followed by the European Union (EUR 295 billion) and China (EUR 252 billion). The relative weight of the United States and the European Union in global R&D expenditure has fallen over time, mainly due to the rapid rise of China. Global R&D performance remains concentrated in three geographic regions: North America, Europe and East Asia.

China has become a leader in innovation. The growing importance of China is also reflected in measures of innovation other than R&D spending, including the stock of international patents related to digital technologies such as artificial intelligence, machine learning, robotics, biotechnology and new materials (OECD, 2019).[3] Over the past decade, China has also increased its contribution to highly cited scientific research and its share of the world's top 1% most-cited publications, which rose from less than 2% in 2000 to 18% in 2016 (European Commission, 2020). China falls only behind the European Union and the United States for top-cited publications.

3 See Chapter 8 of this report, which shows the rapid increase in patenting activities by Chinese firms, especially for digital technologies.

As a share of GDP, the European Union and China are investing less in R&D than the United States. Over the past 15 years, China and South Korea have increased their R&D investment intensity (R&D expenditure as a percentage of GDP), while the United States, the European Union and Japan have been less dynamic (Figure 2). South Korea has the highest R&D intensity among major economies, at 4.5% of GDP in 2018, after overtaking Japan in 2010 and Finland in 2012. With an R&D intensity of 2.14% of GDP in 2018, China is catching up with the European Union (2.18% of GDP).[4] The European Union has been investing less in R&D as a share of GDP than the United States, Japan and South Korea over the past two decades, a trend that may negatively affect innovation and long-term growth. If policy measures are not taken to support R&D, some highly innovative EU firms may lose their comparative advantage. Lagging EU companies may also find it difficult to catch up and adopt technologies developed elsewhere.

Figure 2
R&D investment intensity 2000-2018 (in %)

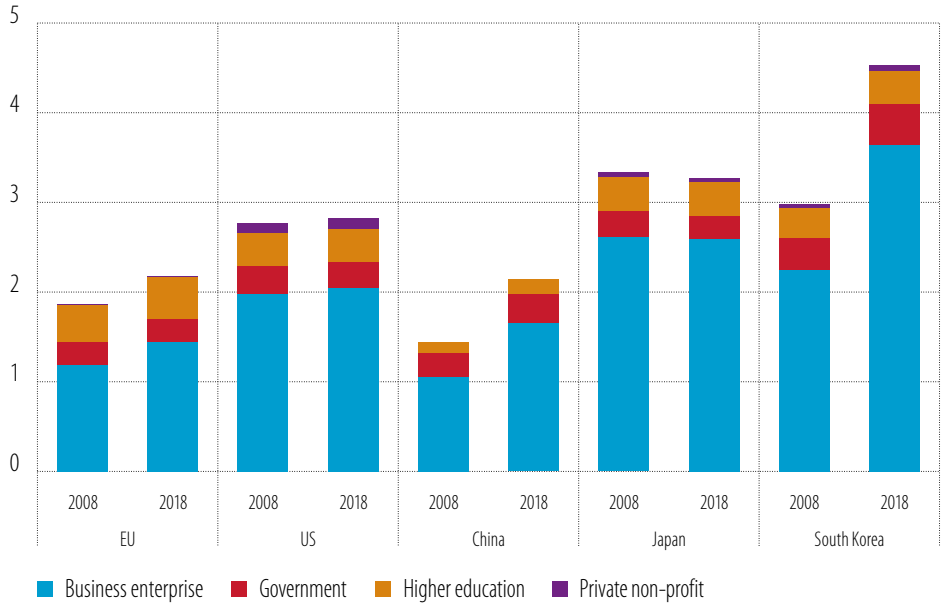


Source: *Eurostat.*
Note: *GERD (gross domestic expenditure on R&D) as a percentage of GDP. China excluding Hong Kong. No data for China in 2000.*

The share of total R&D investment undertaken by businesses is lower in the European Union than in the United States or China. Total R&D expenditure can be broken down by sector: business, government, higher education and private non-profit institutions (including charities). The share of business R&D as a total of R&D expenditure is lower in the European Union (at 67%) than in the United States (73%), or China, Japan and South Korea (78% to 80%). The private sector is driving the rapid increase in R&D expenditure in China and South Korea (Figure 3). However, even if most R&D is undertaken by businesses, the governments in these countries are still actively supporting business R&D. For example, in China, many large companies are directly and indirectly controlled by the state (Veugelers, 2013).

4 The R&D intensity of the United Kingdom is lower than that of the European Union. As a result, the R&D intensity of the European Union is higher when the United Kingdom is removed from EU figures.

Figure 3
Composition of R&D expenditures in 2006 and 2018 (in % of GDP)



Source: *Eurostat.*
Note: *GERD (gross domestic expenditure on R&D) as a percentage of GDP. China excluding Hong Kong. No data on the private non-profit sector in China.*

It remains to be seen whether the sharp contraction in global economic activity in 2020 will lower R&D investment. It is too early to assess the short and long-term impacts of the COVID-19 crisis on R&D and innovation. Major disasters typically compromise incentives to invest in R&D by increasing business costs and causing wide-scale institutional dysfunction (World Bank, 2020). For example, most R&D projects not related to COVID-19 – including important clinical trials – were put on hold, as many universities, research institutes and private companies had to shut down and researchers cut working hours during the first half of 2020 (Cornell University, INSEAD and WIPO, 2020). The strong decline in economic activity following the pandemic may therefore also hit R&D expenditure, especially in the private sector, in 2020.

R&D spending in Europe is too low to meet the Europe 2020 target, which calls for spending equivalent to 3% of GDP. The annual R&D investment gap in the European Union is estimated to be EUR 109 billion. R&D is one of the five headline targets of the Europe 2020 strategy, together with employment, climate change and energy, education, and poverty and social exclusion. By 2020, the European Union was aiming for overall R&D intensity of 3% (and 2% of GDP for business R&D expenditure) through different national targets. Gross domestic spending on R&D in the European Union was EUR 295 billion in 2018, equal to 2.19% of GDP (the most recent figures available). Actual spending in R&D falls short of the target by 0.81 percentage points, equivalent to about EUR 109 billion in 2018. Similarly, R&D expenditure by businesses reached EUR 196 billion (1.45% of GDP) in 2018. Spending fell short of the target of 2% of GDP by 0.55 percentage points, equal to about EUR 74 billion. The R&D investment gap in the European Union remains significant, especially in the business sector.

The rise of software and internet firms among the top global R&D companies

R&D investment is highly concentrated, with a small number of companies, sectors and countries accounting for a large share of business R&D expenditure. For example, the world's top 2 500 R&D companies account for close to 90% of business R&D expenditure, and the top 50 firms account for 40% (Hernández et al., 2020).[5] R&D concentration is particularly pronounced in high-tech sectors such as software and computer services, pharmaceuticals and biotechnology, and manufacture of technology hardware, but also in traditional industries such as the automotive sector.[6] Compared to sales or employment, R&D investment is more concentrated among a small number of incumbent firms that have grown bigger over time.

The global R&D landscape changed rapidly over the past decade as the digital economy increased in importance. With more than EUR 18.3 billion spent in 2018, Alphabet (the parent company of Google) was the top global R&D spender, followed by Samsung and Microsoft (Figure 4). The list of the ten largest R&D investors is dominated by US and Asian companies selling software and computer services (Alphabet and Microsoft) or producing electronic and hardware technology equipment (Samsung, Huawei, Intel and Apple). The only EU companies in the top ten are two German car manufacturers (Volkswagen and Daimler). Two pharmaceutical companies (Roche and Johnson & Johnson) are also in the top ten. The top 25 companies include six additional firms in the automotive industry (from Japan, the United States and Germany), five additional companies in pharmaceuticals and biotechnology (from the United States, Switzerland and France), two US software and internet companies (Facebook and Oracle), and two companies producing hardware (Siemens and Cisco Systems). The European Union is thus relatively well represented in the top 25 with six companies, even though the United States is clearly leading with 13 firms. Sanofi and Siemens are the only two EU companies in the top 25 that are not in the automotive sector.

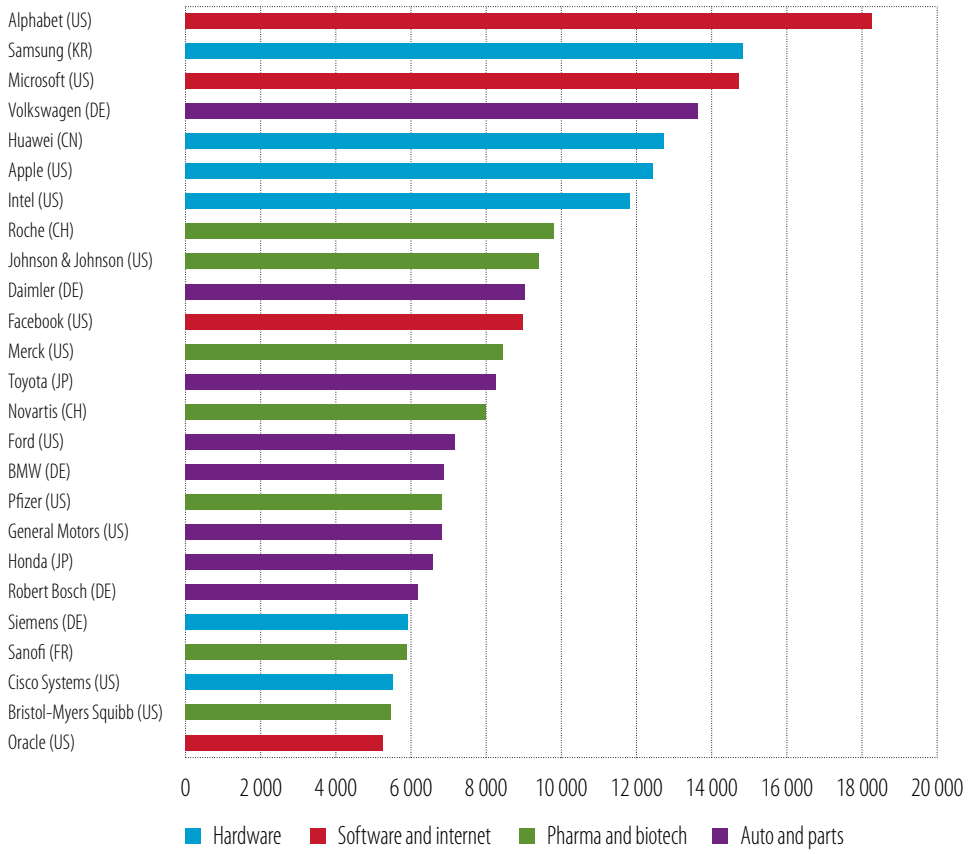
European companies are major global players in R&D and innovation, but the share of EU firms in the top 2 500 R&D investors has fallen over time. The share of firms from the European Union, the United States and Japan on the list of the top 2 500 R&D investors – as well as the share of total R&D investment of these firms – fell from 2006 to 2018 (Figure 5). This fall is largely attributable to the emergence of Chinese firms. While the United States remains an innovation leader, the number of Chinese companies included on the list of big R&D spenders has risen fast – from 0.5% in 2006 to 20% in 2018 – and is now higher than the number of EU companies.

The European Union generates fewer new R&D leaders than China or the United States. China and the United States have a higher number of recent entrants into the list of global innovators – firms that are "new to the club" and not among the top 2 500 global innovators before 2016 – than the European Union and Japan. China has generated 39% of new entrants since 2016, while the United States is responsible for 32% and the European Union only generated 10%. For the United States, the high number of new firms added to the top 2 500 R&D companies was balanced out by firms leaving the list. Otherwise, the number of US firms in the list would presumably have increased over time.

5 The world's top 2 500 R&D companies included in the 2019 EU Industrial R&D Investment Scoreboard invested EUR 823 billion in R&D in 2018.

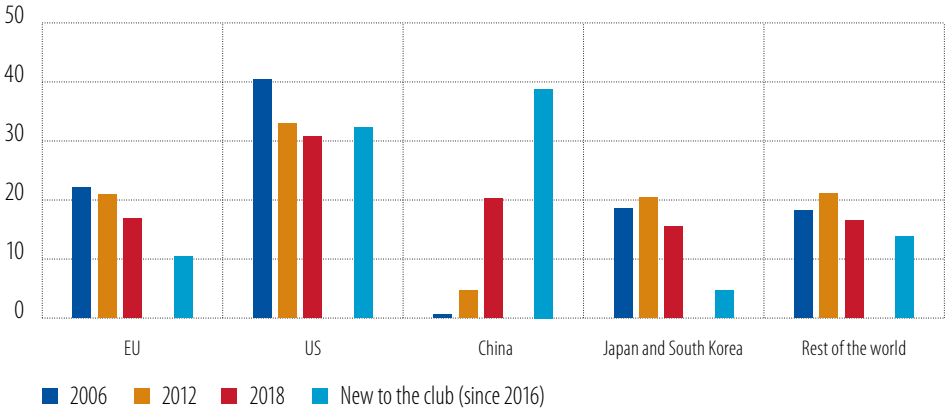
6 Eurostat classifies motor vehicle manufacturing as a medium-high-tech sector, whereas pharmaceuticals, computer, electronic and optical products, as well as computer programming and related activities are considered to be high-tech sectors.

Figure 4
R&D expenditure by the top 25 global R&D investors in 2018 (in EUR million)



Source: *EU Industrial R&D Investment Scoreboard.*
Note: *The companies are ranked based on their R&D expenditure in 2018. Hardware: electronic and electrical equipment, technology hardware and equipment. Software and internet: software and computer services. Pharma and biotech: pharmaceuticals and biotechnology. Auto and parts: automobiles and parts.*

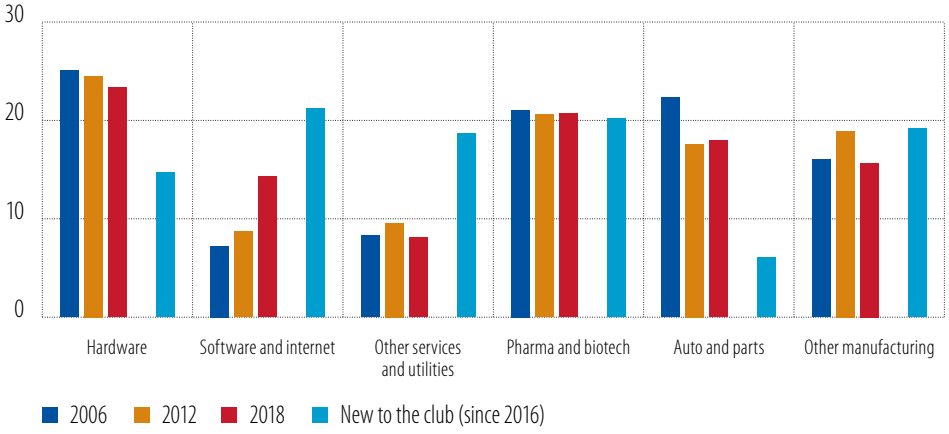
Figure 5
Share of top global R&D companies (in %)



Source: *EIB calculations based on EU Industrial R&D Investment Scoreboard.*
Note: *Share of the total number of firms in the list of the top R&D investors, by country. "New to the club" refers to firms that entered the list of top global R&D investors after 2015.*

Companies producing hardware represent almost a quarter of total R&D expenditure, while companies selling software are growing fast and generate more than a fifth of new R&D leaders. Electronic equipment and hardware represent 23% of total R&D spending by the top 2 500 companies, followed by pharmaceuticals and biotechnology, which account for 21% (Figure 6). R&D spending by companies selling software and computer services has increased rapidly over the past decade, with their share rising from 7% in 2006 to 14% in 2018.[7] In addition, R&D expenditure by companies that are "new to the club" is largest among software and internet firms, followed by pharmaceuticals and biotechnology, and other manufacturing (manufacturing other than automobiles).[8] The automotive industry remains a solid R&D spender but does not generate many new leaders. For example, a recent entrant to this sector is the US company Tesla, which was founded in 2003 and started car production in 2008.

Figure 6
Share of R&D expenditure 2006-2018 (in %)



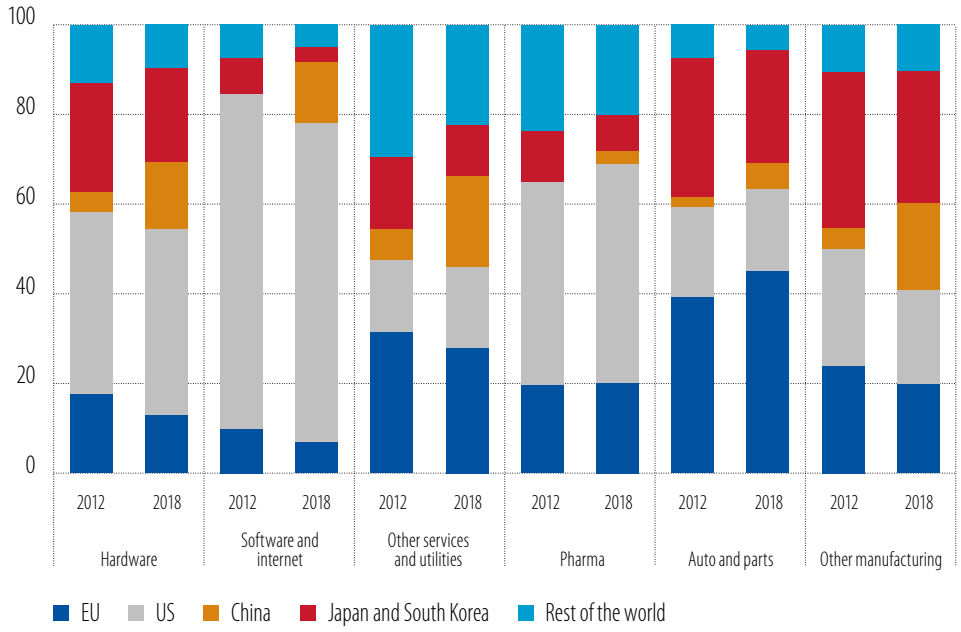
Source: *EIB calculations based on EU Industrial R&D Investment Scoreboard.*
Note: *Share of R&D expenditure by the top R&D investors, by sector. "New to the club" refers to firms that entered the list of top global R&D investors after 2015. Hardware: electronic & electrical equipment, technology hardware and equipment. Software and internet: software and computer services. Other services and utilities: fixed line telecommunications, mobile telecommunications, food and drug retailers, general retailers, industrial transportation, travel and leisure, media, banks, equity investment instruments, life insurance, non-equity investment instruments, non-life insurance, real estate investment and services, support services, alternative energy, electricity, gas, water and multi-utilities, industrial metals and mining, oil and gas producers, oil equipment, services and distribution. Pharma and biotech: pharmaceuticals and biotechnology; healthcare equipment and services. Auto and parts: aerospace and defence, automobile and parts. Other manufacturing: beverages, food producers, tobacco, chemicals, construction and materials, forestry and paper, general industrials, industrial engineering, household goods and home construction, leisure goods, personal goods.*

The European Union specialises less in software and computer services than the United States and China. The European Union only represents 7% of R&D expenditure among the leading companies in software and computer services, compared with 71% for the United States, 14% for China, and 3% for Japan and South Korea (Figure 7). Similarly, the European Union accounts for 13% of R&D expenditure among leading companies producing technology hardware and electronic equipment, compared with 42% for the United States, 21% for Japan and South Korea, and 15% for China.

7 The growth in venture capital investment during this period was also largely driven by investment in software and computer services (Cornell University, INSEAD and WIPO, 2020).

8 Alphabet, the largest R&D spender according to the 2019 EU Industrial Scoreboard, was created through a restructuring of Google in October 2015. It is included in the software and internet sector but not in the "new to the club (since 2016)" category.

Figure 7
Share of R&D expenditure in 2012 and 2018 (in %)



Source: *EIB calculations based on EU Industrial R&D Investment Scoreboard.*
Note: *Share of R&D expenditure by the top R&D investors, by sector and country. See note to Figure 6 for a detailed list of industries.*

The difference in business conditions and the regulatory environment may explain the gap between the European Union and the United States in creating new leading innovators. Business conditions in the European Union and the United States differ, including access to finance and the regulatory environment. The European Union's regulatory environment may not sufficiently support young European firms undertaking risky and innovative investments (European Commission, 2018). For instance, the venture capital market is smaller in Europe than in the United States or Asia – where it has grown rapidly in recent years, especially in China.[9] The European Union does not appear to be generating many new innovation leaders, especially in fast-growing sectors such as software and computer services. This may jeopardise Europe's long-term competitiveness.

Europe's weaknesses could lead to the emergence of future tech champions in other regions of the world, where companies developing new technologies are better supported by the existing digital infrastructure, including hardware, software and digital services. The COVID-19 crisis has highlighted the need for EU firms to aggressively invest in digital technologies. Substantial investments are needed to improve information and communications technology (ICT) infrastructure and increase the digital skills of the workforce. A weak digital sector means that EU companies and citizens will lack ownership of their data, leaving the data to be controlled outside the European Union – as illustrated by the discussion in various countries on whether to use equipment provided by the Chinese company Huawei in new 5G telecommunication networks.

Europe has strong traditional industrial sectors that were not born digital. Many indicators suggest Europe is falling behind in the digital transformation at a time when industry 4.0, the use of automation

9 Venture capital in the United States, Asia and Europe declined sharply in the first quarter of 2020. This is expected to affect young and small firms in particular. At the same time, recent venture capital deals financing innovation seem to have been redirected towards health, online education, big data, e-commerce and robotics (Cornell University, INSEAD and WIPO, 2020).

and data in manufacturing, is gaining momentum and has started to substantially change the business models of traditional industries (EIB, 2019). Digitalisation pervades the global economy and is arguably one of the most important drivers of firms' innovation, competitiveness and growth (Rückert, Veugelers and Weiss, 2020). The digital transformation of traditional industries and the development and adoption of new technologies in the European Union require large investments in R&D and innovation.

The pharmaceuticals and biotechnology sector is dominated by US companies, which account for almost half of the R&D spending of the sector's top companies. Nevertheless, EU companies continue to be important players, accounting for 20% of global R&D investment in this sector (Veugelers, 2013). Most R&D investment in pharmaceuticals and biotechnology is concentrated in a handful of champions: the top ten firms make up half of R&D expenditure.[10] However, even in this sector, the share of R&D expenditure from Chinese companies has increased rapidly over time. The pandemic has renewed the focus on R&D in the health sector, which is likely to grow strongly in the short and medium term. Box A discusses the EU response to accelerate the search for COVID-19 vaccines, including support for health-related R&D efforts. The sector is also adopting digital technologies rapidly as they allow for faster and more precise diagnosis of diseases. That faster diagnosis enables treatments to start earlier, which can improve patients' health and save lives.

10 The large share of R&D expenditure in pharmaceuticals and biotechnology attributed to the rest of the world is driven by two Swiss pharmaceutical companies (Roche and Novartis).

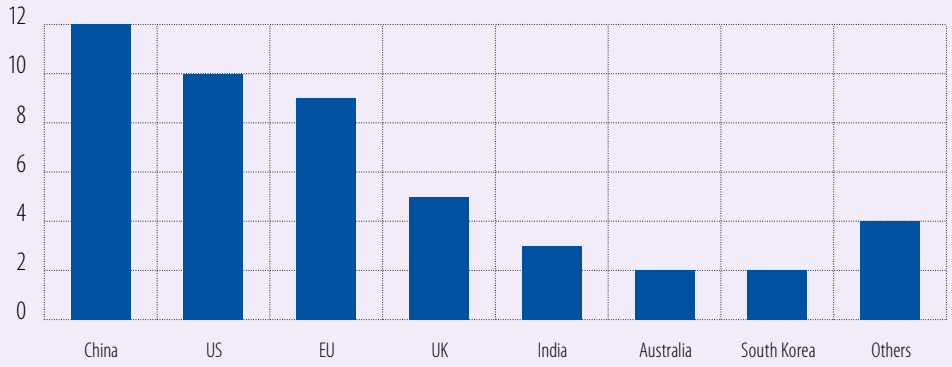
Box A

The European strategy in the search for COVID-19 vaccines

The global crisis caused by the pandemic spurred a healthcare development race that is unprecedented in scale and pace. In the ten months following the discovery of the pathogen, global research efforts have rapidly expanded. As of October 2020, those efforts encompassed more than 190 candidate vaccines, including 40 in clinical trials on humans (Figure A.1). Additionally, many health sector companies have shifted their focus to delivering tests and therapeutics for COVID-19. In parallel to investing in R&D, countries must also rapidly scale up manufacturing capacity, secure procurement agreements and ensure prompt delivery of the vaccine.

Figure A.1

Number of developers of vaccines in clinical trials as of October 2020



Source: *World Health Organisation.*
Note: *Partnerships between international firms count as multiple countries. For example, Sanofi-GSK is developing one vaccine, but it is a partnership between a French and British firm, and therefore counts as one for the European Union and one for United Kingdom. "Others:" Cuba, Japan, Kazakhstan, and Singapore – where one vaccine is being developed in each country.*

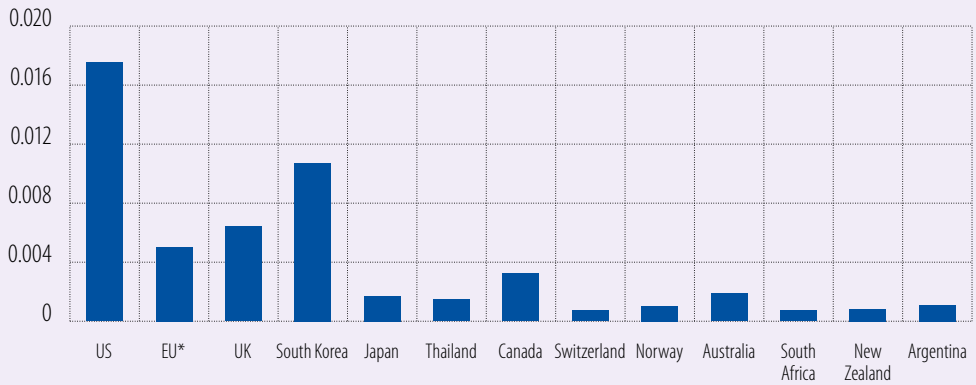
In this challenging landscape, European institutions have made a substantial effort to support EU companies' R&D, while also improving the regulatory framework and helping firms to increase manufacturing capacity. The European Union approached all funding projects from a technology-neutral perspective, supporting a wide range of competing innovation processes and research on various vaccines. The European Commission has already invested EUR 459 million from its Horizon 2020 research and innovation programme in more than 100 projects tackling the consequences of the health crisis. These projects include the development of diagnostics, treatments, and vaccines, as well as the creation of infrastructure and data resources needed for research.

The EIB has provided debt financing to support the research and development of the most promising COVID-19-related projects. For example, it provided EUR 100 million in financing for the German company BioNTech to support its BNT162 vaccine programme, as well as EUR 75 million for CureVac and its CVnCoV vaccine. BioNTech, which received EIB funding, developed the first vaccine approved in the United States, the United Kingdom and the European Union. The company also had the third-largest manufacturing capacity of potential vaccine makers, with an estimated 1.3 billion doses ready to be produced by the end of 2021.

The European Commission has also started contracting advance purchase agreements with manufacturers. These agreements specify that, in return for the right to buy a specified number of vaccine doses in a given time frame, the Commission agrees to finance part of the upfront costs faced by vaccine producers. As of October 2020, the Commission had signed contracts with British-Swedish firm AstraZeneca and British-French company Sanofi-GSK, and had held exploratory talks with Johnson & Johnson, CureVac, Moderna and BioNTech.

As of September 2020, EU members and other EU agencies had provided EUR 786 million in R&D funding, which corresponds to about 0.005% of EU GDP (Figure A.2). The United States is the only country that has provided more R&D funding for COVID-19 vaccines than the European Union –on the back of a USD 2 billion grant provided to the US Biomedical Advanced Research and Development Authority (BARDA). The United States has also provided the highest level of R&D funding as a percentage of GDP, followed by South Korea, the United Kingdom and the European Union.

Figure A.2
Funding for COVID-19-related R&D as of September 2020 (in % of GDP)



Source: *EIB calculations based on R&D data from the OECD Global Science Forum (GSF) Research Funding Initiative, 2019 GDP data from the OECD.*
Note: *EU* includes funding by Member States and EU agencies. Countries are ranked based on total R&D funding (in USD) as of September 2020. In some cases, R&D funding has been announced but without indicating the amount. That funding is therefore not included in the figures.*

Once a candidate vaccine is approved, it is critical that manufacturing and distribution capacities are ready to supply a significant number of doses. Even prioritising the most at-risk population worldwide (healthcare workforce, frail and elderly, patients with co-morbidities, etc.), a vaccine requiring two doses to be administered would equal 3.6 billion doses globally. It is therefore crucial that EU capacity be sufficient to ensure adequate immunisation campaigns for its Member States and other countries in the medium to long term.

To cope with these capacity requirements, the European Union's strategy has been to expand production and logistics facilities. The funding initiatives discussed above will also help scale up manufacturing capacity in Europe. In addition, in late September 2020 the European Commission and EIB jointly pledged to invest EUR 400 million in the COVAX facility, an international platform for the development and manufacturing of COVID-19 vaccine candidates. All COVAX participating countries (approximately 170 countries as of October 2020) will have equal access to these vaccines, regardless of their level of contribution to the financing of the platform. The initiative will enable residents of low and middle-income countries to access COVID-19 vaccines once developed.

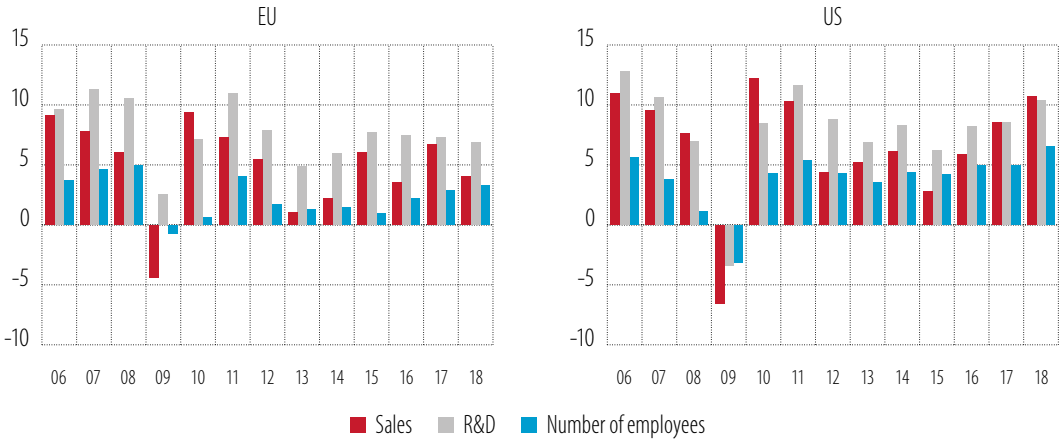
Europe remains a global leader in R&D investment in the automotive industry. Global R&D expenditure by companies in aerospace, defence and automobiles is heavily concentrated in a few European countries, Japan and South Korea, with these countries accounting for about 70% of total R&D spending. The US share has fallen over time, while the presence of China is becoming more evident, particularly as the country develops electric vehicles (EIB, 2019).[11] The automotive sector is being transformed by the need to develop engines that are not reliant on fossil fuels, as well as the increased use of digital technologies and new trends such as electric vehicles, autonomous driving and car sharing. If EU firms are not able to better integrate digital technologies into their business models, they risk becoming less relevant, even in sectors where they currently lead. Laying the foundation for the rapid digitalisation of this sector is crucial, and the European Union can benefit from its leading position in climate action (see Chapter 8 for further discussion).

Although it is difficult to predict how business R&D spending will react to the current crisis, experience from the financial and sovereign debt crisis shows that R&D investment and sales for leading EU and US companies can recover rapidly. At the same time, the rebound in the number of workers employed by the top 500 and R&D investors in the European Union and United States was more modest, especially in the European Union (Figure 8). It is difficult to predict whether similar patterns will be observed after the COVID-19 crisis. The top EU companies appear to be less dynamic than their US peers. At the same time, robust growth among US companies (especially in the number of employees) could also reflect their rising market concentration in digital sectors, where economies of scale and winner-takes-all dynamics are very important (Calligaris, Criscuolo and Marcolin, 2018).

11 About 47% of the 7.2 million electric cars sold from 2010 to 2019 were in China (International Energy Agency (IEA), 2020). In addition, close to 98% of the 500 000 electric buses in operation globally have been deployed in Chinese cities. China also continues to lead in the rollout of publicly accessible electric chargers, especially fast chargers.

Figure 8

Median annual growth of sales, R&D expenditure and number of employees among the top 500 R&D companies in the European Union and United States (in %)



Source: *EIB calculations based on EU Industrial R&D Investment Scoreboard.*
Note: *Median annual growth rate of sales, R&D expenditure and the number of employees (in %) among the top 500 EU and US companies that already existed in 2005.*

Box B

Towards a sustainable ICT sector?

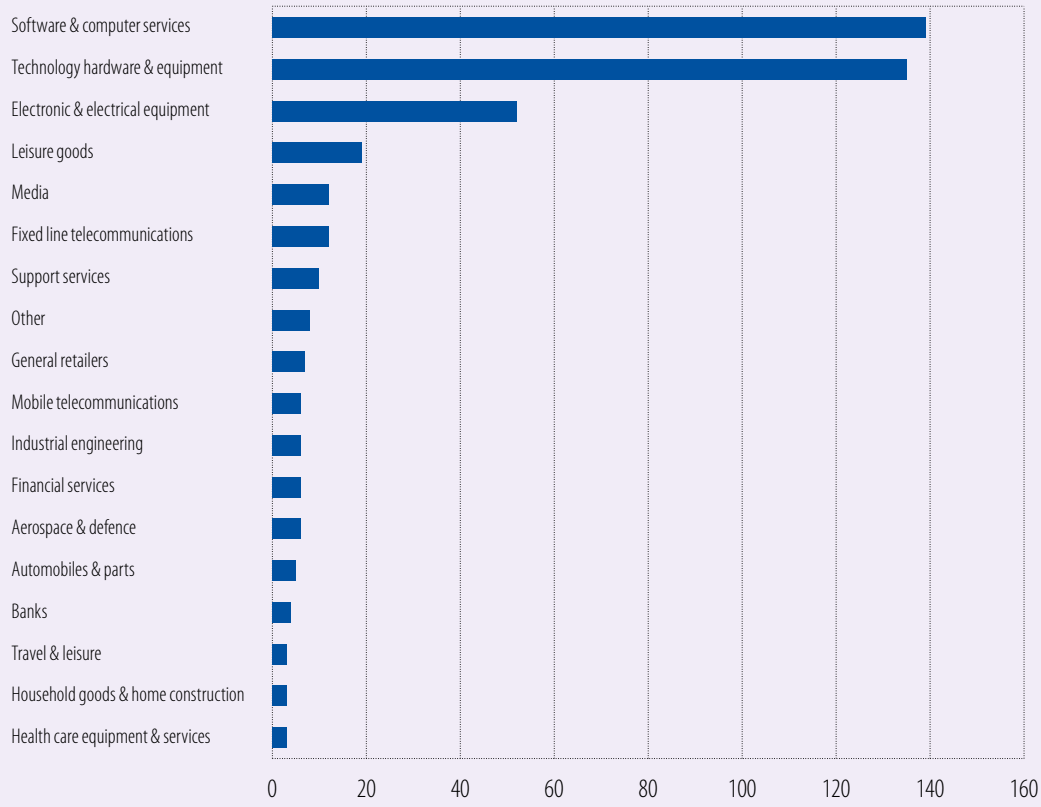
Formulating policies that promote sustainability and the reduction of global greenhouse gas emissions is necessary to address climate change. The ICT sector is responsible for a significant amount of greenhouse gas emissions and, at current trends, could turn into one of the largest global contributors. However, by fostering the development of green technologies, the ICT industry could also prove essential to transitioning to a green economy. To assess the current contribution of the sector to green development, the analysis described in this box breaks down the R&D output of global ICT leaders into green and non-green patents. The results suggest that a significant portion of the investment made by leading ICT firms contributes to climate change mitigation and adaptation.

The ICT industry is estimated to consume 6% to 10% of global electricity and to contribute 3% to 9% of greenhouse gas emissions (Andrae and Edler, 2015; Belkhir and Elmeligi, 2018; Malmodin and Lundén, 2018). While these figures may overestimate the actual ICT footprint (Malmodin and Lundén, 2016; Shehabi et al., 2016), the ICT sector is large, growing, and its impact on society is pervasive.

ICT industry's ability to produce a sustainable model depend on the balance struck between the increasing demand for ICT services and devices and the sector's ability to increase its energy efficiency, including the use of efficient technologies. Many players are active in the development and adoption of sustainable ICT (or "green IT", as labelled by Herzog, Lefèvre and Pierson, 2015): "They span from individual persons (e.g., an activist, a researcher, a consultant), research groups in academia (research institutes, universities, academic research networks), companies (developing technologies, advising companies), groups of companies (influential and lobbying groups), governments (through public incentives, laws), to groups of governments (e.g., European Union)."

This box focuses on one type of player: large companies that invest in R&D. Their size and position in the industry allow them to significantly influence the development of green technology. Large incumbent tech giants are more able to react and support green ICT development. Data on the largest global ICT-related companies (such as Hewlett-Packard, IBM, Cisco, etc.) from the EU Industrial R&D Investment Scoreboard are used to analyse trends in the development of new technologies and patenting activities in green IT.

Figure B.1
Number of ICT-specialised companies, by sector



Source: *The 2017 EU Industrial R&D Investment Scoreboard, European Commission, Joint Research Centre (JRC) / Directorate General for Research and Innovation (DG RTD).*

The selection of leading ICT companies is not limited to the sectoral classification, but rather to the ICT taxonomy based on International Patent Classification patent families[12] (Daiko et al., 2017) grouped into 12 broad categories.[13] Companies are defined as technologically specialised in ICT when they are predominantly active in the development of IP5 patent families pertinent to these ICT categories.[14] The

12 The patent families in this analysis are fractionally counted according to their year of worldwide first filing, commonly known as the priority year, which is closest to the date of invention. Patent assignee data from PATSTAT are matched with data from EU Industrial R&D Investment Scoreboard at the level of individual companies (including subsidiaries where available) using a series of probabilistic string-matching algorithms.

13 The 12 categories are: high speed networks, mobile communication, security, sensor and device networks, high-speed computing, large-capacity and high-speed storage, large-capacity information analysis, cognition and meaning understanding, human-interface, imaging and sound technology, information communication devices, electronic measurement, and others.

14 IP5 is the name given to a forum of the five largest intellectual property offices in the world: the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the National Intellectual Property Administration of the People's Republic of China (CNIPA), and the United States Patent and Trademark Office (USPTO).

technological specialisation of top R&D investors is derived from revealed technological advantage (RTA) indicators, compiled at the company level.

The RTA index is defined as the share of a firm's patents that are pertinent to a particular technology divided by the share of patents from all firms in that technology.[15] The index is equal to 0 when the company has no patents in an ICT-related technology. It takes a value of between 0 and 1 when the company does not specialise in ICT per se, and it is larger than 1 when it is relatively specialised in ICT technologies.

Among the 1 824 Investment Scoreboard firms with IP5 families in from 2007 to 2018, 436 companies had an RTA in ICT-related technologies larger than 1. Figure B.1 reports the number of firms that are technologically specialised in ICT, by their original sector classifications. While the majority of ICT-specialised firms belong to classical ICT sectors (such as software and computer services, technology hardware and equipment), the list also includes firms in industrial engineering, aerospace and defence, automobile and parts or banks, which are not ICT companies but are specialised in ICT technologies.

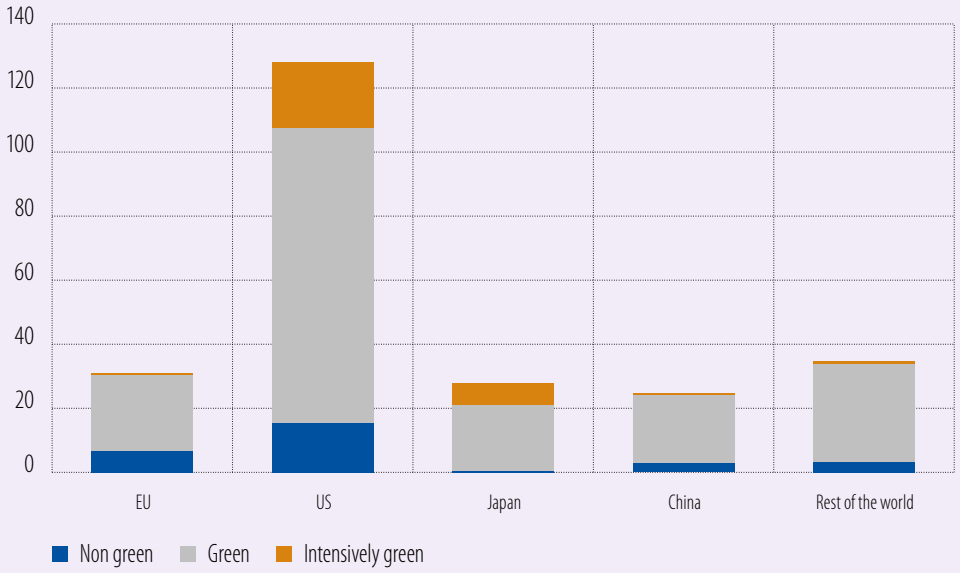
Top R&D investors worldwide play a leading role in the development of ICT-related technologies. Together they own about 75% of world IP5 patent families in ICT technologies (Daiko et al., 2017). The 436 ICT-specialised companies represented 34% of the total R&D spending of the top 2 000 R&D investors worldwide in 2016. The majority of these ICT companies are located in the United States, representing half of R&D spending and 40% of net sales of the ICT sample.

To measure ICT companies' efforts in developing green technologies, green patent families have been identified based on the Cooperative Patent Classification (CPC) classification scheme. More specifically a patent is classified as green if it contains CPC codes that belong in the Y02 and/or Y04 subclasses. Among the 436 ICT-specialised companies, 270 firms are also active in filing green patents and, among those, 44 firms are "intensively green" (highly patenting in green technologies, with a green RTA higher than 1). The analysis also identifies 4 136 patent families, which are classified as pertinent to both ICT and green technologies at the same time.

The majority of the R&D investment is done by ICT companies that also patent in green technologies (Figure B.2). Half of the "intensively green" ICT companies are located in the United States (22 of 44 firms). About 20%-25% of the patents of ICT companies are in green technologies (Figure B.3). ICT companies from Japan and South Korea (included in rest of the world) have been outperforming companies in other regions for the past decade. The overall share of green patents has been decreasing since 2012, potentially due to the lag between the first filing date and the patent issuance date. Chinese ICT companies are alone in having increased their share of green patents, reaching and sometimes surpassing the levels of European ICT companies in 2012. The main green technologies developed by ICT include: ICT energy reduction and technologies aiming at reducing greenhouse gas emissions (Figure B.4).

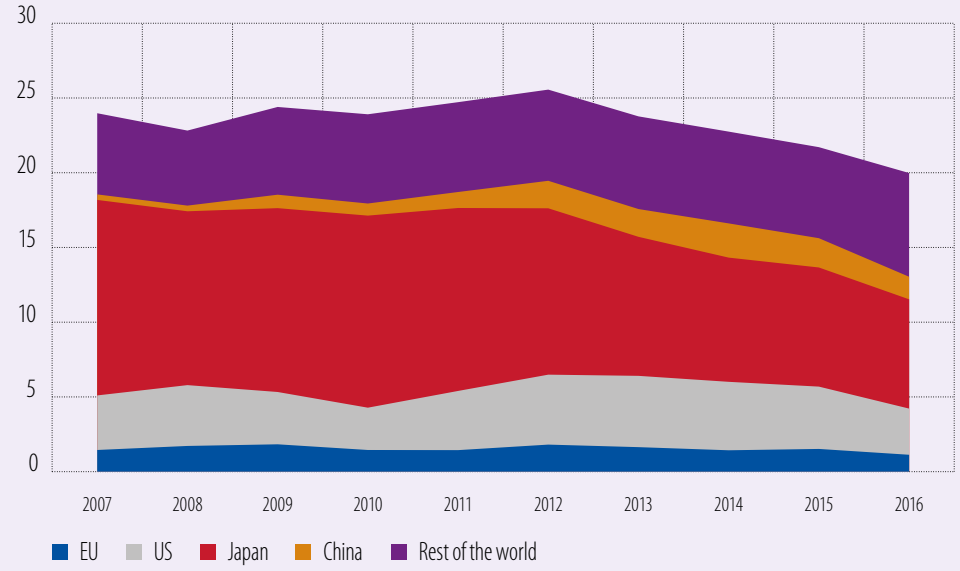
15 The RTA is a ratio of two shares: the share of patents in tech T by firm j over the patents of all firms in the same tech T.

Figure B.2
R&D investment of ICT-specialised companies (in EUR million)**, by green technology**



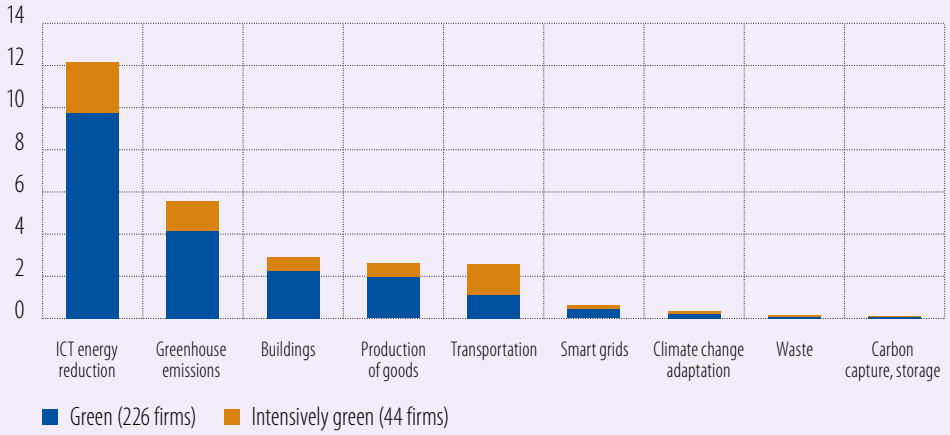
Source: *The 2017 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.*

Figure B.3
Share of green patents of ICT-specialised companies (in %)**, by region**



Source: *JRC/OECD COR&DIP© Database, v.2. 2019.*

Figure B.4
Average number of patents of ICT-specialised companies, by green technology



Source: *JRC/OECD COR&DIP© Database, v.2. 2019.*

Policymakers are placing ICT at the centre of their environmental strategies to monitor climate change and to facilitate the transition towards a green and circular economy. ICT is therefore an industry critical to ensuring the co-existence of economic growth and the environment. To manage the negative impact that ICT may have on the environment and to harness its potential to achieve sustainable growth, the ICT industry will also need to be more involved in developing regulations and standards. In addition, creating incentives for the private sector to invest in green ICT may help accelerate the development of a market.

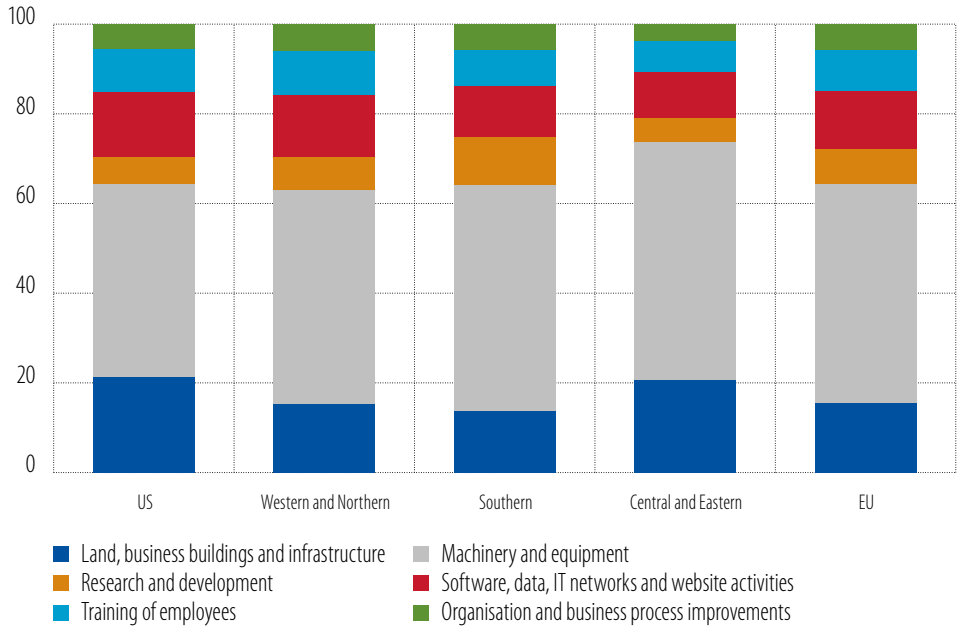
Intangible investment in the European Union and the United States

R&D investment is an important component of business performance but other types of intangible assets – including software and data management, employee training and organisational capital – are increasingly important. According to EIBIS data, firms in the European Union and the United States allocated 36% of their total investment to intangibles in 2019: R&D, software and data management, employee training, and organisational and business process improvements (Figure 9). Within the European Union, the share of investment spent on intangibles is lower in Central and Eastern Europe (26%) than in Western and Northern Europe (37%) or Southern Europe (36%). The differences in intangibles registered within the European Union is in line with estimates from macroeconomic statistics on intangible capital (EIB, 2016).

Manufacturing firms tend to invest more in R&D than companies from other sectors, while firms in services allocate a higher share of investment to software and data, IT networks and website activities. Manufacturing firms in the European Union allocated 13% of total investment to R&D and 9% to software and data in 2019 (Figure 10). During the same period, EU firms in services only allocated 4% to R&D but more than 19% to software and data. The pattern for US firms is very similar. Overall, machinery and equipment remains the most important investment area for all firms, even for those in services.

Figure 9

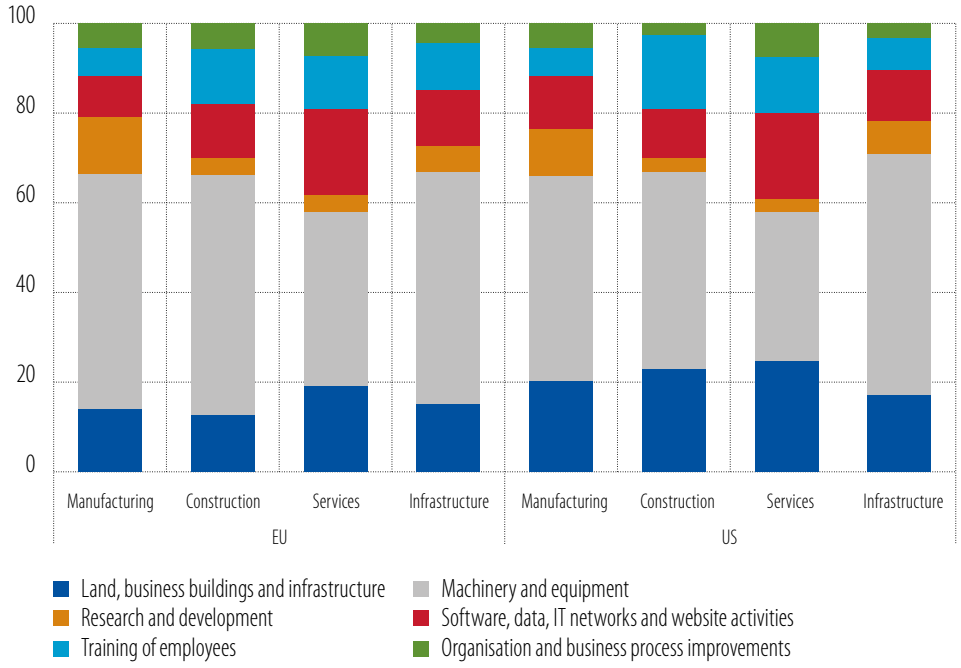
Composition of investment across the European Union and the United States (in %)



Source: *EIBIS 2020.*
Note: *Firms are weighted with 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?*

Figure 10

Composition of investment in the European Union and the United States (in %)**, by sector**

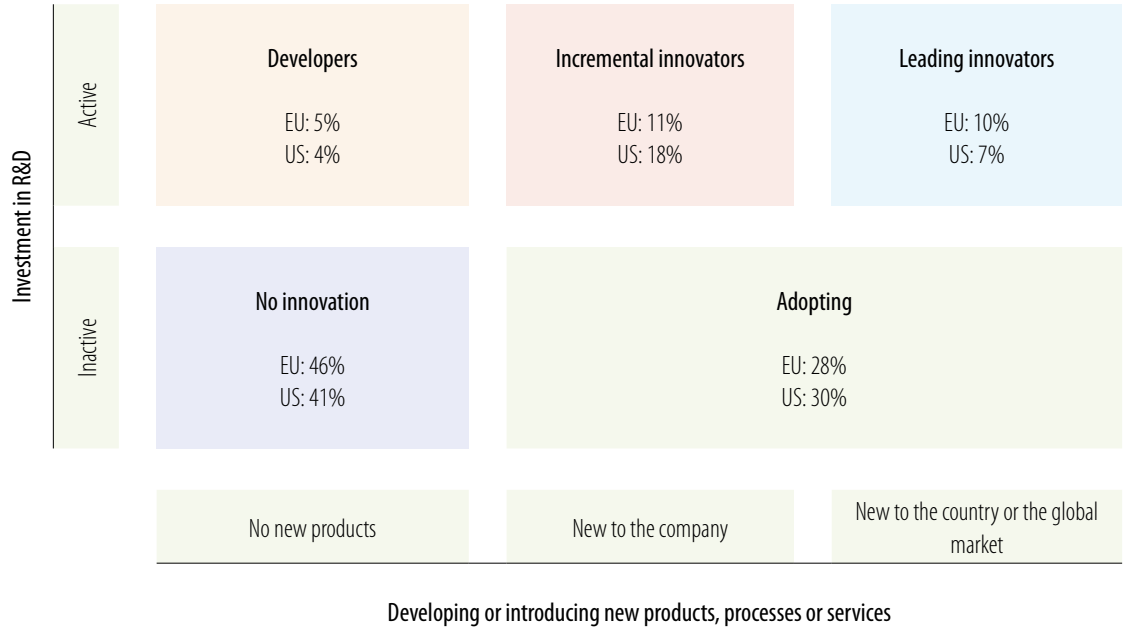


Source: *EIBIS 2020.*
Note: *Firms are weighted with value added.*
Question: *In the previous financial year, how much did your business invest in each of the following with the intention of maintaining or increasing your company's future earnings?*

Firms that invest more in intangible assets tend to be more productive and innovative. They are more likely to develop or introduce new products, processes or services (EIB, 2018). While R&D investment (including the acquisition of intellectual property) is a big factor, investment in software and databases and in organisation and business processes is also important. Complementary intangible assets help spur innovation (Haskel and Westlake, 2017; Brynjolfsson, Rock and Syverson, 2018; Cincera et al., 2019).

The United States has a higher share of active innovators than the European Union. Firms can be classified under five different innovation profiles based on R&D investment and innovation activities (Veugelers et al., 2019). The five innovation profiles are: firms that do not innovate, adopting firms, developers, incremental innovators and leading innovators (Figure 11). The European Union has a higher share of firms that do not innovate than the United States. These firms are passive as they do not invest in R&D and do not invest to develop or introduce new products, processes or services. The European Union also has a lower share of active innovators – the firms that actively invest in R&D (developers, incremental and leading innovators) – than the United States. The difference stems from a lack of incremental innovators in Europe. Incremental innovators are firms that invest in R&D and introduce products, processes or services that are new to the company (but not to their market). Innovation policy in Europe needs to better target firms with the potential to grow, and active innovators tend to grow faster than other firms, are more likely to export their products or services, are more competitive and have higher productivity (EIB, 2018).

Figure 11
Innovation profiles in the European Union and the United States



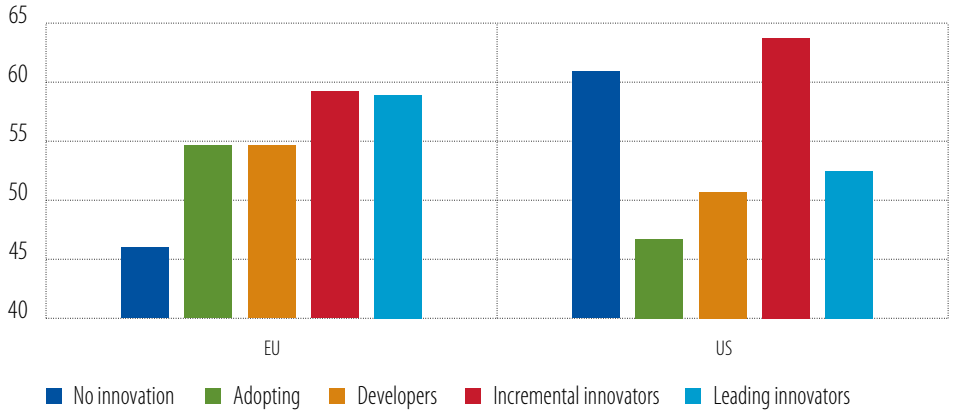
Source: *EIBIS 2020.*
Note: *R&D inactive refers to firms with an R&D investment intensity (R&D investment divided by turnover) below 0.1%. Firms are weighted by value added.*
Question: *In the previous financial year, how much did your business invest in each of the following with the intention of maintaining or increasing your company's future earnings? What proportion of the total investment in the previous financial year was allocated to developing or introducing new products, processes or services?*

More innovative firms tend to report that the pandemic will have a long-term positive impact on the use of digital technologies. The majority of firms in the European Union (52%) and the United States (56%) expect the pandemic to boost digitalisation, for example to prevent business disruption or to improve communication with customers, suppliers and employees. In the European Union, firms' views on the pandemic's impact depend on their innovation profiles. While only 46% of non-innovative

firms expect the use of digital technologies to increase in the long term due to the pandemic, this share increases to 54% for adopters and developers, and to 59% for incremental and leading innovators. The relationship is less clear-cut for the United States, where a large share of firms that do not innovate also expect COVID-19 to boost digitalisation.

Figure 12

Share of firms that expect the pandemic to have a long-term impact on the use of digital technologies in the European Union and the United States (in %)**, by innovation profile**



Source: *EIBIS 2020.*
Note: *See Figure 11 for a definition of innovation profiles. Firms are weighted with value added.*
Question: *Do you expect the coronavirus outbreak to have a long-term impact on the increased use of digital technologies (in order to prevent business discontinuity or improve communication with customers, suppliers and employees)?*

Adoption of digital technologies in the European Union and the United States

The COVID-19 crisis has led to wider recognition of the importance of innovation and digital transformation. Until recently, the implementation of digital technologies was considered an important contributor to market success and usually associated with the most innovative and modern companies. The pandemic, however, has made the digital transformation an integral part of many firms' survival. Digitalisation is indispensable to preventing business disruption, organising work remotely, improving communication with customers, suppliers and employees, and selling products and services online.

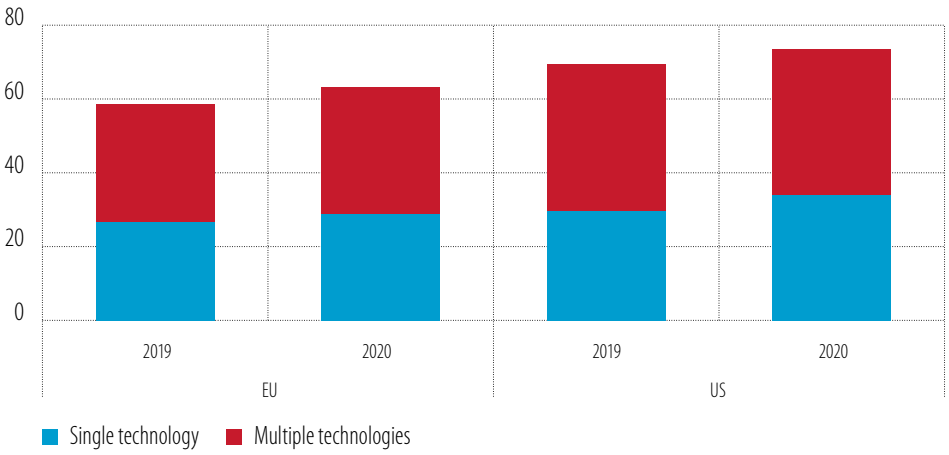
Digital adoption rates are lower for EU firms than US firms. In 2020, 37% of firms in the European Union had not implemented any digital technology, compared to only 27% of firms in the United States (Figure 13). Digital adoption is expanding rapidly among businesses. The share of firms with at least one digital technology has increased compared to EIBIS survey results from last year, both in the European Union and the United States. However, the European Union is not closing its digital gap with the United States.

The majority of firms that are already digital have implemented more than one digital technology. At the same time, about 40% firms report having adopted at least one of the technologies in the past year. Digitalisation therefore appears to be a recent priority for many firms. This suggests that the European Union needs to make efforts to support investment in digitalisation to catch up with US firms.

The difference in digital adoption rates between the European Union and the United States is particularly large in the construction and service sectors. The share of construction firms that are non-digital is 60% in the European Union, compared to only 23% in the United States (Figure 14). The difference

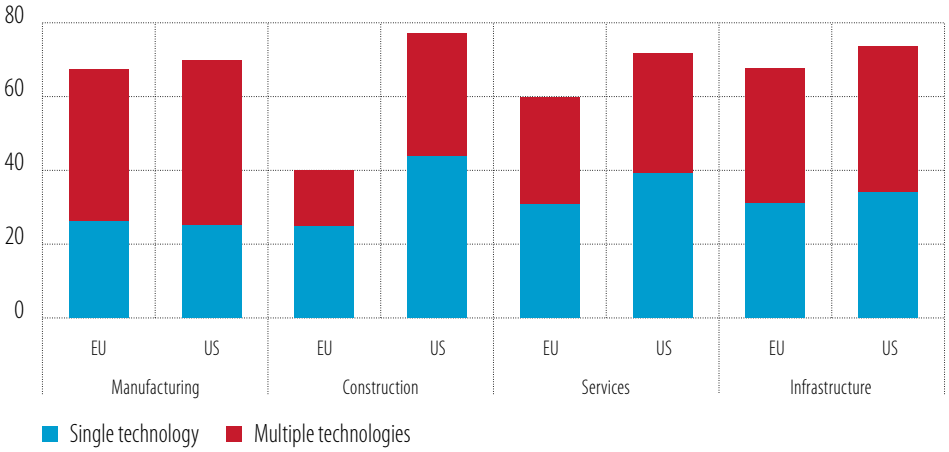
in digital adoption rates between EU and US firms is 12 percentage points in services, 6 percentage points in the infrastructure sector and 3 percentage points in manufacturing. In the manufacturing and infrastructure sectors, most firms that are already digital have implemented more than one technology. However, most firms in construction and services – the sectors in which EU firms also have the largest gap with the United States – have only implemented one technology.

Figure 13
Adoption of digital technologies (in %)



Source: *EIBIS 2019 and 2020.*
Note: *A firm is identified as "digital, single technology" if one digital technology was implemented in parts of the business and/or if the entire business is organised around one digital technology. A firm is identified as "digital, multiple technologies" if at least two digital technologies were implemented in parts of the business and/or if the entire business is organised around at least two digital technologies. Firms are weighted using value added.*
Question: *Can you tell me for each of the following digital technologies if you have heard about them, not heard about them, implemented them in parts of your business, or whether your entire business is organised around them? Firms are asked to answer the question for four different digital technologies specific to their sector (see the note to Figure 15 for the definition of digital technologies).*

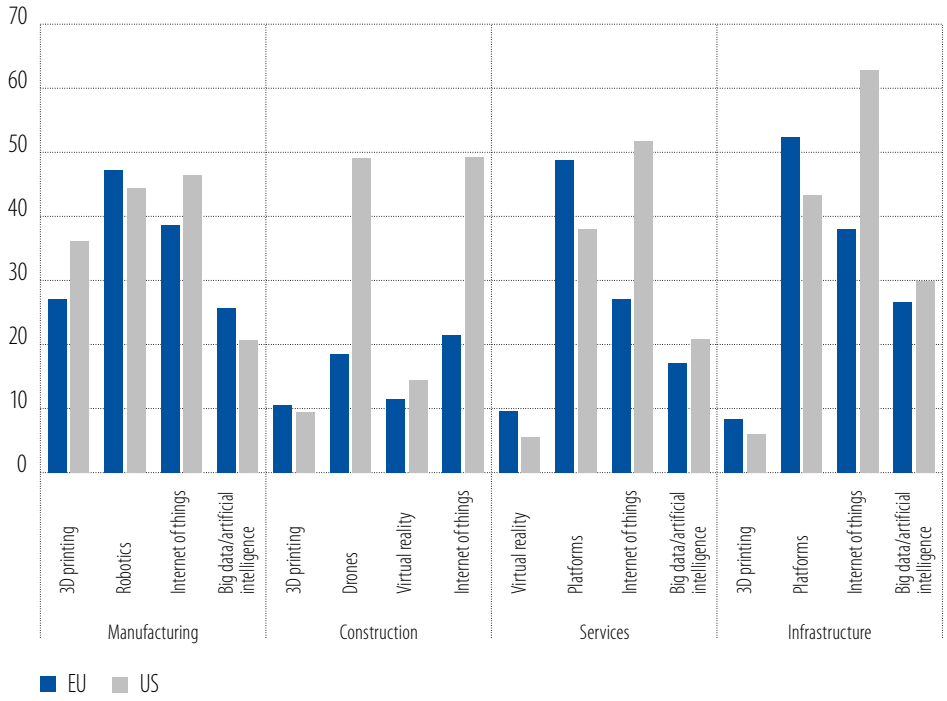
Figure 14
Adoption of digital technologies (in %)**, by sector**



Source: *EIBIS 2020.*
Note: *See note to Figure 13 for the definition of digital adoption. Firms are weighted by value added.*

EU firms have lower adoption rates for the internet of things than US firms. Data on specific digital technologies within the four sectors indicate that the adoption rate differences between the European Union and the United States are driven by the lower adoption rates of internet of things technologies, such as electronic devices that communicate with each other without assistance (Figure 15). In addition, US construction firms employ drones more often than firms in the European Union.

Figure 15
Adoption of different digital technologies (in %)

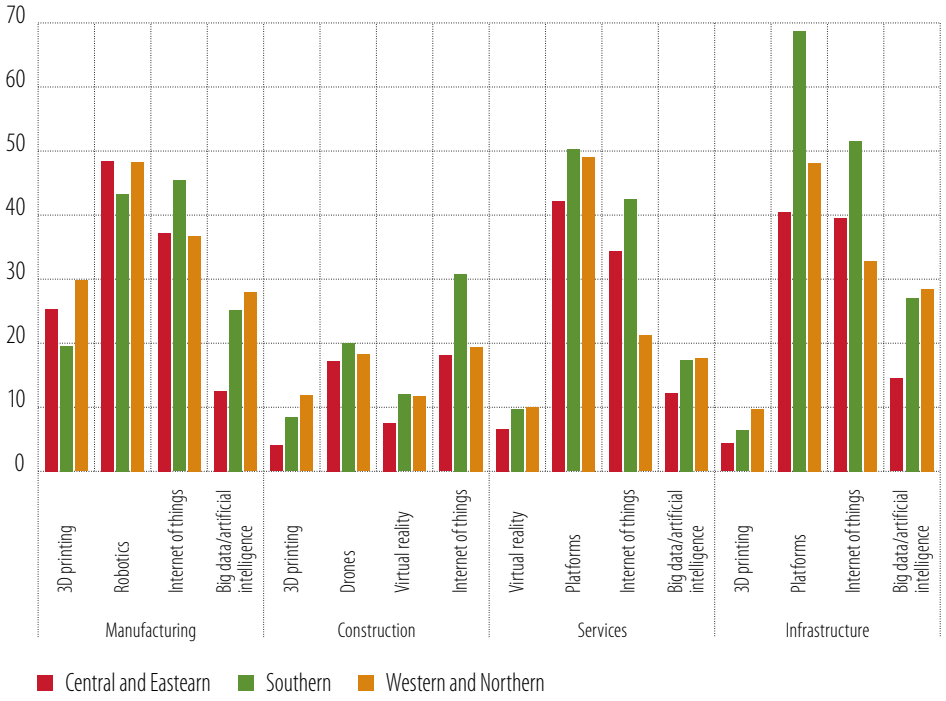


Source: *EIBIS 2020.*
Note: "3D printing"*: also known as additive manufacturing;* "Robotics"*: automation via advanced robotics;* "Internet of things"*: refers to electronic devices that communicate with each other without human assistance;* "Big data/artificial intelligence"*: cognitive technologies, such as big data analytics and artificial intelligence;* "Drones"*: unmanned aerial vehicles;* "Virtual reality"*: augmented or virtual reality, such as presenting information integrated with real-world objects presented using a head-mounted display;* "Platforms"*: platform that connects customers with businesses or customers with other customers. Firms are weighted using value added.*

Firms in Southern Europe are more likely to have implemented internet of things and platform technologies than in Western and Northern Europe or Central and Eastern Europe. This helps to explain the higher rate of digital adoption in Southern Europe, especially in the construction and infrastructure sectors. At the same time, firms in Western and Northern Europe more often report having adopted 3D printing and cognitive technologies, such as big data analytics and artificial intelligence (Figure 16).

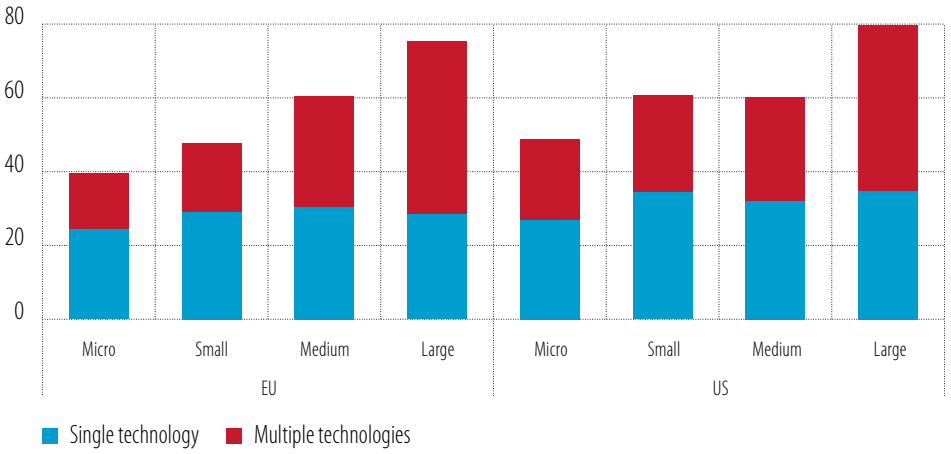
Larger firms have higher rates of digital adoption than smaller firms. In the European Union, only 40% of microfirms (five to nine employees) have implemented at least one digital technology, while 75% of large firms (with more than 250 employees) are already digital (Figure 17). Perhaps unsurprisingly, large firms are also much more likely to have implemented multiple technologies. The difference in digital adoption rates between the European Union and the United States appears to be particularly important for small firms (10 to 49 employees). Zooming in on the four different sectors, the size definitely plays a role for manufacturing firms. For example, only 30% of EU manufacturing firms with fewer than ten employees are digital, whereas 79% of large EU manufacturing firms have implemented digital technologies. However, the size effect is observed in the other sectors as well, both in the European Union and the United States.

Figure 16
Adoption of different digital technologies across the European Union (in %)



Source: *EIBIS 2020.*
Note: *See note to Figure 15 for the definition of the digital technologies. Firms are weighted by value added.*

Figure 17
Adoption of digital technologies (in %)**, by firm size**

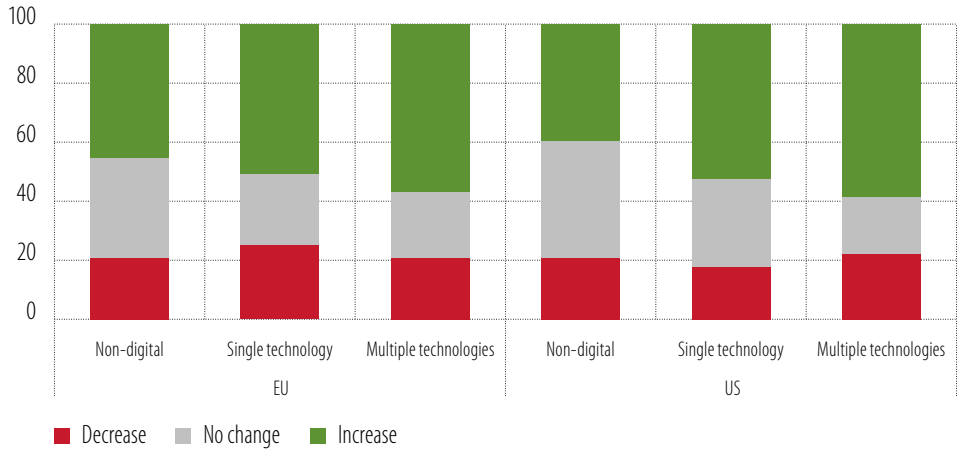


Source: *EIBIS 2020.*
Note: *See note to Figure 13 for the definition of digital adoption. Firms are weighted by value added.*

Firm size and market segmentation are holding back European firms' digital adoption. EU firms are, on average, smaller than US firms. Investment in digital technologies often entails high fixed costs, making the adoption (of one or multiple technologies) easier for larger firms that can spread the costs over a larger revenue stream. Market fragmentation in the European Union prevents firms from quickly adopting digital technologies, preventing EU firms from closing the gap with their US peers.

Digital firms grow faster than firms that have not implemented digital technologies. Digital firms are more likely to have hired new employees over the past three years, both in the European Union and the United States, while a larger share of non-digital firms are stagnating (Figure 18). This indicates that firms moving ahead with digitalisation – in particular, firms that have already implemented multiple technologies – are more dynamic than firms that do not invest in digitalisation and are left behind (Rückert, Veugelers and Weiss, 2020). Looking ahead, firms that have implemented multiple technologies often expect digitalisation to increase the number of employees in their business over the next three years.[16]

Figure 18
Employment growth over the past three years (in %)**, by digital intensity**



Source: *EIBIS 2020.*
Note: *See note to Figure 13 for the definition of digital adoption. Firms are weighted using weighted by value added.*
Questions: How many people does your company employ either full or part-time at all its locations, including yourself? How many people did your company employ either full or part-time at all its locations, three years ago?

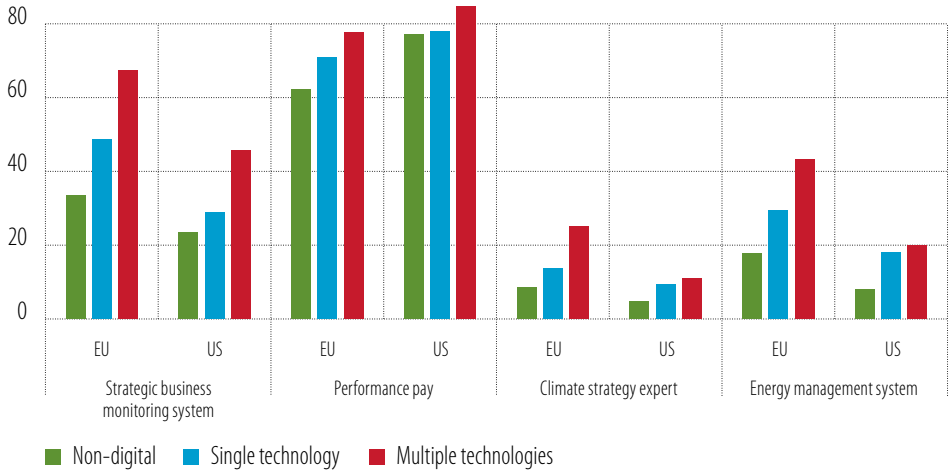
Digital firms tend to implement better management practices than non-digital firms. Digital firms use formal strategic business monitoring systems (with key performance indicators) more often than non-digital companies, both in the European Union and the United States (Figure 19). The effect is even larger for firms that have implemented multiple digital technologies. Digital companies also tend to reward individual performance with higher pay. In addition, they are more likely to have appointed a designated person responsible for defining and monitoring climate change strategies. Those firms report more frequently that they have set and are monitoring targets on carbon emissions and energy consumption.[17] This EIBIS-based evidence is in line with results from previous studies highlighting the importance of management practices for technology adoption and firm performance (Bloom et al., 2019). The European Union and its Member States need to create incentives for firms to improve their track record on environmental, social and corporate governance (ESG) metrics – an area where digital technologies may help firms monitor progress.

16 See also the discussion on digitalisation and skills in Chapter 10 of this report.

17 The positive associations between digital intensity and management practices also hold in regression analysis that controls for firm size as well as country and sector. In other words, this association is not driven by a firm size effect.

Figure 19

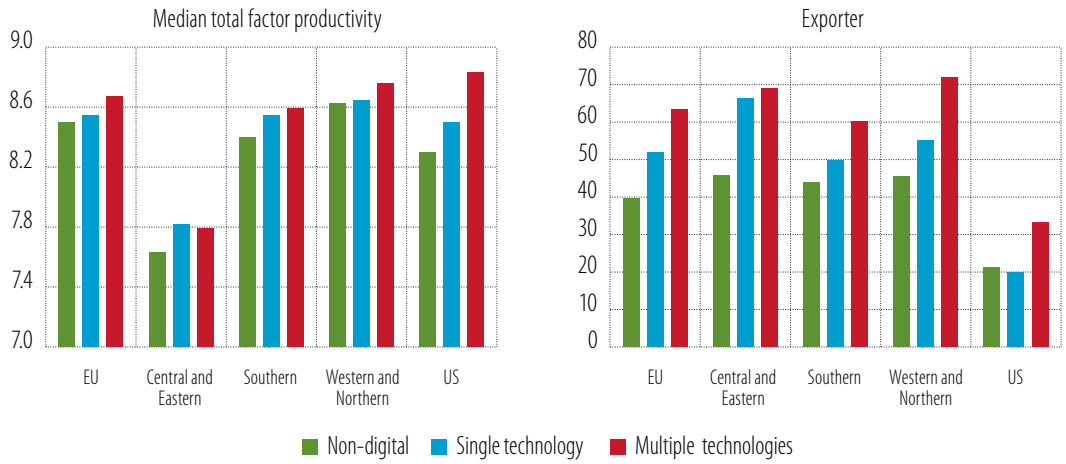
Management practices (in %)**, by digital intensity**



Source: *EIBIS 2020.*
Note: *See note to Figure 13 for the definition of digital adoption. Firms are weighted using value added.*
Question: *In 2019 and under normal conditions, did your company use a formal strategic business monitoring system; reward individual performance with higher pay; have a designated person responsible for defining and monitoring climate change strategies; set and monitor internal targets on carbon emissions and energy consumption?*

Figure 20

Total factor productivity (in logarithm)**, and exporting goods and services to another country** (in %)**, by digital intensity**

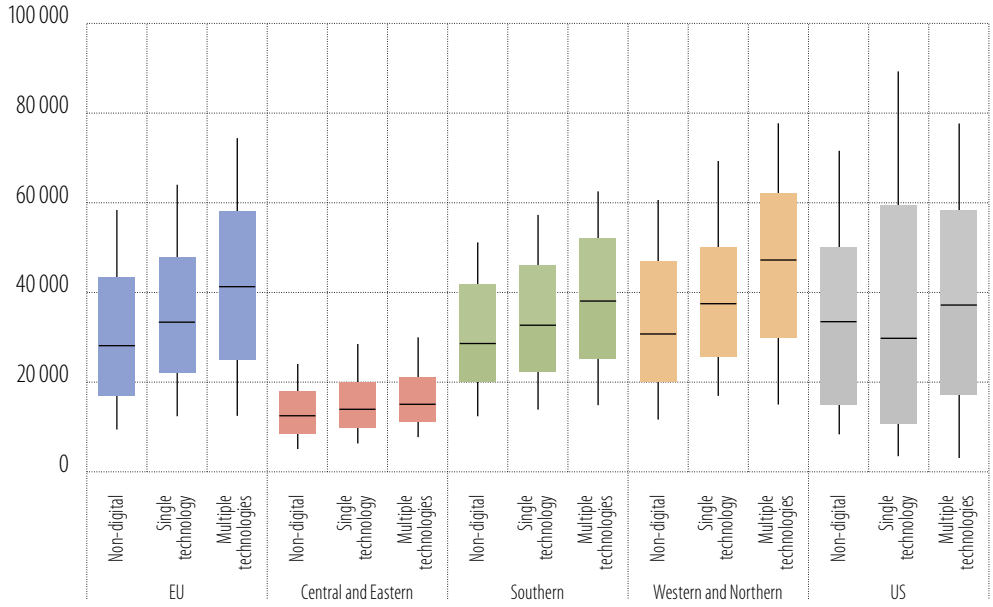


Source: *EIBIS 2020.*
Note: *See note to Figure 13 for the definition of digital adoption. Total factor productivity (TFP) is computed as the residual from ordinary least squares (OLS) regressions with value added as the dependent variable, and the value of fixed assets and the number of employees as explanatory variables. The regressions are estimated separately for different sectors, controlling for the interactions of country and year fixed effects. The figure (left panel) shows the median TFP for different categories. Firms are weighted weighted by value added.*
Question (right panel): In the previous financial year, has your company directly exported goods and services to another country?

Digital firms tend to be more productive and are more likely to export their products and services. Digital firms, especially firms that have implemented multiple digital technologies, have higher median labour productivity and higher median total factor productivity than non-digital firms, both in the European Union and in the United States (Figure 20). The effect is particularly pronounced for US firms. These results support previous empirical evidence on the positive effect of digital adoption – including the use of platform technologies in the services sector – on productivity in Europe and the United States (Falk and Hagsten, 2015; Bailin Rivares et al., 2019; Gal et al., 2019). Digital firms are also more likely to directly export goods and services to another country, which is in line with studies stressing that exporters tend to be more productive (Melitz and Redding, 2015).[18] Investing in digital technologies therefore appears to be especially relevant to these firms if they want to be able to compete in international markets.

Digital firms pay higher wages on average. Many economists argue that digital technologies – such as artificial intelligence, machine learning and industrial robots – have an impact on employment, wages, the demand for skills and job polarisation because of automation and skill-biased technological change (Acemoglu and Autor, 2011; Autor, 2015; EIB, 2018; Frank et al., 2019; Acemoglu and Restrepo, 2020). Analysis based on the EIBIS shows that firms that have adopted multiple technologies tend to pay higher wages (Figure 21). While digitalisation can disrupt employment and tasks, the jobs created by digital firms often appear to be relatively well paid. Compared to other regions, wages are lower in Central and Eastern Europe and the wage premium for digital firms is weaker. In addition, the distribution of wages tends to be wider for digital firms, especially in the United States, which may support the evidence of wage polarisation in the labour market.

Figure 21
Distribution of average wage per employee (in EUR)**, by digital intensity**

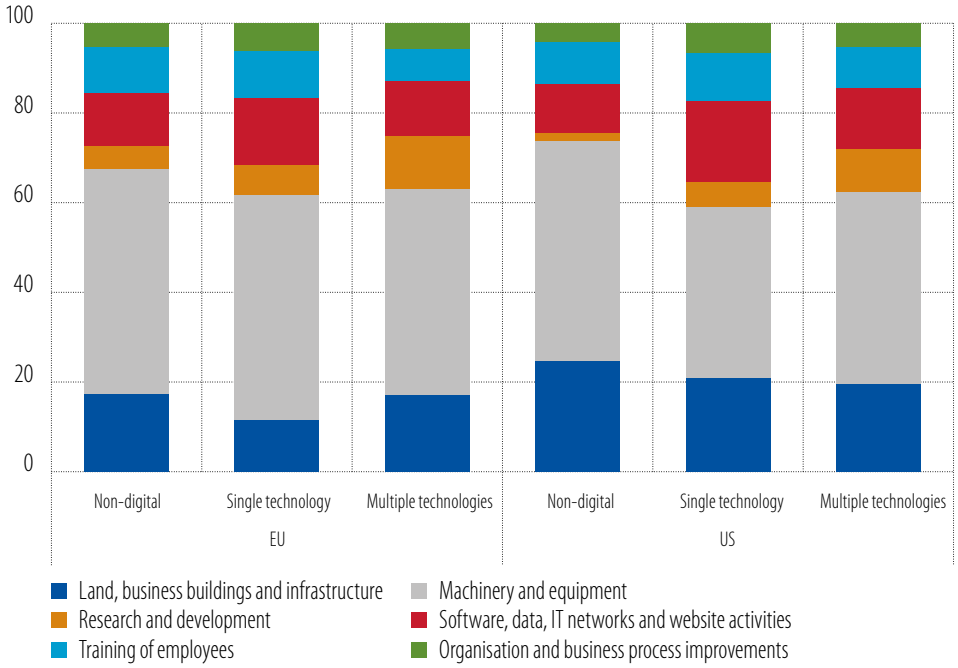


Source: *EIBIS 2020.*
Note: *See note to Figure 13 for the definition of digital adoption. The figure shows the 10th, 25th, 50th, 75th and 90th percentiles of the distribution of the average wage per employee. The average wage per employee is computed as the wage bill divided by the number of employees. Firms are weighted weighted by value added.*
Question: *How much did the company spend on wages in the previous financial year?*

18 In regression analysis that controls for firm size, country and sector, both total factor productivity and export status are positively associated with digital intensity.

Digital firms invest more in R&D than firms that are non-digital. The stronger focus on R&D (including the acquisition of intellectual property) is particularly pronounced for firms that have already implemented multiple technologies (Figure 22). In addition, digital firms tend to have higher investment intensity.[19] They also report having increased investment in the past year more often than non-digital firms.

Figure 22
Composition of investment (in %)**, by digital intensity**

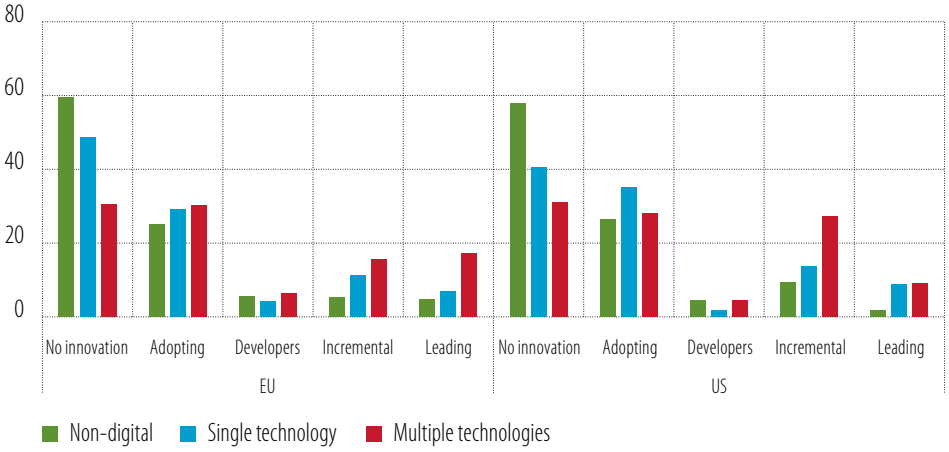


Source: *EIBIS 2020.*
Note: *See note to Figure 13 for the definition of digital adoption. Firms are weighted weighted by value added.*
Question: *In the previous financial year, how much did your business invest in each of the following with the intention of maintaining or increasing your company's future earnings?*

Firms that have implemented multiple digital technologies more often engage in innovation activities. The share of active innovators, either incremental innovators or leading innovators (such as firms that invest in R&D and introduce new products, processes and services, see Figure 11), is higher among adopters of multiple digital technologies (Figure 23). At the same time, non-digital firms are more likely to be firms that do not innovate – as they do not conduct any R&D and do not develop new products, processes or services. Big data analytics and artificial intelligence (AI) appear to be strongly linked to the innovation activities of digital firms. To make the most of these technologies, firms have to collect and analyse large amounts of information. Big data analytics or AI can thus act as a new enabler of the innovation process (Haskel and Westlake, 2017; Cockburn, Henderson and Stern, 2018).

19 The higher investment intensity of digital firms is also observed when zooming into sectors and size classes.

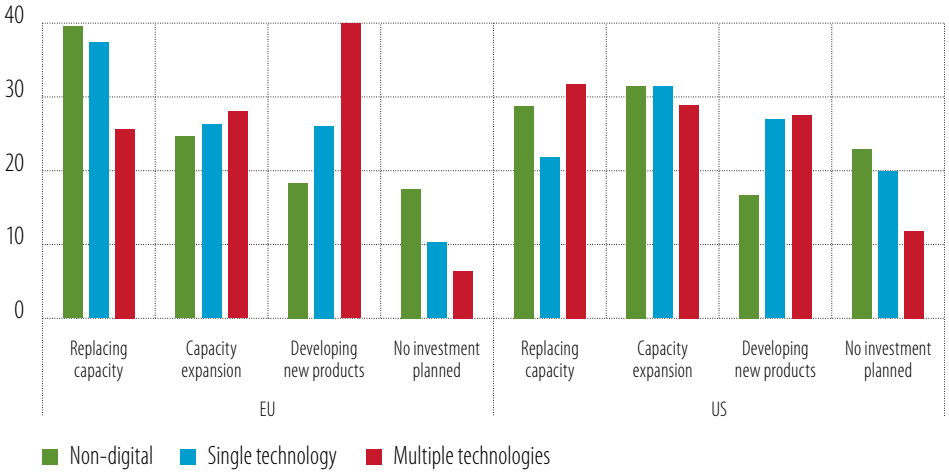
Figure 23
Innovation profiles (in %)**, by digital intensity**



Source: *EIBIS 2020.*
Note: *See Figure 11 for the definition of innovation profiles and note to Figure 13 for the definition of digital adoption. Firms are weighted using weighted by value added.*

Looking ahead to the next three years, the investment priority for digital firms is to develop new products, processes or services. Firms that have implemented multiple digital technologies more often report that they plan to invest (Figure 24). They also tend to have different investment priorities. For non-digital EU firms, replacing capacity (including existing buildings, machinery, equipment and IT) is more often mentioned as the investment priority for the next three years.

Figure 24
Investment priority over the next three years (in %)**, by digital intensity**



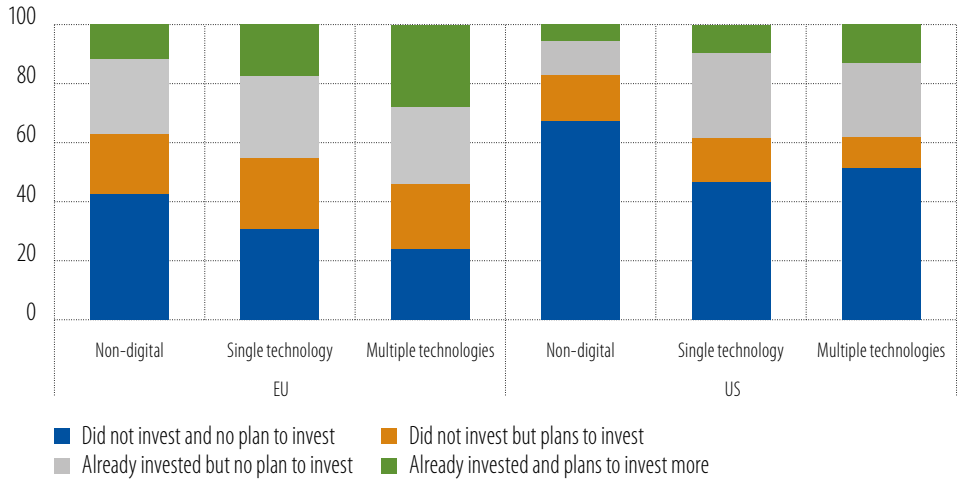
Source: *EIBIS 2020.*
Note: *See note to Figure 13 for the definition of digital adoption. Firms are weighted using value added.*
Question: *Looking ahead to the next three years, which of the following is your investment priority?*

Digital firms are also more likely to invest to meet the challenges of climate change, such as preparing for extreme weather events and reducing their carbon emissions. Firms with multiple technologies tend to report that they have plans to invest more in climate adaptation in the next three years (Figure 25). In addition, EU firms make green investments more often than US firms. These findings support the idea that

digital technologies can serve as critical enablers for attaining the goals of the European Green Deal. If used in the right way, emerging technologies could be critical to tackling today's environmental challenges. Examples of those technologies include smart urban mobility, precision agriculture, sustainable supply chains, environmental monitoring and better disaster alert systems. The potential of these digital tools needs to be unlocked if the European Union is to meet the Paris Agreement targets.

Figure 25

Investments to tackle the impact of weather events and to reduce carbon emissions (in %)**, by digital intensity**



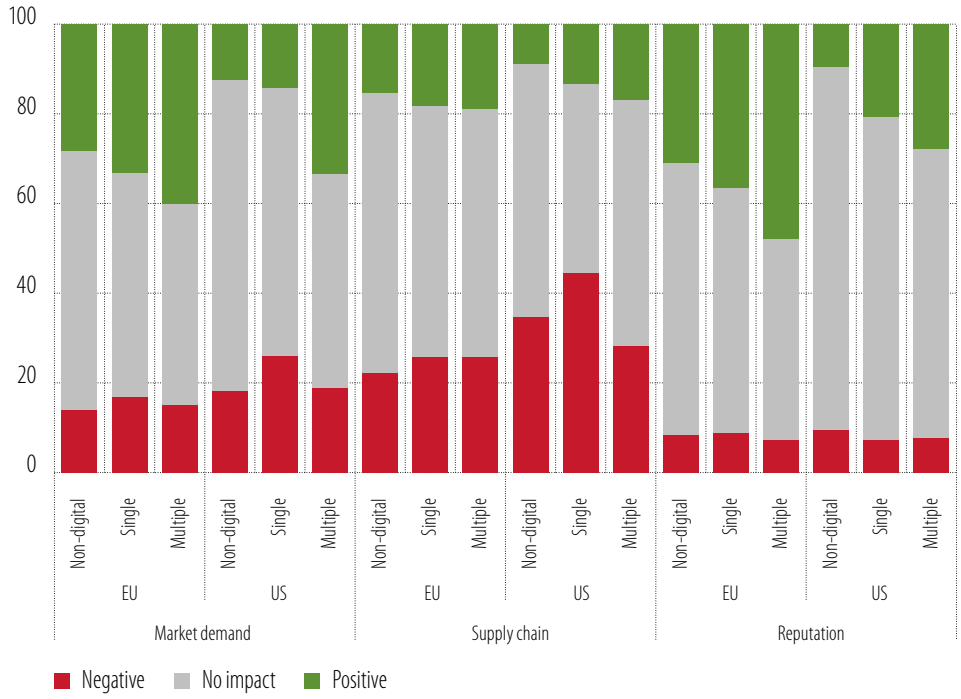
Source: *EIBIS 2020.*
Note: *See note to Figure 13 for the definition of digital adoption. Firms are weighted using value added.*
Question: *Thinking about investments to tackle the impacts of weather events and reduction in carbon emissions, which of the following applies?*

Digital firms are more prone to thinking that reducing carbon emissions will positively affect the market for their products and their reputation over the next five years. Limiting global warming requires a reduction of global carbon emissions over the coming decades. Digital firms, especially firms that have implemented multiple technologies, more often report that global efforts to reduce carbon emissions will positively impact their business in the next five years, increasing the market for their products and their reputation (Figure 26). Reducing global carbon emissions is expected to change demand for goods and services as consumer preferences shift in the medium term, according to firms that have already implemented digital technologies. Shareholders' and customers' climate concerns may also affect the reputation of some companies. Overall, this evidence is in line with the other findings, such as investments to tackle transition risks from climate change (Figure 25), where digital firms report more often that they already focused on green investments.

The digital transformation can support the transition to a low-emission economy, but action must be taken now. As outlined above, a shift in consumer preferences linked to a reduction in carbon emissions is expected to affect global supply chains and change demand for goods and services. However, the proliferation of cutting-edge technologies – such as advanced robotics, artificial intelligence, blockchain technology and 5G telecommunication – is contributing to rapidly growing energy consumption. Innovative businesses, policymakers and consumers need to come together to take responsibility for this complex issue, take timely action to successfully leverage digital technologies and enable the much-needed shift towards a circular economy, in line with the priorities of the European Green Deal.

Figure 26

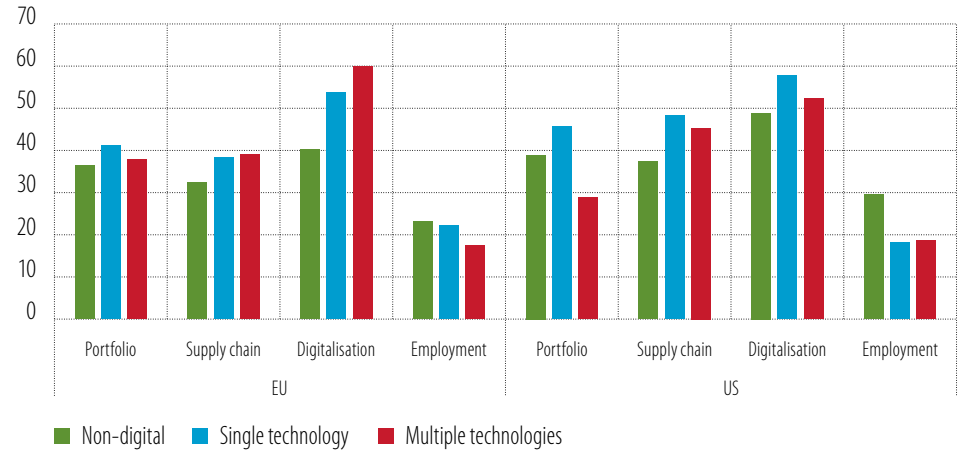
Impact of reducing global carbon emissions in the next five years (in %)**, by digital intensity**



Source: *EIBIS 2020.*
Note: *See note to Figure 13 for the definition of digital adoption. Firms are weighted using value added.*
Question: *What impact, if any, will this transition to a reduction in carbon emissions have on the following aspects of your business over the next five years? A positive impact, a negative impact, or no impact?*

Figure 27

Long-term impact of COVID-19 (in %)**, by digital intensity**



Source: *EIBIS 2020.*
Note: *See note to Figure 13 for the definition of digital adoption. Firms are weighted using value added.*
Question: *Do you expect the coronavirus outbreak to have a long-term impact on any of the following?*

Following the coronavirus pandemic, investment in digitalisation has become an urgent priority. The majority of digital firms expect digital technologies to become more important in the future. More than 57% of digital firms in the European Union and 55% in the United States expect digital technologies to gain importance in coming years, compared with 40% of non-digital firms in the European Union and 49% in the United States. The large share of non-digital firms that do not take the digital transformation seriously implies that the digital divide between firms may grow over time (Rückert, Veugelers and Weiss, 2020). Digitalisation may also further increase the market power of firms that are already in a privileged market situation, reinforcing the idea of winner-takes-all dynamics as a result of digital technologies (Gutiérrez and Philippon, 2017; Calligaris, Criscuolo and Marcolin, 2018; De Loecker, Eeckhout and Unger, 2020). In addition, digital firms report less often that the COVID-19 outbreak will lead to a permanent reduction in employment, especially in the United States.[20] When it comes to the expected long-term impact of COVID-19 on services, product portfolios, and supply chains, the responses of digital and non-digital firms are similar.

20 This result could also be driven by digital firms, which state more often that they intend to reduce investment, whereas non-digital firms state more often that they will not invest at all.

Conclusion and policy implications

Policymakers in the European Union should be concerned about the lack of investment in digital technologies by many EU firms, as the COVID-19 crisis is likely to exacerbate the digital divide. The European Union is not only lagging behind in digital innovation, but also in digital adoption, potentially jeopardising the long-term competitiveness of the European Union. A substantial share of EU firms are not implementing any digital technology and have no plans to start investing in digitalisation. Unprecedented changes in workforce arrangements make the crisis a unique opportunity to raise awareness and encourage non-digital firms to reassess their management strategies and to start taking digital transformation seriously – before it is too late. Effective policy implementation is especially needed since the COVID-19 crisis may exacerbate the digital divide between firms. The crisis may foster digital adoption rates, as some firms realise the benefits of implementing digital products, switching to robotic production, using internet of things applications or harnessing big data and artificial intelligence. On the other hand, firms that fail to innovate risk being left behind.

To address the long-term impact of COVID-19, the European Union will need to create better conditions for innovation and the digital transformation. To ensure that EU firms do not lose ground compared to their US peers, policymakers should strive to preserve a well-functioning, competitive and integrated EU market environment that will push firms to invest more in digitalisation. For example, EU members need to review regulations that prevent firms from growing and reaching the size needed for the successful adoption and integration of multiple technologies within their business. Policy action should develop measures to improve the digital skills of workers through training, and make it easier to finance investments in digital technologies.

Europe should aim to generate more new leaders in digital sectors and put pressure on leading companies to help push the technological frontier and foster the green transition. A weak European digital sector means that EU companies and citizens will lack ownership of their data, leaving the data to be controlled outside the European Union. It is also critical to support fast-growing small and young innovative firms, to counter winner-takes-all dynamics that can be caused by digital technologies. Supporting young firms requires improvements to competition, environmental, data and trade regulations, and the rapid implementation of the digital single market in the European Union.

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Chapter 8

Innovating for climate change: The green and digital twin transition

Developing new green technologies is crucial in the fight against climate change and covers more than innovations in the energy sector. Green innovation is an essential part of the decarbonisation effort, as many of the technologies needed in a net-zero emissions world are still far from mature. While energy systems are paramount to the transition, they are not the only way forward: materials, land use and many other fields are at least equally important. In addition, mitigating climate change cannot be the sole focus. Societies need to also focus on adaptation and creating a circular economy, along with other initiatives. Digital technologies are also frequently put forward as having enormous potential to address climate change.

The European Union is currently leading the way in combining the potential of green and digital technologies, despite its persistent lag in digital innovation and adoption. While the European Union's position is encouraging, other countries threaten to overtake it. Moreover, developing knowledge is one thing, but implementing it is just as important.

For the twin transition to be successful, the European Union needs to leverage its innovation, while also ensuring that knowledge is circulating among EU members and that technologies are being adopted more widely. Europe seems to diffuse knowledge relatively well compared to other regions. However, some successful practices and know-how remain stuck behind country borders.

For investment in both green and digital technologies, the corporate sector in Europe is well ahead of the United States. EU companies are investing heavily in these areas with plans to step up their spending even further in the coming years.

To move forward, the European Union should maintain the creation of green and digital innovations and actively support their diffusion. This is not just about creating a healthy policy mix to foster green innovation, but also about inclusiveness, reconfiguring markets and changing lifestyles and business practices. COVID-19 is also a potent reminder of the destruction a crisis can cause. Climate change, which has potentially even greater consequences, should be dealt with now. Otherwise, societies could find themselves jumping from one crisis into the next.

Introduction

New green technologies can help the European Union meet the demanding goals of its climate change agenda (World Meteorological Organization (WMO), 2020). As mentioned in previous chapters, climate action is needed now. Technical progress must be made in a variety of sectors, and green innovations can incorporate technologies from different fields, such as the digital sector. Investing in environmentally friendly technologies and supporting innovation in the private sector are clearly stated ambitions of the European Green Deal (European Commission, 2019). In addition, Europe's ambitions require a twin transition in which both green and digital technologies play a central role.

In this chapter, we combine data from a range of sources to assess where Europe stands in the twin transition of digital and green technologies. One major source is patent data taken from the PATSTAT database, which makes it possible to evaluate the development and spread of green and digital technologies. In addition, we use data from the EIB Investment Survey (EIBIS) to study the uptake of digital and green technologies by the corporate sector. Furthermore, to analyse the development of young firms in the energy and sustainability fields, we use data from Crunchbase, an online platform where newly launched companies around the world can present their businesses and current financing needs. Finally, we rely on a new data source, the EIB Online Survey on Environmental Innovations, which asks firms specifically about their different environmental innovations, the motivations and barriers and their views on current regulatory frameworks (for more information on the different data sources used, see Data annex).

The purpose of this chapter is to gauge Europe's position in climate and digitalisation innovation and to examine lessons from the past. The first section will map climate innovation patterns across different regions and technologies. In the second, we point out that although the European Union is lagging behind in purely digital innovation, it is at the forefront of developments in the areas where green and digital technologies meet. We also look at where the corporate sector stands. We conclude the chapter with a discussion of policy measures that can, in our view, help consolidate and further boost green and digital innovation in Europe.

The climate innovation landscape

The development and diffusion of technologies that generate environmental benefits are crucial for green growth. It is evident by now that the challenge of climate change cannot be tackled without technological advances (Aghion et al., 2019). However, investment in green technologies is generally considered to be below the socially optimal level. As with any other type of innovation, information asymmetries between firms and external suppliers of finance – along with the high risk that outside firms will ultimately benefit from innovation – can deter private investments in green innovation (Jaffe et al., 2005; Rodrik, 2014; Aghion et al., 2016).

Market prices might not take into account the environmental benefits associated with green technologies. The gap between market prices and the environmental benefit is specific to green innovation (Popp, 2019). Market prices, particularly in the context of misaligned carbon pricing, provide insufficient incentives for the development and uptake of innovations that lower emissions. Private-sector players cannot be expected to ignore their own bottom lines, and the imbalance is driving green investment below socially optimal levels. This section assesses how Europe measures up in climate innovation and proposes some hypotheses about why innovation in the energy sector has declined in the last decade.

Box A

Patent data as a measure of innovation activity

Patents grant the applicant exclusive rights to produce or use a specific new device, apparatus or process for a limited period. More specifically, the legal protection gives patent-holders the exclusive right to make, use, sell or import the patented invention for a set period of time, usually 20 years from the filing date, in the country or countries covered.

By providing protection and exclusivity, a patent encourages investment in research and the subsequent innovative work that will put those inventions to practical use. By providing temporary exclusivity on intellectual property, patents give their holders a competitive advantage. Patents can also be licensed or used to help create or finance a spin-off company. A patent holder, therefore, can derive value from the patent even if the holder is unable to manufacture the product (for instance, universities).

As such, patents reflect a country's inventive activity and its capacity to use and develop knowledge for potential economic gain. A patent filing also contains a wealth of technical information that can be useful for follow-up inventions. In addition, the elaborate and well-structured information stored in patent documents allows for systematic and objective quantitative analyses that can provide insights into technological progress. Indicators based on patent statistics are widely used to assess the inventive and innovative performance of a country or a region.

In addition to containing technical details about the innovation in question, patent applications also disclose material on prior inventions, such as any other relevant patents. While patent statistics can be used to measure innovation, statistics on patent citations can be used to assess the spread of knowledge and technology.

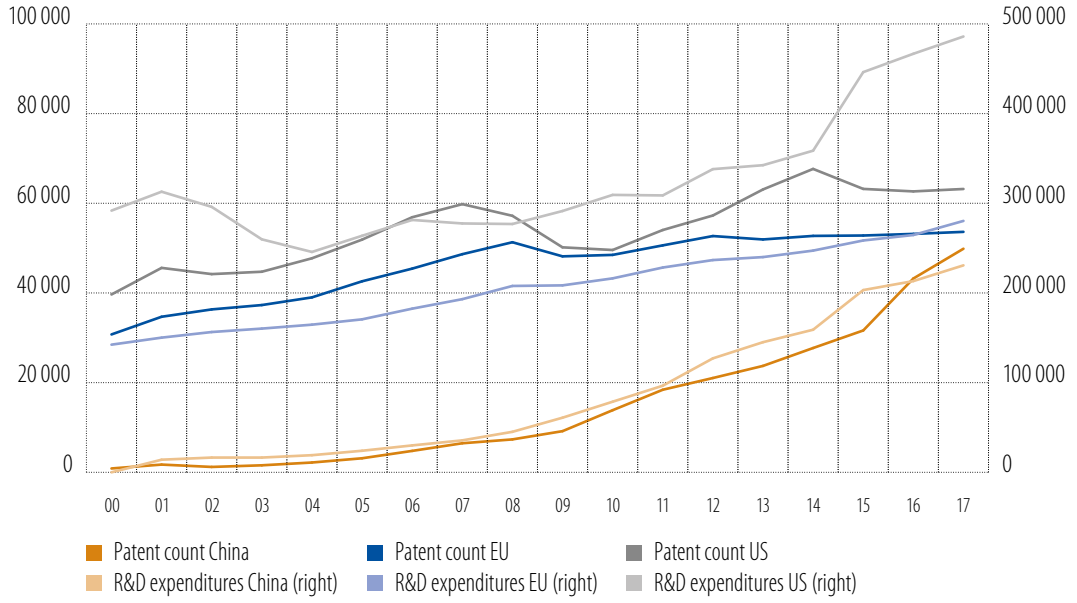
Nevertheless, some caveats exist for patent-based indicators. First of all, the propensity to patent varies by technological domain and region. Second, not all innovations are patented (for reasons of secrecy, for example), and not all patented inventions are innovative or even marketable products. At the same time, obtaining a patent does not necessarily mean the patented technology is important or has any commercial value. The value of patents varies widely. Lastly, part of the patent activity stems from strategic behaviour (such as blocking out or scaring off potential competitors) rather than innovative and valuable R&D efforts.

The patent data used in this chapter are sourced from PATSTAT (Worldwide PATent STATistical Database). PATSTAT is a patent statistics database held by the European Patent Office (EPO) and developed in cooperation with the World Intellectual Property Organisation (WIPO), the Organisation for Economic Co-operation and Development (OECD) and Eurostat. PATSTAT was founded in 2006 and concentrates on raw data, leaving licensed users to create indicators. PATSTAT's raw patent data are collected from more than 100 regional and national patent offices worldwide, including the most important and largest offices such as the EPO, the United States Patent and Trademark Office (USPTO), the WIPO, the Japanese Patent Office (JPO) and the Chinese Patent Office (SIPO). PATSTAT is a relational database: more than 20 related tables contain information on relevant dates (filing, publication, grant, etc.), applicants and inventors, technological domains, references to prior art, etc. The database is updated twice a year, in the spring and autumn. The data sourced for this chapter were produced in collaboration with the Centre for Research and Development Monitoring (ECOOM) in Belgium.

Where Europe stands in green innovation

The European Union is often criticised for being poor at creating knowledge, compared to other regions such as the United States, and for losing ground to China. Patent data, however, do not reflect badly on the European Union. The data referring to the number of absolute patents across all domains suggest that the European Union is still leading in volume, together with the United States, while China is rapidly catching up. This trend runs in parallel to R&D expenditure over time, confirming that patent data can be reliably used to measure R&D activities.

Figure 1
Patents and R&D expenditure over time, patent count (left axis) **and R&D expenditure** (million PPS at 2005 prices, right axis)



Source: *Authors' calculations based upon PATSTAT (PCT) data in collaboration with ECOOM and Eurostat data on intramural R&D expenditure (GERD).*
Note: *PPS stands for purchasing power standard.*

The European Union is responsible for the highest number of newly introduced green patents. The European Union is one of the main players in green patenting. It is closely followed by Japan, but well ahead of the United States and China (Figure 2). In 2017, the number of green patents by the European Union was almost 50% higher than the United States. As a share of the total portfolio, green patents in Europe were 70% higher than in the United States.

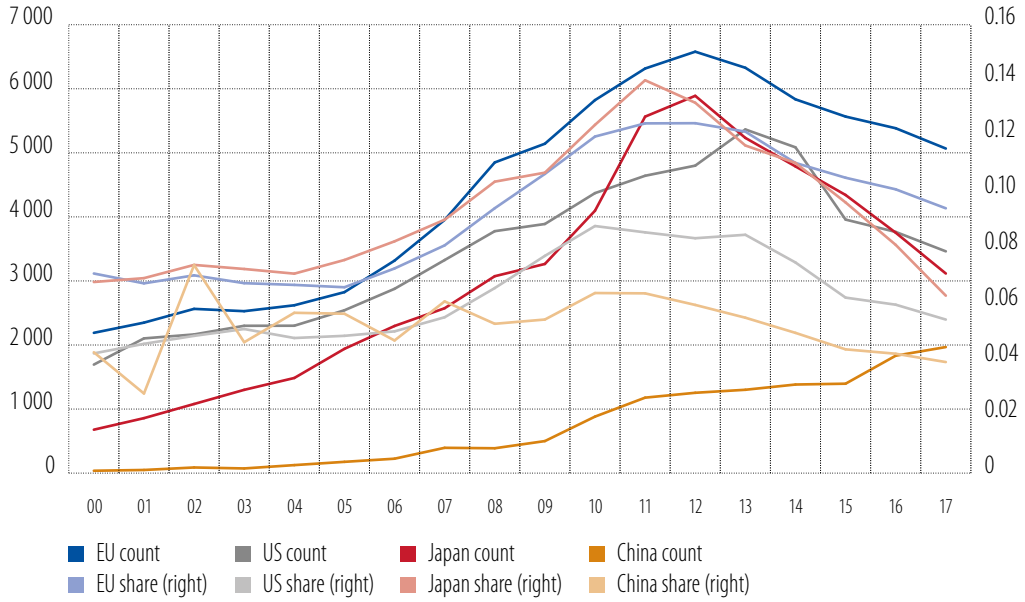
Within Europe, green patenting activities are mainly driven by countries in Northern and Western Europe. These countries hold more than 90% of all green patents in the European Union (Figure 3). Northern and Western Europe leads in absolute terms and in the number of patents as a share of Gross Domestic Product (GDP). Even though the number of green patents in Central and Eastern Europe and in Southern Europe is significantly lower than in Western and Northern Europe, the share of green patents in those regions' total patent portfolio is comparable to Western and Northern Europe.

Patenting in green technologies increased in most EU regions until early 2010, then started to decline (Figure 4). Green patenting reached its peak in the European Union, the United States and Japan around 2012, remaining relatively strong immediately after the global financial crisis and despite a stagnation in overall patent activity. After 2012, however, green patenting activities began to drop off. China followed

a different path, showing persistent growth, with a decline in the share of green patents relative to total patents only apparent in recent years.

Figure 2

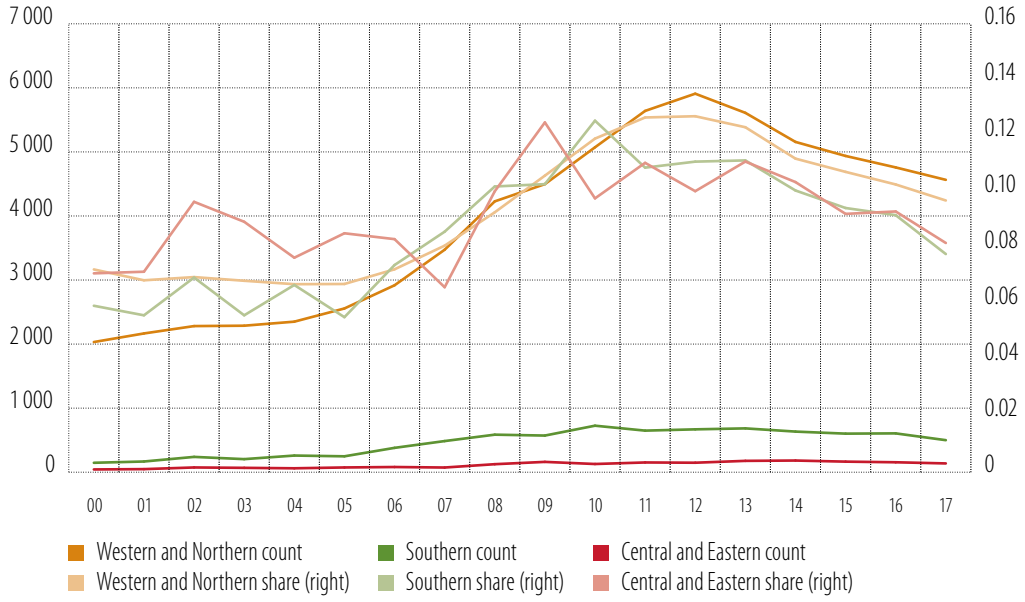
Green patents, patent count (left axis) **and share of green in total patent portfolio** (right axis)



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

Figure 3

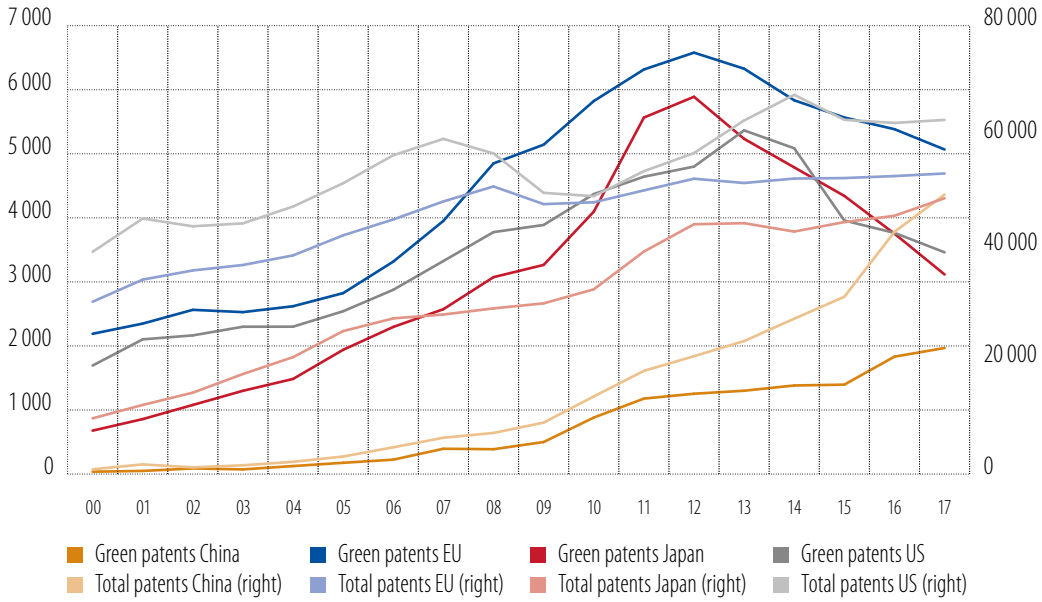
Green patents in Europe, patent count (left axis) **and share of green in total patent portfolio** (right axis)



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

Figure 4

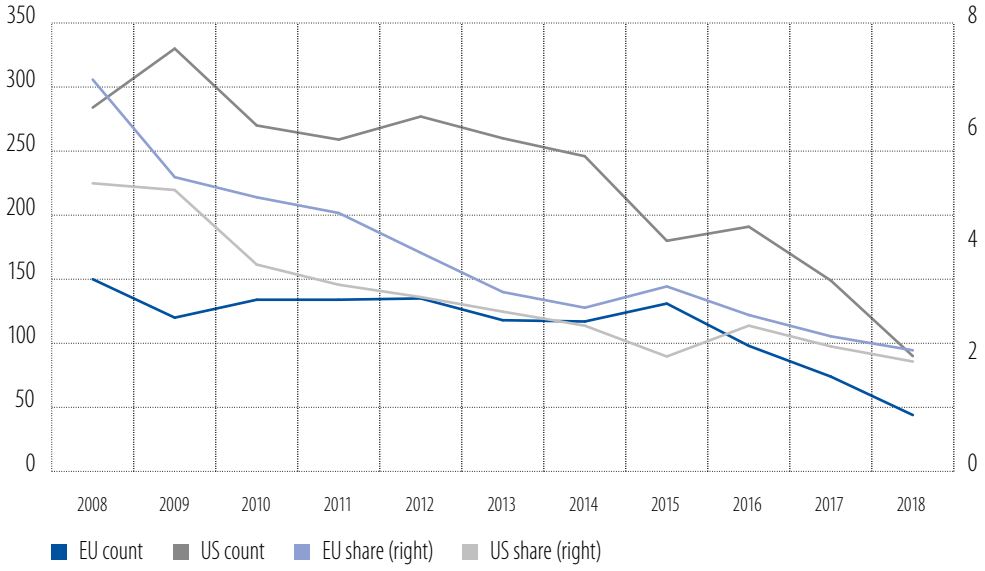
Green patents and total patents, green patent count (left axis) **and total patent count** (right axis)



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

Figure 5

Start-ups and scale-ups in the energy and sustainability sector, number of start-ups (left axis) **and share of total start-ups, %** (right axis)



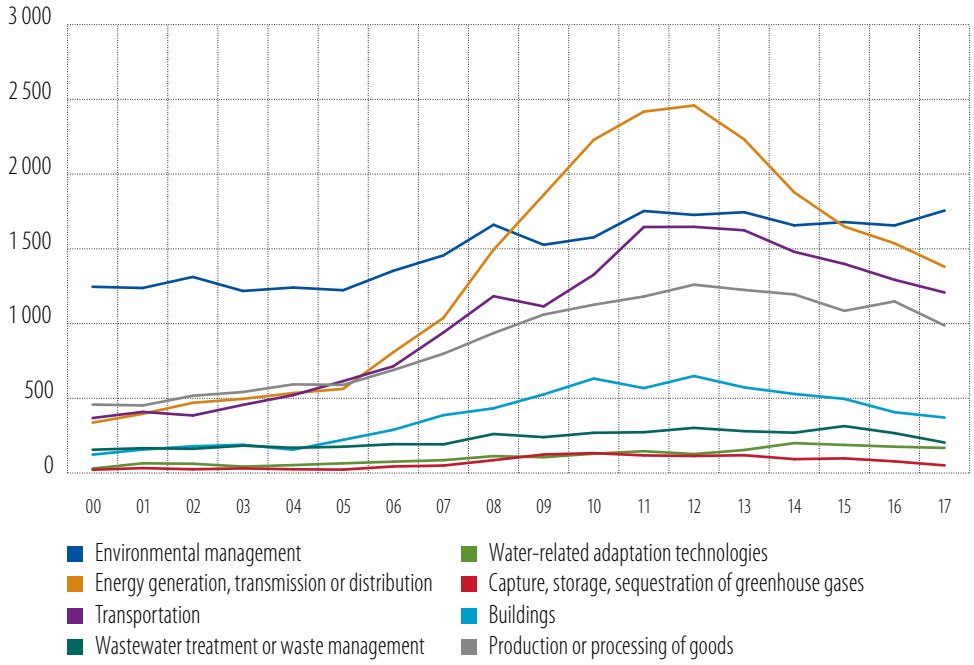
Source: *Crunchbase, authors' calculation.*
Base: *Firms founded from 2008 to 2018 that are still active.*
Note: *Start-ups self-reporting that they belong to the energy and sustainability sector.*

The decline in patenting activities since 2012 has gone hand-in-hand with a drop in the share of start-ups and scale-ups in the energy and sustainability sectors (Figure 5). The decline raises some questions, given that start-ups are important drivers of aggregate investment activities and significant carriers of innovation (Acemoglu et al., 2013; EIB, 2019). The EIB Online Survey on Environmental Innovations seems to support the idea that start-ups were contributing to the green transition with innovative solutions. The start-ups surveyed were more likely to say that the environmental changes they implemented are not only new to the company, but also to the country and the global market (50% of start-ups claim that their innovation is new to the world, compared with 19% of traditional firms). As green innovation is a core part of any successful green transition, we need to understand better what drove this slowdown.

The inverse U explained

Across all regions, the most recent slowdown in green patenting is mainly driven by innovations related to energy generation, transmission or distribution. Green patents are classified using eight different areas, which mostly cover different technologies to mitigate or adapt to climate change. The evolution of each area can be traced over time (Box B). While the relative share of energy patents was still fairly low in 2000, their number rose constantly until 2012. In the European Union, energy patents represented 40% of total green patents at around that time, before a decline set in (Figure 6).

Figure 6
Green innovation subdomains in the European Union, patent count



Source: *Authors' calculations based upon PATSTAT (PCT) data in collaboration with ECOOM.*
Note: *The different lines reflect the count of patents in the different subdomains of green patents.*

Energy generation, transmission and distribution are central to reducing carbon emissions, even though they are only part of the solution. It is therefore important to understand why we see this decline, in spite of a maintained strong discourse in favour of the technologies within that domain (International Energy Agency (IEA), 2020a).

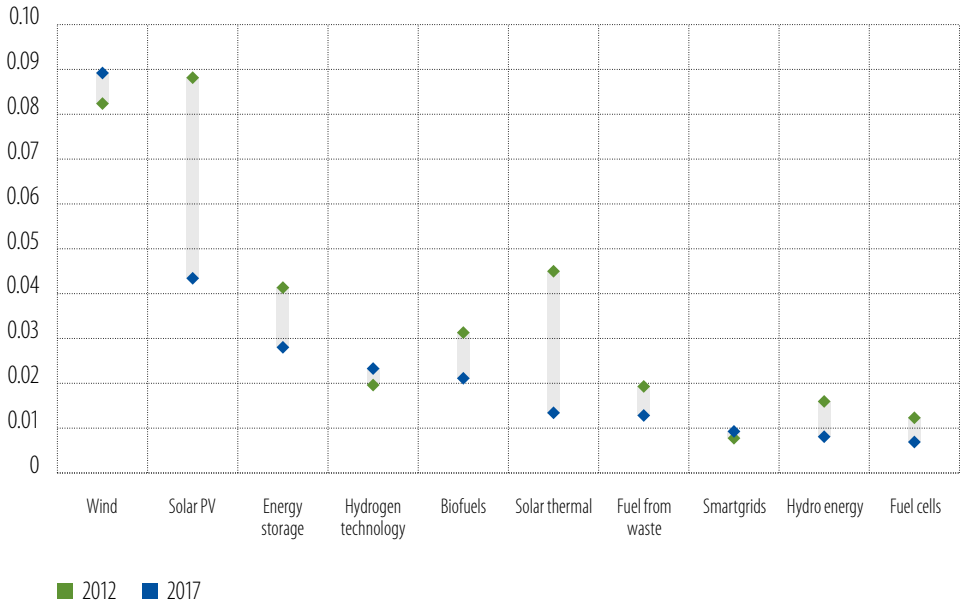
Several factors can explain the pattern of energy patents, such as technological developments outside Europe and technological maturity. Green innovation has not always been a priority, because of insufficient demand or a lack of technological advancement.

Innovation's natural life cycle

As technologies mature, the pace of innovation slows down. This is a well-known phenomenon, and not generally something to worry about (see the seminal paper of Teece, 1986). Once a dominant design becomes established, the effort devoted to innovation often decreases.

For solar photovoltaics (PV), the downward trend seems to be fully consistent with a technology entering its maturity stage. This is not the case for other technologies, however. In solar PV, costs came down as manufacturing increased, mainly in China, and the technology began to be rolled out. Overall, the focus shifted to marketing rather than innovation, and to China from Europe. Nevertheless, the slowdown in green innovation can also be seen in other segments in the energy sector (Figure 7). For most, the downtrend is less clearly attributable to the maturing of underlying technologies. Energy storage and hydrogen technology are good examples of areas considered very promising for carbon neutrality. Yet patenting has also dipped for these technologies, suggesting that European innovators are not responding to the potential.

Figure 7
Energy segments in the European Union, share of patents



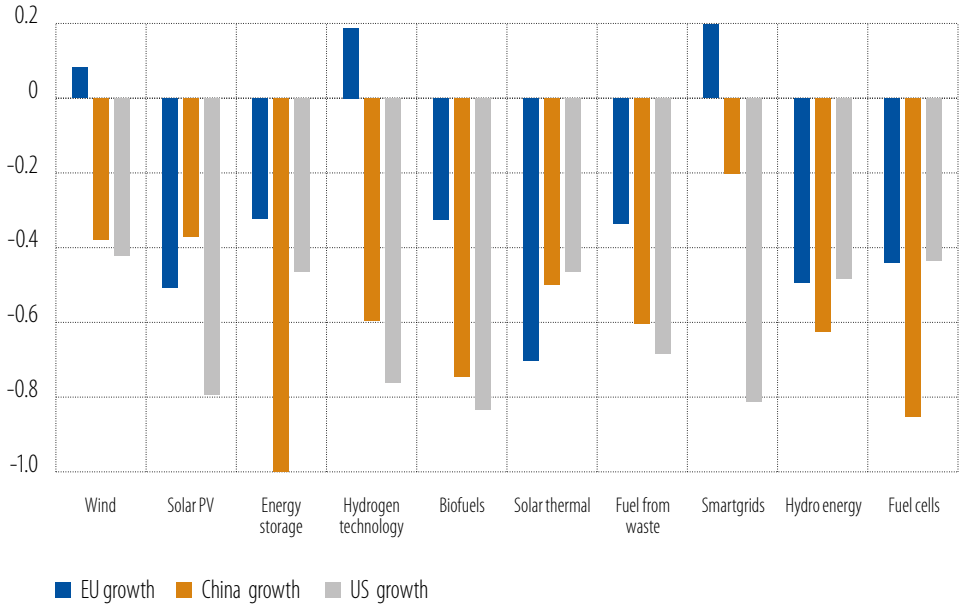
Source: *Authors' calculations based upon PATSTAT (PCT) data in collaboration with ECOOM.*
Note: *The different dots reflect the share of a certain energy segment in the total patent portfolio of the European Union over time (2012 vs. 2017).*

In addition, even for relatively mature technologies, follow-up innovations are necessary to accommodate for new circumstances. It seems that researchers decided against looking for new ways to improve these technologies, possibly because the market was over-crowded. However, if carbon neutrality is to be achieved, follow-up innovations remain highly relevant also in the mature sectors (IEA, 2020).

The decline in energy patents is a global phenomenon, with the European Union experiencing a relatively smaller decrease than other regions. For the majority of technologies, the decline in patent

applications in the United States and China is greater than in the European Union. In fact, the number of patents in the European Union has even increased in wind energy, hydrogen technology and smart grids. It is important that Europe maintains its competitive advantage in these different technologies, ensuring that the market does not shift to another region, as was the case with solar PV.

Figure 8
Evolution of energy segments by region, growth rate from 2012 to 2017



Source: *Authors' calculations based upon PATSTAT (PCT) data in collaboration with ECOOM.*
Note: *The different bars reflect the change in the share of a certain energy segment of the total patent portfolio in the different regions over time (from 2012 to 2017).*

Price incentives and difficulties in finding funding

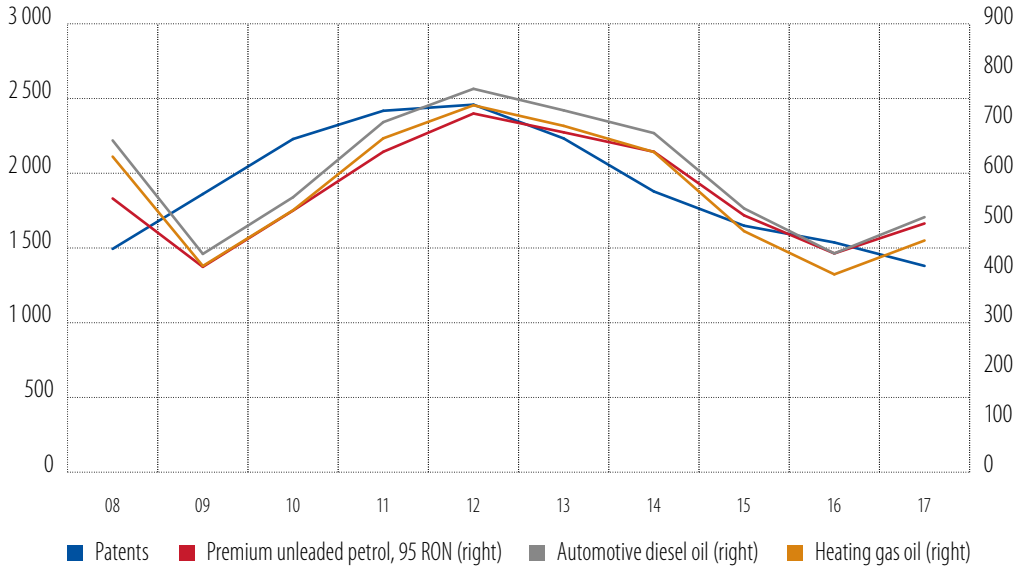
The decline in patenting activities occurred at the same time as the drop in fossil fuel prices (Figure 9). This suggests – at least from 2012 onwards – a very strong correlation between fossil fuel prices and energy patents. Higher prices are an incentive for finding new, alternative energy sources. However, if prices decline, market players have less to gain from making substantial investments in alternatives to fossil fuels. R&D investors will therefore have less reason to continue these developments, which makes it difficult for these technologies to become widespread (Popp, 2002; Verdolini and Galeotti, 2011). The market will feel less inclined to switch to alternative energy if the prices of conventional energy drop (Dechezleprêtre et al., 2019). Using patent data, Aghion et al. (2016) focused on the car industry, showing that higher fuel prices boost innovation in low-carbon technologies while curbing innovation in the high-carbon ones.

Recent developments, such as the widespread exploitation of shale gas, could hurt the climate in the long run. While shale gas decreases carbon emissions in the short run by encouraging a shift away from coal, a boom in this industry will presumably increase carbon emissions in the long term, given that shale investment has negatively affected research into clean technologies (Acemoglu et al., 2019).

Public policy is another crucial driver of low-carbon technologies (Johnstone et al., 2010), in particular in the heavily regulated energy sector. As explained above, R&D investments by the private sector are largely profit-motivated. If the technologies to be developed are not seen as adding value, most firms and investors will not sign up for what is, after all, a risky endeavour.

Figure 9

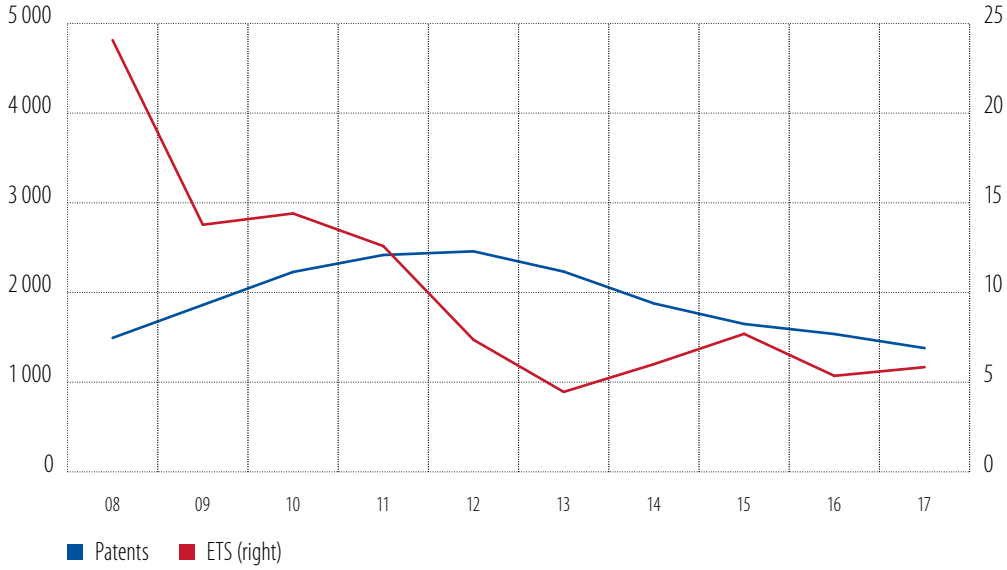
Energy patents in the European Union and fossil fuel prices, patent count (left axis) **and price of fossil fuels** (right axis)



Source: *Authors' calculations based upon PATSTAT (PCT) data in collaboration with ECOOM and fossil fuel prices as published by the European Commission via https://ec.europa.eu/energy/observatory/reports/.*
Note: *The figure presents the evolution of energy patents and fossil fuel prices.*

Figure 10

Energy patents and EU Emissions Trading System (ETS) prices, patent count (left axis) **and ETS price** (right axis)



Source: *Authors' calculations based upon PATSTAT (PCT) data in collaboration with ECOOM and carbon price data from EMBER (https://ember-climate.org/data/carbon-price-viewer/)*
Note: *The figure reflects the evolution of energy patents and the ETS price over time.*

Putting a price on carbon incentivises R&D investment in low-emission technologies. Europe saw a significant fall in carbon prices set by the EU Emissions Trading System (ETS) after the start of the global financial crisis in 2008 and again around 2011. Price declines of this magnitude reduce incentives for

investing in green innovations (Calel and Dechezleprêtre, 2016). Figure 10 seems to confirm that the drop in ETS prices was followed by reduced patent activity.

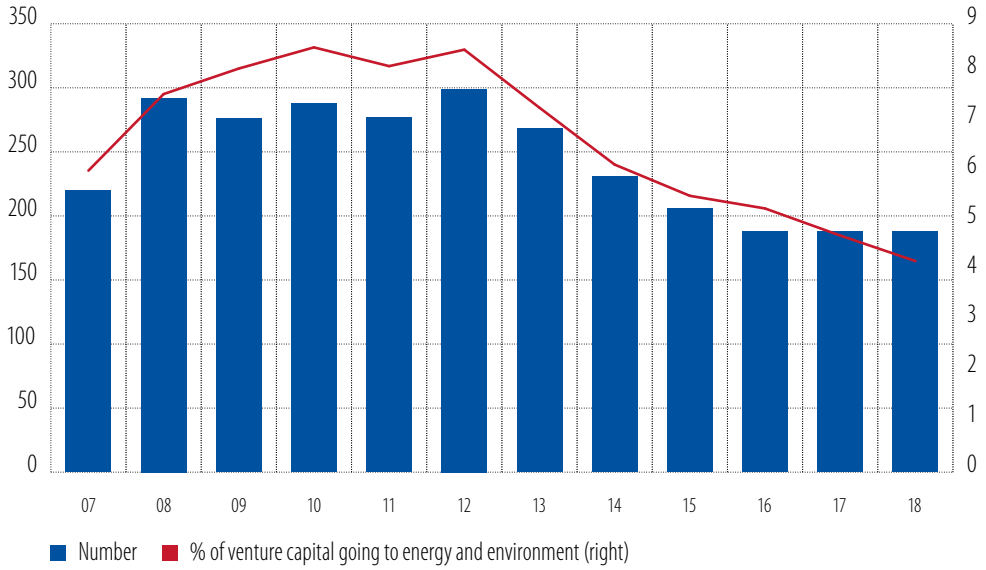
Nevertheless, trends in fossil fuel and ETS prices explain only part of the patent decline. Despite the financial crisis and a drop in fossil fuel prices, green patents continued to increase from 2000 to 2012 (Figure 1). Similarly, the decrease in ETS prices in the aftermath of the global financial crisis did not lead to a decline in green patenting activities.

Public policy intervention could be behind the counter-cyclical trend. The implementation of the EU Climate Change Package in 2008 can partly explain the uptick in energy patenting during the global financial crisis. This package of measures, which was introduced despite the dire economic outlook at the time, helped to establish the European Union as a major player in climate change. On top of the EU Climate Change Package, several countries – such as Germany and the Nordic countries – introduced targeted policies to lower emissions (Dechezleprêtre et al., 2019). These policies were later trimmed back, heightening uncertainty and suppressing innovation. Ko and Simons (2020) argue that subsidy cuts of this kind can affect innovation not only domestically, but also globally.

Even if firms devote resources to green technologies, finding funding for energy innovations – and climate innovation in general – could be challenging. Due to their novelty, the high risk of spillovers and the high sunk costs, energy and climate innovations often lack valuable collateral, hence the potential difficulties in securing the necessary financing. The often experimental nature of green innovations exacerbates this problem (Nordhaus, 2009; Rodrik, 2014; Popp, 2019).

Figure 11

Venture capital funding to firms in the energy and environment sectors, number of firms (left axis) **and share of venture capital** (in %) (right axis)



Source: *Invest Europe, authors' calculation (http://investeurope.eu).*
Note: *The figures reflect the number and share of firms (as a percentage of total firms) in the energy and environment sectors that received venture capital funding.*

In addition, the energy sector is plagued by a relatively high concentration of market power and the larger incumbent firms are aggravating the lack of finance for smaller firms. Incumbents that engage in innovation generally build up a good track record and therefore have more collateral to offer to external financiers (Czarnitzki & Hottenrott, 2009). These large firms may prevent smaller, innovative firms with breakthrough technologies from reaching the momentum needed to attract finance.

In addition, venture capital funding to start-ups and scale-ups active in energy and the environment seems to be decreasing. Figure 11 shows a decline in venture capital funding over time, both in absolute and relative terms. These funds are also often criticised for not investing with the sufficiently long horizon needed to support the transition (EIB, 2019).

The above explanations and the way they reinforce each other seem to underpin the inverse U-pattern of energy patents. The above findings suggest an interplay between a variety of issues, with none being a determining factor. Nevertheless, this pattern and its underlying factors are instrumental in defining the policies and actions needed to move forward. The end of this chapter looks more at this issue.

In addition, not only the creation, but also the diffusion of innovation is critical if Europe wants to remain at the forefront of green innovation. Green technologies, no matter how advanced they may be, are essentially useless if they are not widely adopted. Knowledge creation, and especially its circulation and exploitation, is crucial for growth in our knowledge-based economies (Griliches, 1998; Cockburn and Henderson, 1998). Even if the green energy technologies required to curb emissions exist, the obstacles to their diffusion hamper further development.

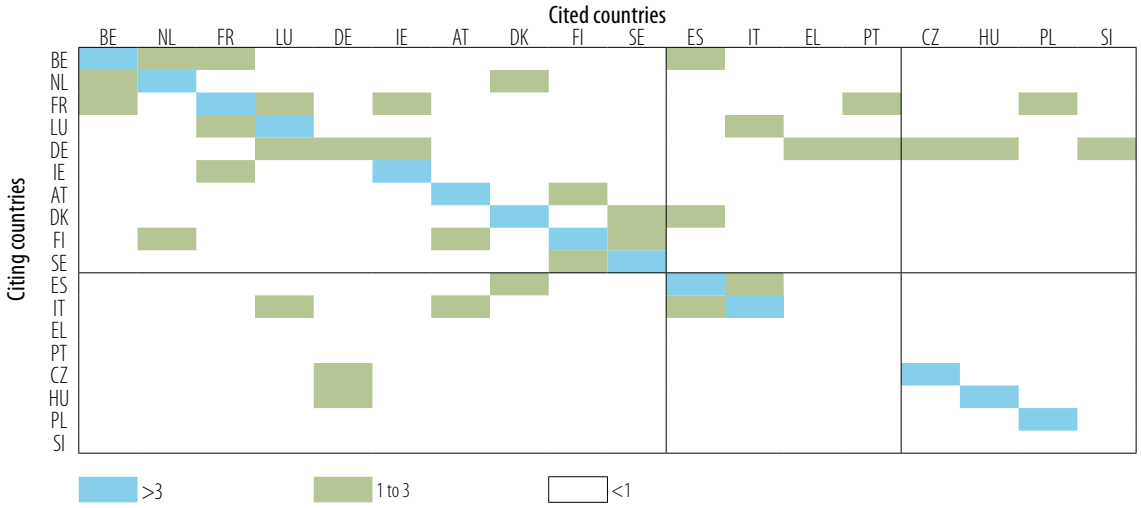
Diffusion of the green knowledge created by the European Union

Existing research suggests that low-carbon technologies are not diffused less than other technologies. Comparing low-carbon and high-carbon technologies to a range of other emerging technologies, Dechezleprêtre et al. (2017) find that the intensity of knowledge that spills over from low-carbon technologies is similar to that of other emerging technologies. Knowledge spillovers from high-carbon technologies, however, lag behind.

In green innovations, the strongest ties in terms of knowledge flows remain national. The cross-country citation index measures how often countries refer to one another in relative terms (known as citation intensity). It indicates that most green knowledge stays within national borders or regions (as shown in the diagonal cells in Figure 12, based on the relative intensities of the links between the countries citing patents and those being cited).

Figure 12

Cross-country green patent citations within the European Union



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

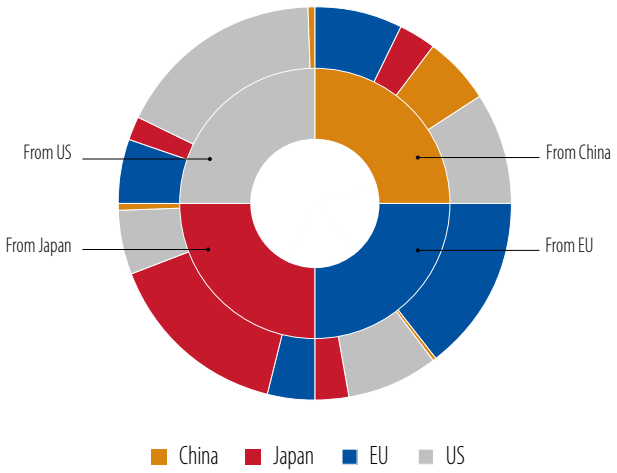
Note: *The figure shows the cross-country citation links for the different European countries.*

This index, $CCC_{ij} = \frac{\left(\#\text{cit of i to j} / \text{total \# cit of i}\right)}{\left(\#\text{cit to j}\right) / \left(\text{total \# cit}\right)}$ *represents the relative intensities of citations between citing country* i *and cited country* j.

Beyond national borders, the strongest ties are within Western and Northern Europe, and mainly between countries sharing borders. This finding is in line with the EIB's analysis (2019), which shows that geographical and technological barriers have a major impact on knowledge flows across countries. However, knowledge must circulate between different regions to ensure the greening of the economy on a global scale (Dechezleprêtre et al., 2017). While knowledge flows seem to strongly depend on national and regional ties, climate change remains a global problem, and more exchange is needed.

The home bias in knowledge flows is even greater in the United States than in Europe: 70% of citations for the United States remain within the country's own borders vs. only 47% of citations for the European Union (or 68% and 58% when focusing on the four main regions of comparison, as shown in Figure 13 below).

Figure 13
Green patent citation links across the European Union, Japan, the United States and China



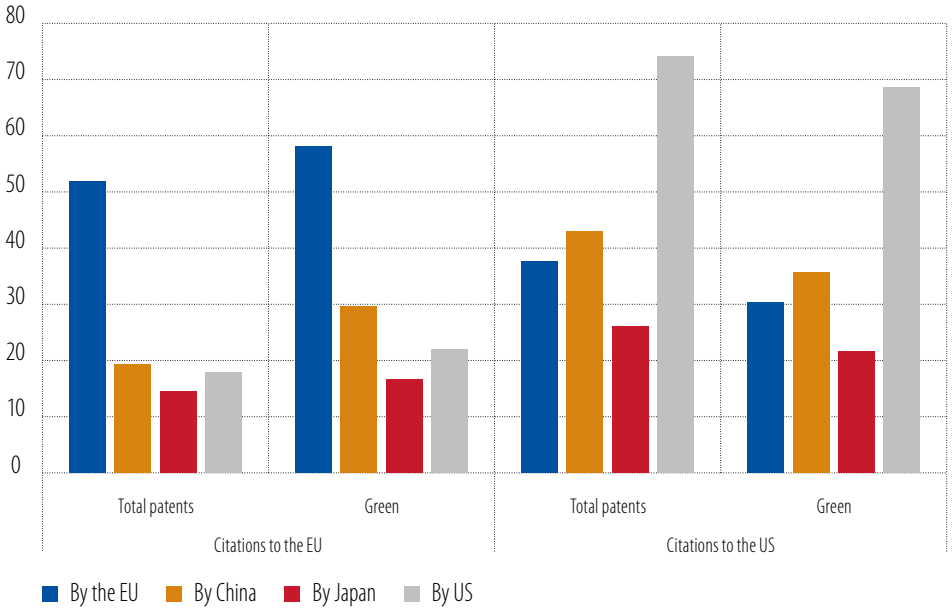
Source: *Authors' calculations based upon PATSTAT (PCT) data in collaboration with ECOOM.*
Note: *Share of total patent citations from a region to another region – not including any other citations of other regions.*

Globally, European patents represent a substantial source of new knowledge, confirming the value of the knowledge being created in the European Union. While Figure 13 confirms that most green patents are cited from within the home region, citations of EU patents account for a significant share of overall citations in all regions. In spite of this, citations of European green patents are not necessarily proportional to the amount of knowledge being created (see Figure 2), as the United States is also cited frequently.

Proportionally, green patents created by the European Union are more intensively cited than the total patent portfolio, unlike in the United States. Of all citations, green patents from the European Union attract more attention on a global scale (Figure 14). For the United States, the opposite picture emerges. US green patents do not receive an outsized number of citations from other regions compared to their overall patent portfolio.

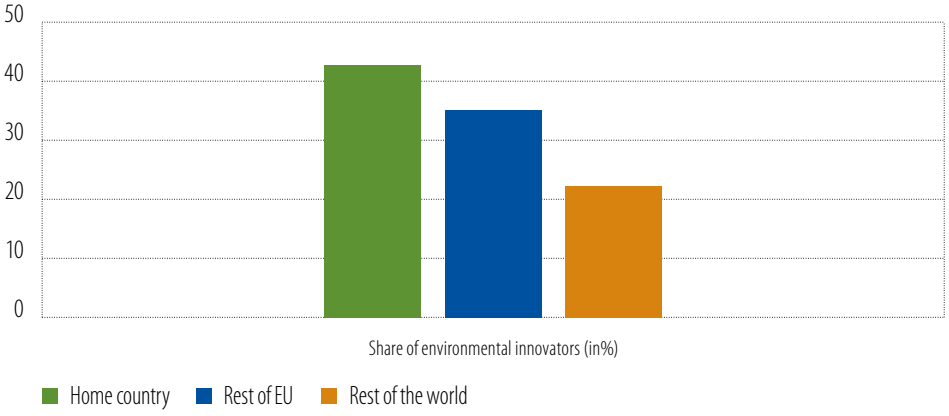
These observations are in line with the findings of the EIB Online Survey on Environmental Innovations, which also confirms that knowledge circulation largely remains within country boundaries. The EIB asked firms that recently introduced a green innovation whether they collaborated in the development, and if so, with whom. The results of this new survey reveal that most collaborations take place within the home country, another substantial share remains within EU borders, and slightly more than 20% of collaborations are with partners outside the European Union (Figure 15).

Figure 14
Share of citations overall and share of citations of green patents (in %)



Source: *Authors' calculations based upon PATSTAT (PCT) data in collaboration with ECOOM.*
Note: *The different bars reflect the share of a region's total citations of EU or US patents, for the total patent portfolio and for the green patent portfolio.*

Figure 15
Collaboration patterns of green innovators, share of environmental innovators (in %)



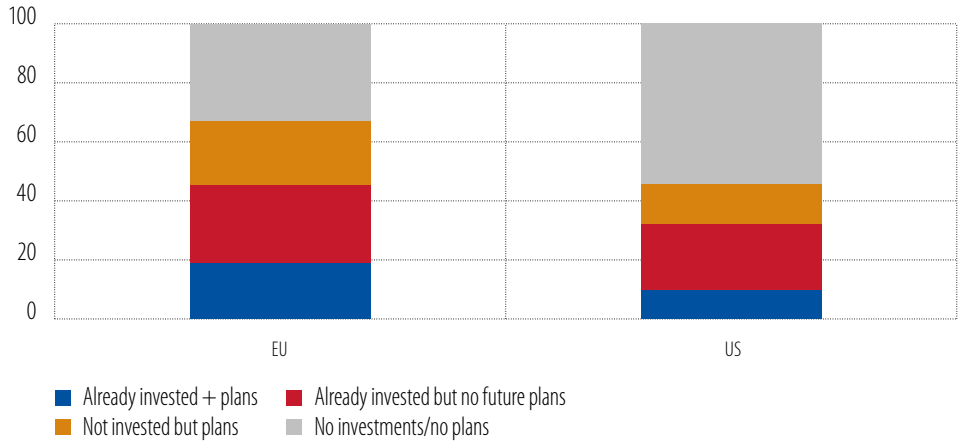
Source: *EIB Online Survey on Environmental Innovations.*
Base: *All green innovators.*
Question: *What type of organisation did your company collaborate with to develop these products, services or processes? For each, please indicate where the collaborators are located.*

While the diffusion of technological knowledge is crucial, the adoption of green innovations by other market players is at least as important. Knowledge that is developed and further diffused can only unleash its full potential if the related technologies are also adopted by users. The EIB Investment Survey allows us to examine this aspect from the angle of the corporate sector.

The adoption of green technologies by the corporate sector

Not only do European firms generate more green technologies than companies in other regions, they also invest more in tackling the effects of climate change than US firms. According to the latest results of the EIBIS, 45.3% of EU firms have already invested in confronting the impact of weather events and in contributing to the global reduction in carbon emissions, compared with 32.4% of US firms (Figure 16). In addition, the European Union clearly has a higher share of firms planning to make green investments over the next three years (including those that have already invested before and those that have not). Only 32.8% of European firms report that they have not yet invested and have no plans to do so, lower than the corresponding 50% in the United States.

Figure 16
Climate investment behaviour, share of firms (in %)

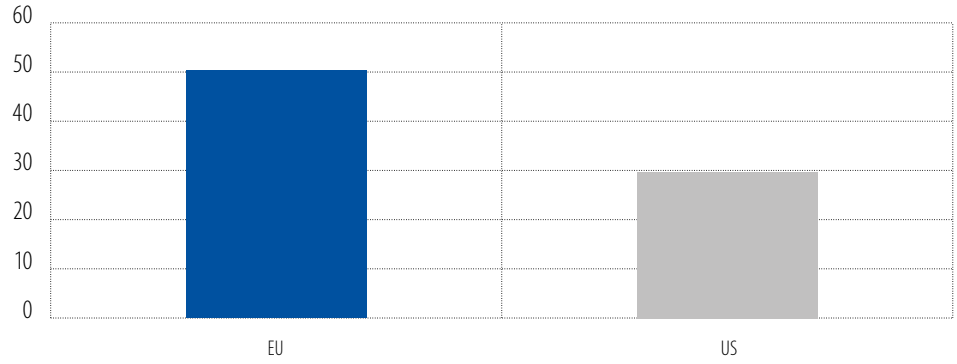


Source: *EIB Investment Survey (EIBIS 2020).*
Base: *All firms.*
Note: *Weighted by value added.*
Question: *Thinking about investments to tackle the impacts of weather events and reduction in carbon emissions, which of the following applies?*

Green innovators in the European Union are also more likely to introduce innovations that are new to the country or the global market than in the United States. The European Union has, on average, more firms that introduced a product, process or service that was new to the country or the global market in 2019 (Figure 17). This highlights the European Union's strong potential for developing or adopting green technologies, along with its solid foundation in ground-breaking innovations that can be further diffused. Ensuring all this valuable knowledge is passed on remains key.

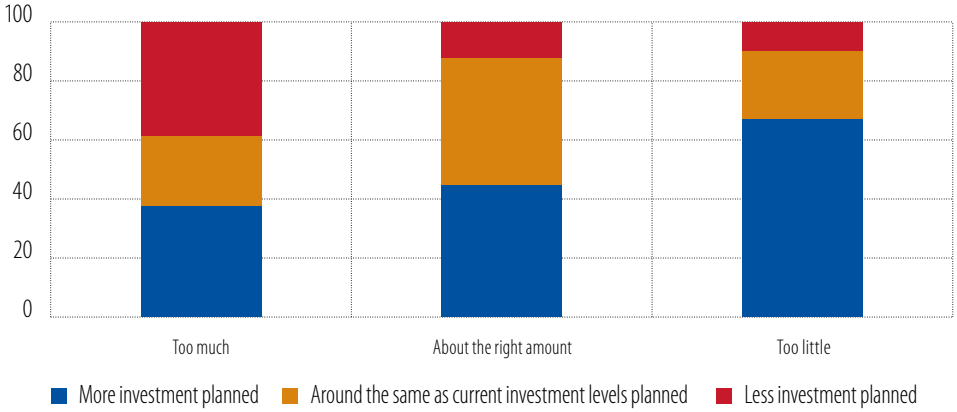
Firms investing in innovations with an environmental impact feel that these investments pay off and plan to increase them further. We asked firms participating in the EIB Online Survey on Environmental Innovations what impact "not investing" would have had on overall levels of sales. More firms responded that "not investing" would have had a negative impact than a positive impact (net balance of 14%). While 15% of firms said that they invested too much, 57% say that they invested about the right amount and 28% consider their investments to be too little. Looking ahead, all firms that invested in the past three years said they were planning to do so again in the next three years. Some rebalancing is to be expected: firms that feel they have underinvested in the recent past plan to invest more in the coming years, while those planning to invest less feel that they have already invested too much (Figure 18).

Figure 17
Innovativeness of green firms that are new to the country/world, as a share of green innovators (in %)



Source: *EIBIS 2020.*
Base: *Green innovators.*
Note: *Green innovators are defined as firms that invested in green technologies, and introduced a new product/process/service (in the firm, local or global market) and/or invested in R&D in the last financial year. Firms are weighted by value added.*
Question: *Were the new products, processes or services...new to the country / company / global market?*

Figure 18
Investment assessment and outlook of environmental innovators, share of environmental innovators (in %)



Source: *EIB Online Survey on Environmental Innovations.*
Base: *All environmental innovators.*
Question: *Q: In terms of the investment you already made in products, services or processes to generate environmental benefits, was the investment too much, too little, or about the right amount to ensure the success of your business going forward?*
Q: Looking ahead to the next three years, do you expect your company to invest more, less, or around the same amount compared to current levels?

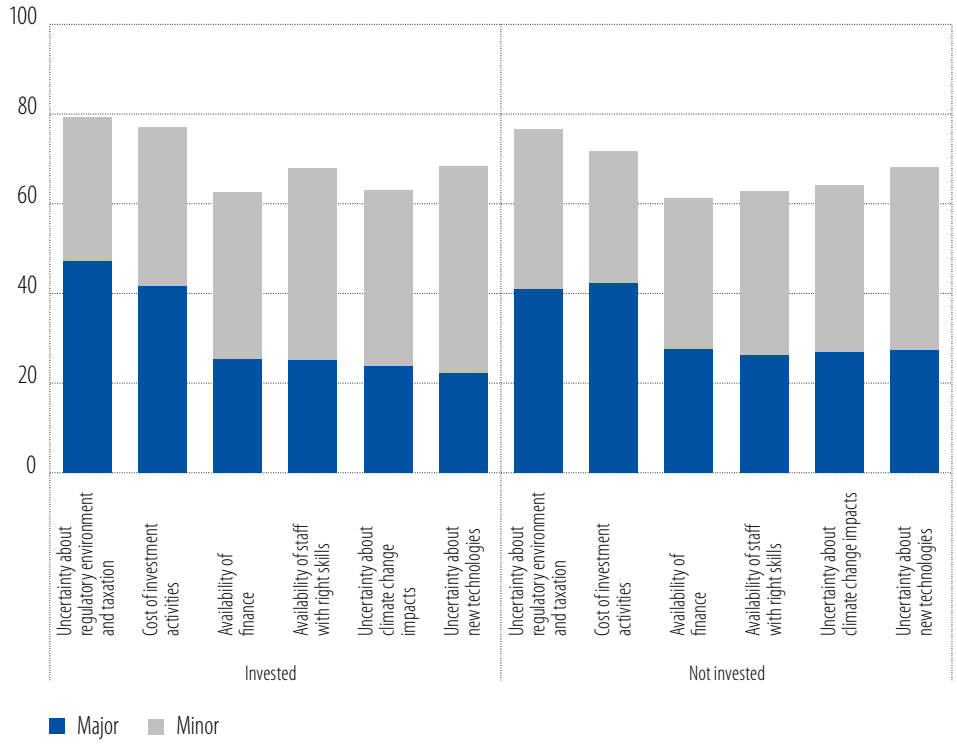
What now: Turning the tide or turning the page?

Europe is in pole position on green technology, but it has to decide where to go from here. How can we continue to ensure that companies develop green technologies and diffuse their knowledge, and that this knowledge will be adopted by different market players? In addition, what direction should the green transition take and what technological opportunities should be further explored?

Overall, the findings suggest that Europe is leading the way in green technologies, and a lot of potential exists for the diffusion and adoption of the knowledge it has created. In addition, the observed inverse U effect is mainly driven by the energy sector and can be largely attributed to policy design, which was a factor in the contra-cyclical uptick before and after the global financial crisis.

The uncertainty about the regulatory environment and taxation remain the main barriers to green investments by innovative firms. Furthermore, the cost of investment activities seems to be a major impediment, especially in the European Union (Figure 19). It is worth noting that the availability of financing is frequently mentioned by EU innovators as a major obstacle. Those willing to invest appear to face difficulties in finding the necessary funds for their plans. Overall, both green innovators and innovators that have not yet invested in green technologies see many barriers. Strikingly, the share of EU innovators that perceive obstacles to green investments is the same as those that have not yet invested.

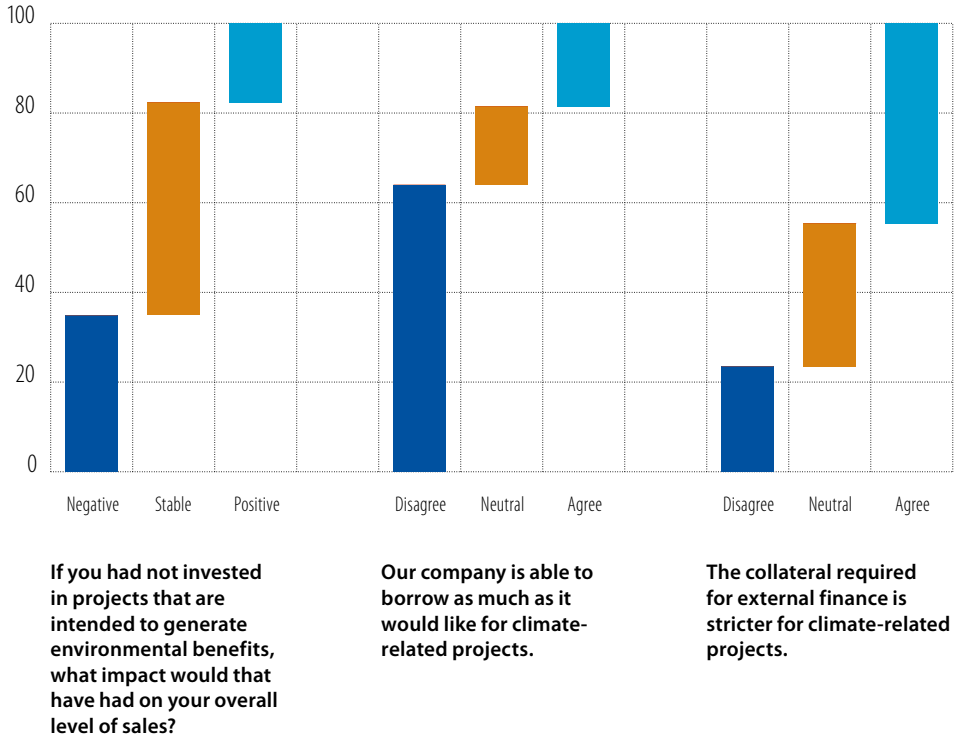
Figure 19
Obstacles to green investment for innovative firms, share of innovators (in %)



Source: *EIBIS 2020.*
Base: *Innovators.*
Note: *Innovators are defined as firms that introduced a new product/process/service (in the firm or the local or global market) and/or invested in R&D in the last financial year. Firms weighted by value added.*
Question: *And to what extent, if at all, is each of the following an obstacle to investing in activities to tackle the impacts of weather events and contribute to emissions reduction?*

In addition, firms are experiencing difficulties in borrowing for climate-related projects and feel that the collateral required is stricter for these projects. More than 60% of firms say that they were not able to borrow as much as they would like for climate-related projects and more than 40% say that the collateral required for external finance is stricter for this type of project (Figure 20). This is striking, given that most firms indicate that they experience no negative impact on sales after investing in environmental innovations.

Figure 20
Impact of investing in environmental innovations and financing constraints, share of environmental innovators (in %)



Source: *EIB Online Survey on Environmental Innovations.*
Base: *All environmental innovators.*
Question: *Q: If you had not invested in projects that are intended to generate environmental benefits, what impact would that have had on your overall level of sales?*
Q: For any investments your company has made in projects intended to generate environmental benefits, to what extent do you agree or disagree with the following?

The challenges point to the need for a clear regulatory environment and a better framework for green innovations, as well as greater financial incentives to overcome the high costs. Support is not only needed for firms that have already invested, it is also crucial for providing incentives to those that have not yet invested. The market-failure arguments outlined above seem to be particularly true in Europe, where a large share of firms complain about the high costs of investments and a lack of financing.

The discussion on fighting climate change focuses primarily on modifying energy systems, but other factors such as materials and land use are also important (Intergovernmental Panel on Climate Change (IPCC), 2018). Steel, cement, aluminium and plastics are some of the materials that make up a large share of carbon emissions and demand for them is increasing rapidly. Another example is the transport sector, which still accounts for 24% of direct carbon emissions from fuel combustion (IEA, 2020b). Several technologies need to be developed to support the transformation of the transport sector.

In this context, digital technologies are seen as having enormous potential. As pointed out by the International Energy Agency (2017), this potential can only be leveraged if there are sufficient incentives for public and private investment in new technologies. Nevertheless, digital improvements could already trigger major changes in traditional sectors (Branstetter et al., 2019), potentially ushering in a new era of technology (Ghobakhloo, 2020).

Box B

Patent data as a measurement of green and digital innovations

Throughout Chapter 8, patent data are used to measure innovation in the green and digital domains. The indicators used in the European Green Deal are broadly based upon the methodology of Haščič and Migotto (2015) for the green aspects and the EPO (2017) for the digital components.

This box provides a brief but comprehensive overview of how these indicators are built to help readers better understand the issues covered.

Green innovation

The green patent classification can be broadly split into two main categories: (1) patents that directly target climate change mitigation technologies; and (2) patents covering technologies that contribute to the issues of climate change indirectly, namely environmental management (air and water pollution, waste disposal, etc.) as well as those directed at adaptation to water scarcity. A breakdown of these different technologies is shown in the table below. When referring to green patents, the report considers all of these technologies. Nevertheless, where relevant, individual subdomains are discussed and presented.

Table B.1

	Including
Environmental management	Air pollution abatement; water pollution abatement; waste management; soil remediation; environmental monitoring
Water-related adaptation technologies	Demand-side technologies (water conservation); supply-side technologies (water availability)
Climate change mitigation	
Energy generation, transmission or distribution	Renewable energy generation; energy generation from fuels of non-fossil origin; combustion technologies with mitigation potential
Capture, storage, sequestration or disposal of greenhouse gases	Carbon capture or storage; capture or disposal of greenhouse gases other than carbon dioxide
Transportation	Road, rail, air, maritime transport; enabling technologies in transport such as electric vehicle charging and application of fuel cell and hydrogen technology to transportation
Buildings	Integration of renewable energy sources; energy efficiency such as lighting, heating, home appliances; thermal performance
Wastewater treatment or waste management	Wastewater treatment; solid waste management
Production or processing of goods	Metal processing; climate mitigation technologies in, amongst others, chemical industry, oil refining and petrochemical industry, minerals and cement, agriculture, livestock or agrifood industries

Digital innovation

The digital patent classification used in this report is based upon a classification of industry 4.0, published by the EPO. This classification identifies three broad categories of patents, each of which is further subdivided into specific technology domains. The resulting cartography aims to capture the buildings blocks of industry 4.0, at least in terms of patent applications. The tables below give an overview of the different domains and their sub-technologies, as also presented by the EPO (2017).

The three main sectors identified in the classification are "core technologies," "enabling technologies" and "application domains." Core technologies are considered to be the basic building blocks upon which the technologies of the fourth industrial revolution are built. This class consists of inventions that contribute to three of the established fields of information and communications technology (ICT) inherited from the previous industrial revolution.

Table B.2

Core technologies	Including
Hardware	Sensors; advanced memories; processors
Software	Intelligent cloud storage and computing structures; adaptive databases; mobile operating systems; virtualisation
Connectivity	Network protocols for massively connected devices; adaptive wireless data systems

The second domain captures enabling technologies. These are technologies that are further built upon and complement the core technologies. The EPO subdivides this second domain into seven technology fields.

Table B.3

Enabling technologies	Including
Analytics	Diagnostic systems for massive data
User interfaces	Virtual reality; information display in eyewear
3D support systems	3D printers and scanners for parts manufacture; automated 3D design and simulation
Artificial intelligence	Machine learning; neural networks
Position determination	Enhanced GPS; device-to-device relative and absolute positioning
Power supply	Situation-aware charging systems; shared power transmission objectives
Security	Adaptive security systems; intelligent safety systems

The third "application" domain captures technologies that are closest to the market and reflect the final applications of digital technologies. This domain is subdivided into six different sectors of applications to indicate in which part of the economy the various technologies can potentially add value.

Table B.4

Application domain	Including
Personal	Personal health monitoring devices; smart wearables; entertainment devices
Home	Smart homes; alarm systems; intelligent lighting and heating; consumer robotics
Vehicles	Autonomous driving; vehicle fleet navigation devices
Enterprise	Intelligent retail and healthcare systems; autonomous office systems; smart offices; agriculture
Manufacture	Smart factories; intelligent robotics; energy saving
Infrastructure	Intelligent energy distribution networks; intelligent transport networks; intelligent lighting and heating systems

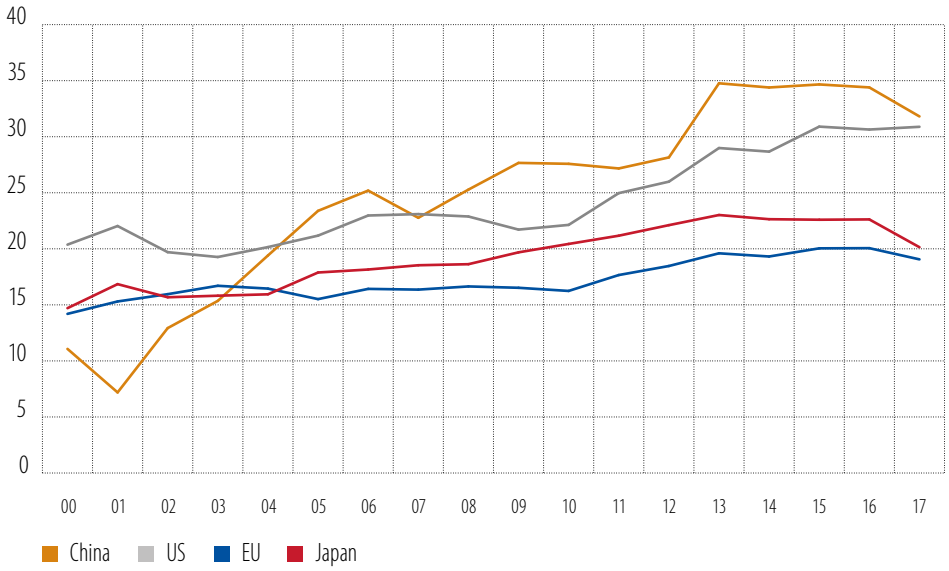
Depending on the focus of the different parts of the chapter, we use different levels of aggregation. When referring to digital patents, we refer to all patents belonging to one of the three main domains of industry 4.0. In some other cases, we break indicators down into the three main classes, namely core technologies, enabling technologies and application domains. Only rarely and in some specific settings do we zoom in on some of the subdomains of these three building blocks of digital patents.

The crossroads between green and digital technologies

Where Europe stands in digital innovation

While Europe is at the forefront of green technologies, its position in digital adoption or innovation is less encouraging. Not only are digital adoption rates of European firms lower than those of their US counterparts (see Chapter 4 for a detailed analysis), innovation in digitalisation is also lower. Patent data reveal that Europe is lagging behind both the United States and China for patent applications relevant to industry 4.0 (Figure 21). Whereas the share of digital patents in the total patent portfolio has remained relatively stable in Europe since 2013, the share in the United States has increased, widening the gap between both regions. Another point is that Europe and China had a similar share of digital patents in their overall portfolios around 2003. Since then, China has managed to double this percentage, whereas it has increased only slightly in Europe. The share of start-ups mentioning artificial intelligence in their description paints a more optimistic picture (Figure 22).

Figure 21
Share of digital patents in total patent portfolio, share of patents (in %)

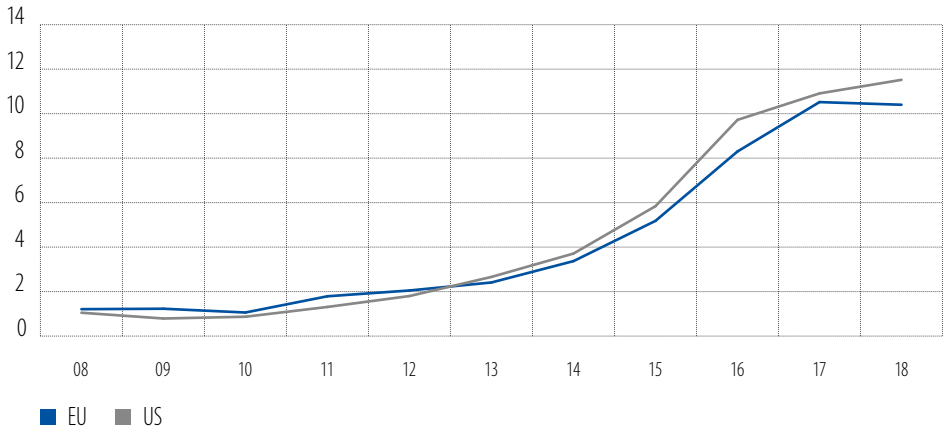


Source: *Authors' calculations based upon PATSTAT (PCT) data in collaboration with ECOOM.*
Note: *The different lines reflect the share of digital patents in the total patent portfolios for the respective regions.*

Also in digital patent citations, Europe is losing its competitive advantage to the United States. In the early 2000s and until recently, European digital patents had a relatively high impact, as measured by the citations they received (forward citations). This has, however, changed in recent years (Figure 23). In 2010, the United States overtook Europe in the number of digital patents receiving forward patent citations

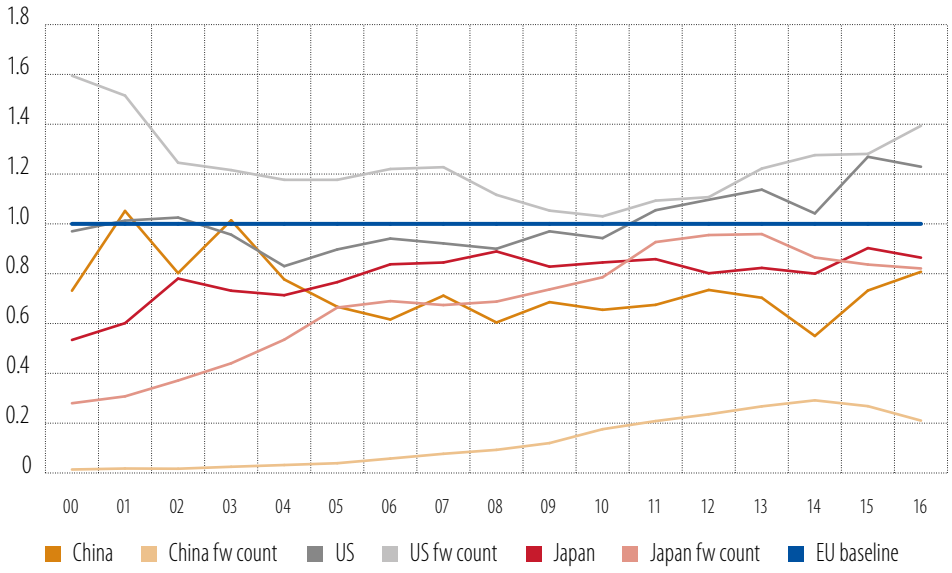
and has continued to outperform since then. Relative to the European Union, China and Japan also have an increasing share of patents receiving forward citations. Overall, these data confirm that Europe has slowly been losing its impact in digital innovation, especially in comparison to the United States.

Figure 22
Share of start-ups (in %) **mentioning artificial intelligence in their description**



Source: *Crunchbase, authors' calculation.*
Base: *Firms founded over 2008-2018 that are still active.*
Note: *The different lines reflect the share of start-ups mentioning artificial intelligence in their description on Crunchbase.*

Figure 23
Forward citation patterns in digital technologies, relative to EU-baseline (1)

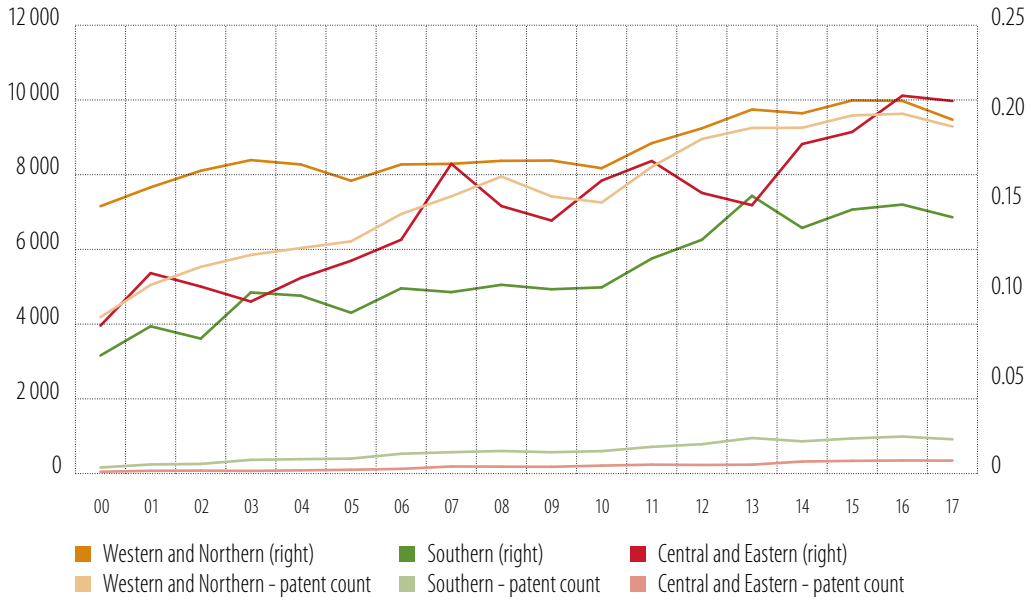


Source: *Authors' calculations based upon PATSTAT (PCT) data in collaboration with ECOOM.*
Note: *The shaded lines measure the average number of times a patent with forward citations gets cited in a three-year window: measured as the ratio of its forward citations to the overall number of patents with forward citations (providing an indicator of the 'depth' of the impact an individual patent has). The solid lines reflect the number of patents with forward citations (providing an indicator of the 'breadth' of the impact or the number of times knowledge is used). Note that we can only show data until 2016 given that forward citations take longer to materialise.*

There are significant differences within Europe, with most digital innovations coming from Western and Northern Europe. In absolute patent counts, Western and Northern Europe dominate the rest of the European Union. However, the picture becomes more nuanced when the share of digital patents in the overall patent portfolio (Figure 24) is factored in. In recent years, Central and Eastern Europe have become a strong runner-up in the relative importance of digital patents, even slightly surpassing Western and Northern Europe in the last few years. In absolute numbers however, Central and Eastern Europe is still lagging behind significantly. Southern Europe is performing relatively weakly, in absolute counts and the share of digital patents in the total patent portfolio.

Figure 24

Digital patents in the European Union, patent count (left axis) **and patent share** (right axis)

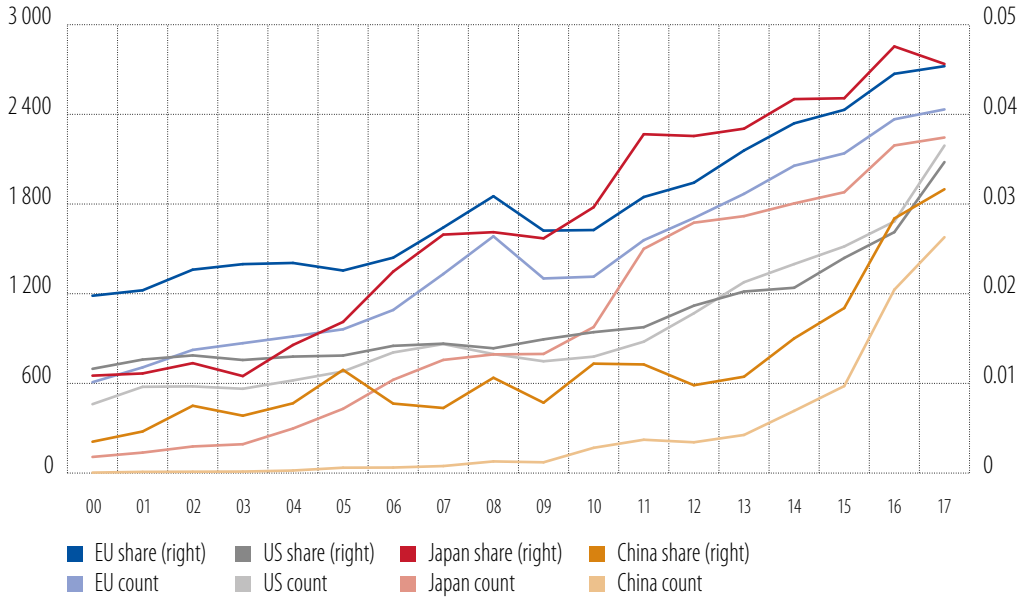


Source: Authors' calculations based upon PATSTAT (PCT) data in collaboration with ECOOM.

Despite its stagnant innovation in digital technology in general, Europe is clearly outperforming its main competitors in certain digital subdomains. While stagnation remains true for the majority of subdomains, it is not the case for digital patents in transportation (Figure 25). In this domain, only Japan is approaching Europe's performance. But even though China and the United States still lag behind Europe, they are rapidly catching up. Europe's position in digital innovation is fragile, even in fields where it is performing relatively well.

Digital technologies are put forward as critical enablers of the green transition and meeting the sustainability goals defined in the European Green Deal. If emerging digital technologies are properly employed, they could play an essential role in tackling environmental challenges. Examples include smart urban mobility, precision agriculture, sustainable supply chains, environmental monitoring and disaster prediction. In addition, digital technologies can be instrumental in monitoring climate change and facilitating the much-needed shift towards a circular economy. Data analytics allow companies to match supply and demand for underused assets and products. The cloud, in combination with mobile and social media, can take products or even entire industries fully online. Moreover, 3D printing creates opportunities for manufacturing biodegradable inputs (Lacy and Rutqvist, 2015). Recent reports claim that although the ICT sector and its recent digital advances are contributing to growing energy consumption, the net benefits outweigh the costs (GeSI 2015; IPCC, 2018).

Figure 25
Digital patents in the transport application domain, patent count (left axis) **and patent share** (right axis)



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

The relatively poor representation of digital technologies in the European Union seems at odds with the apparent need for these technologies in greening the economy. Nevertheless, given that Europe is performing well in the development of green innovations, it is important to understand how it is faring at the intersection of the digital and green domains.

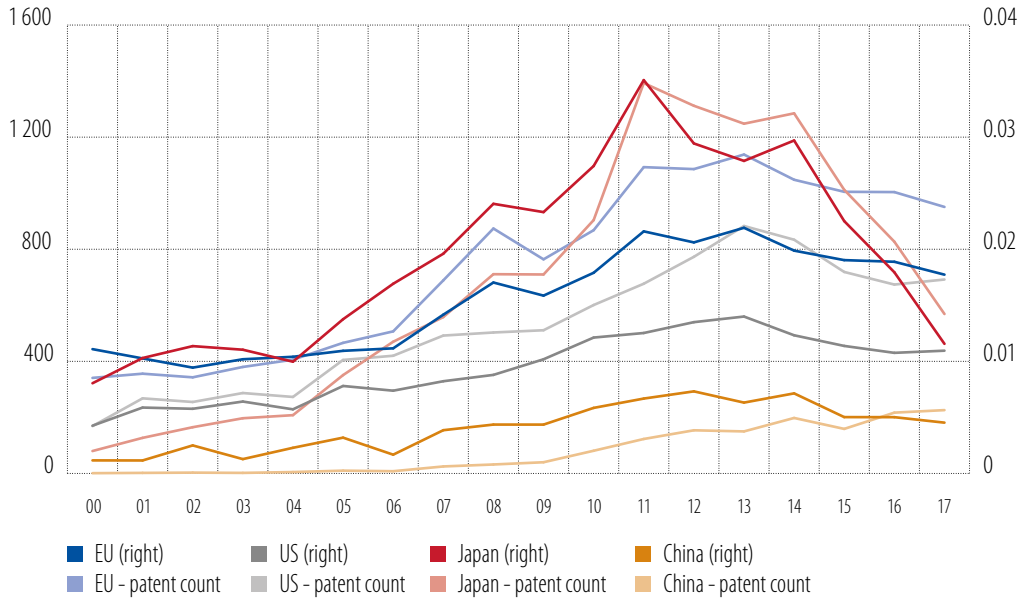
The green and digital crossroads

Europe is currently the leading region in developing the combination of digital and green technologies. In 2017, it had 76% more patents in the digital-green domain than the United States and over four times more than China. Only Japan outpaced Europe in this domain until 2016, before experiencing a steep decline (Figure 26). Europe may not be a global leader when it comes to digitalisation, but it is at the forefront of green technologies and in the combination of digital and green innovations.

The top players in the green and digital field are the Scandinavian countries as well as Germany and France. In the European Union, Western and Northern Europe clearly leads the way. Figure 27 gives an overview of the countries that have an above-average relative technological advantage (RTA) in the digital and green domain or an above-average number of patents in both green and digital innovations. The technological specialisation index captures the share of digital and green patents as a share of a country's total patents, weighted by the same share in the European Union overall. An RTA of above one thus implies that the country is relatively more specialised in digital and green innovations, compared to other European countries. Overall, we can see that the green and digital surge is driven by a handful of countries.

Figure 26

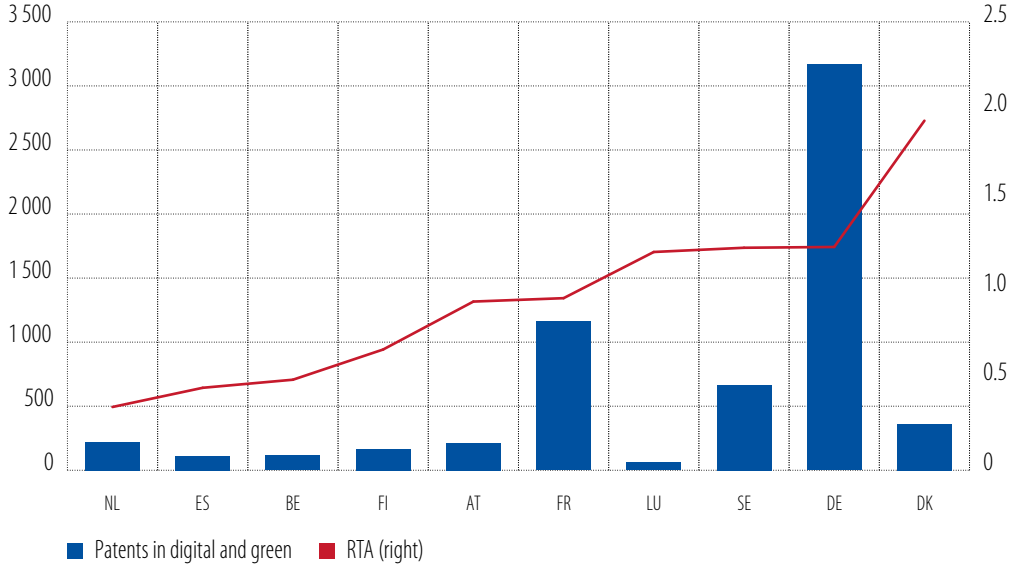
Green and digital patents, patent count (left axis) **and patent share** (right axis)



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

Figure 27

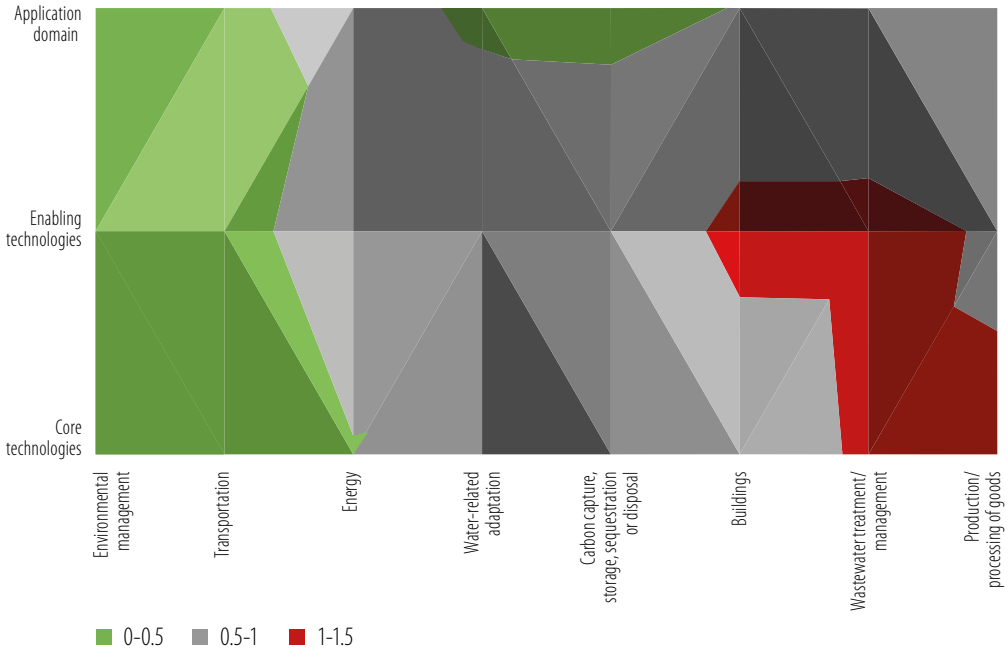
Advantage in green and digital patenting across EU members (2012-2017)



Source: *Authors' calculations based upon PATSTAT (PCT) data in collaboration with ECOOM.*
Note: *The number of digital and green patents (bars) and the RTA (line).*
The RTA index is the share of digital and green patents in the country portfolio relative to the share of digital and green patents in Europe.
Only countries with a sufficient number of digital and green patents are shown in the graph. The index was calculated for the time period 2012-2017.

Europe's main digital and green strengths are in environmental management and transportation technologies (see Box B for a detailed description of the different green and digital domains measured using patent data). Europe co-developed more digital innovations within these green domains than within the others (Figure 28). It is worth noting the same trend is seen in the different subclasses of the digital domains. The full range of digital innovation – from the basic building blocks to the actual applications – is merged with these environmental management and transportation technologies.

Figure 28
Co-occurrence matrix of digital and green patents



Source: *Authors' calculations based upon PATSTAT (PCT) data in collaboration with ECOOM.*
Note: *The graph shows the co-occurrence of patents in core, enabling and application digital technologies for each of the sub-sectors of green patents.*

The mapping presents the outcome of the weighted co-occurrence matrix, defined as $CO = \frac{co_{ij}/co_j}{co_i/\Sigma co_{ij}}$, *with i=digital domain and j = green domain.*
Green means that there is a high rate of co-occurrence while red implies that at that there is a relatively low occurrence of digital and green patents in the respective domains.

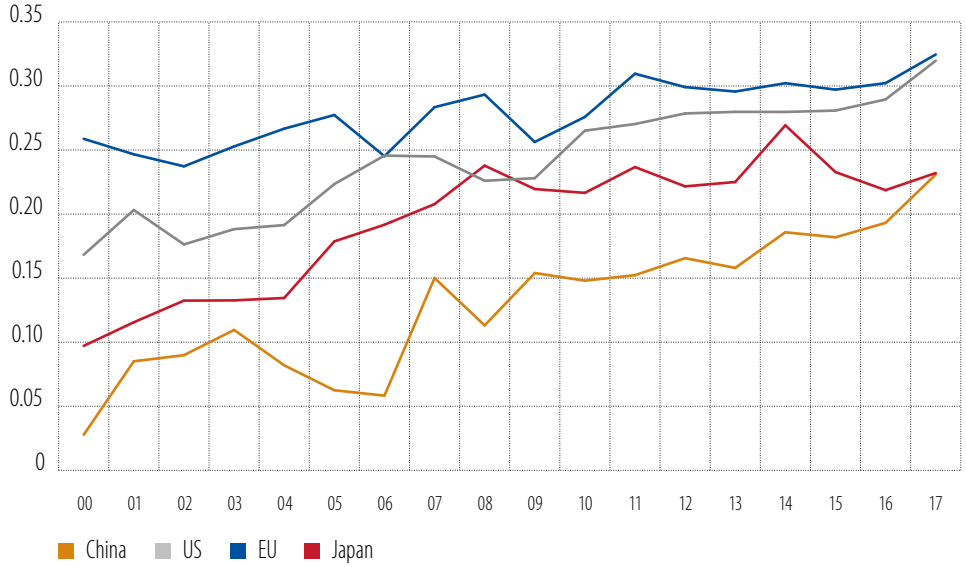
The digitalisation of the transport sector is an integral part of the European Green Deal. Even before the announcement of the deal, the European Commission pinpointed digitalisation as a priority. While Europe is lagging behind in most sectors for digital innovation and digital adoption, the transportation sector is following a different pattern and seems to enjoy a strong head-start. Europe is well ahead of the United States in industry 4.0 patents for vehicle applications, despite trailing in many other areas. The development of environmental management technologies is also an area where the European Union holds a high number of green patents (Figure 6).

Overall, digital technologies are absent from only very few green sectors at this stage. Nevertheless, different green technologies seem to involve different types of digital patents. While energy patents mainly incorporate the basic building blocks of digital technologies (developing core digital technologies), green patents in water-related adaptation and carbon capture and storage are more geared towards actual applications aimed at the end user (developing digital technologies in the application domain).

Green and digital knowledge diffusion

Europe is not only a leading force in the co-occurrence of digital and green development in patents, but also in adopting existing digital knowledge in its green patents. In addition to looking at digital and green technologies in a single patent, we have evaluated the extent to which digital technologies are cited in green patents. Europe has the highest share of green patents in which digital technologies are cited. This citation pattern provides a clear view on the extent to which digital technologies are adopted (and not necessarily co-developed) in green innovation. The share of digital citations in green patents overall is highest in Europe, closely followed by the United States, and is increasing steadily (Figure 29).

Figure 29
Green citing digital, share of green patents

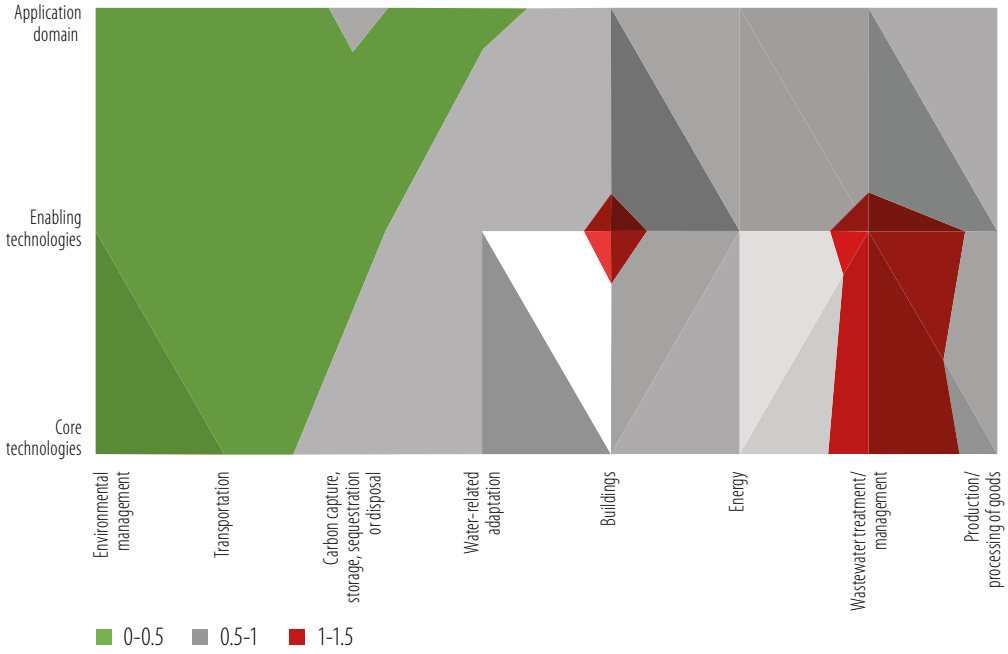


Source: *Authors' calculations based upon PATSTAT (PCT) data in collaboration with ECOOM.*
Note: *Share of green patents with backward citations to digital relative to all green patents with backward citations. Backward citations refer to previous patents on which the current invention is based.*

Not surprisingly, the digital domains that are heavily cited in green patents coincide with the domains that co-occur in green and digital patents (Figure 30). The trend implies that Europe is not only co-developing these digital technologies in patents, but is also adopting pre-existing digital knowledge in its green developments.

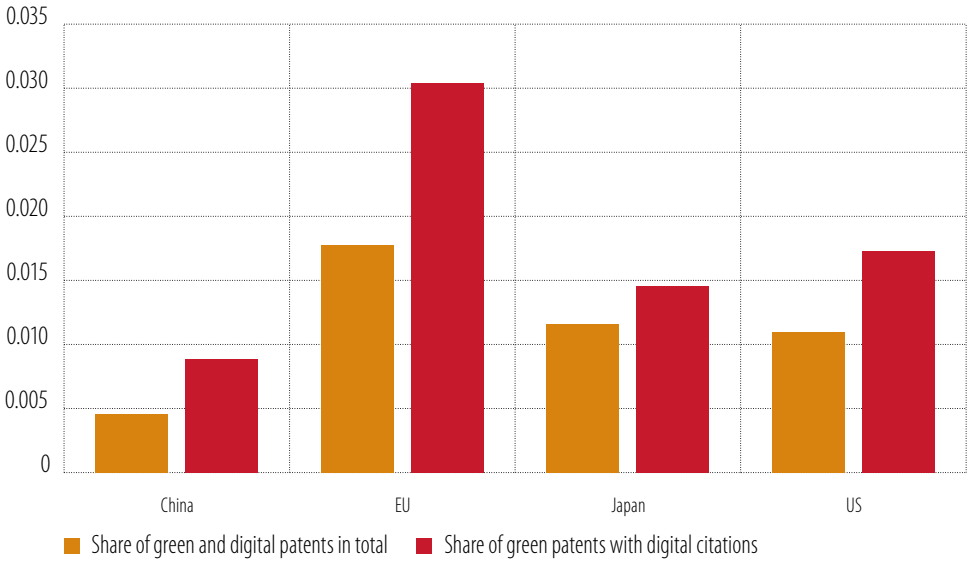
The share of green patents citing digital patents is 70% higher than the share of green patents in which digital technologies are developed at the same time. This demonstrates that digital technologies are successfully circulating and becoming more integrated in green technologies, especially in Europe (Figure 31). Furthermore, it indicates that some of the patents that we would classify as "purely green" also include existing digital knowledge. For the share of green patents citing digital patents, Europe is clearly ahead of other regions. The United States, China and Japan have, on average, 50% fewer digital citations in their green patents than the European Union.

Figure 30
European citation map



Source: *Authors' calculations based upon PATSTAT (PCT) data in collaboration with ECOOM.*
Note: *Share of green patents with backward citations to digital in a certain digital domain, relative to all green patents with backward citations in the respective green domain. This indicator is weighted by the total number of backward citations to digital, relative to all green patents with backward citations.*

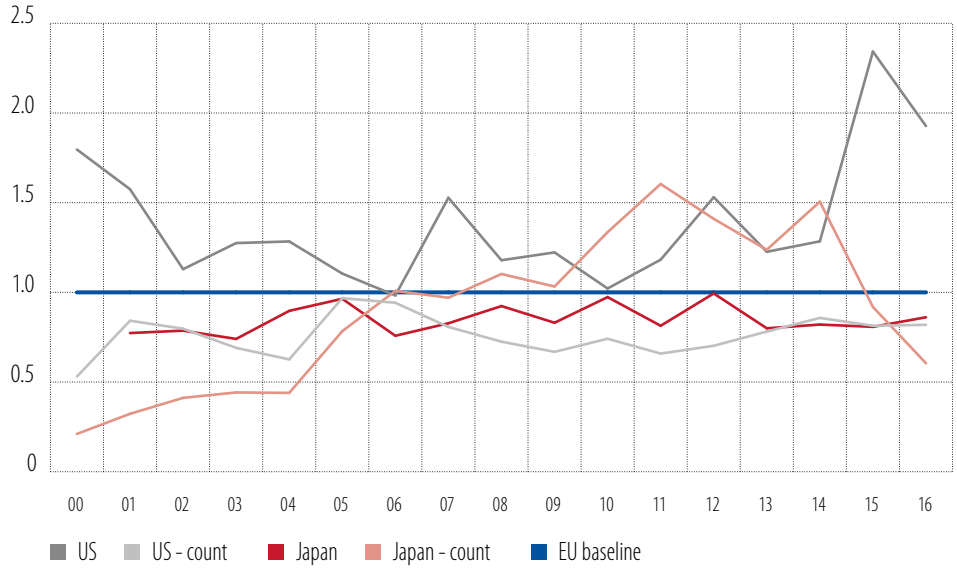
Figure 31
Share of digital-green patents and green patents with digital citations



Source: *Authors' calculations based upon PATSTAT (PCT) data in collaboration with ECOOM.*
Note: *Share of green and digital patents and share of green patents with digital citations.*

The impact of European patents at the digital and green crossroads is higher than in other regions (Figure 32). Even if the share of cited patents is higher for the European Union, the actual number of forward citations to these digital-green patents is higher in the United States. Unlike in the digital field, where Europe at some point had a higher number of forward citations per cited patent, this is not the case for patents developed at the digital and green crossroads. Therefore, it is important to stress that Europe's head-start is fragile and its current advantages could easily collapse.

Figure 32
Forward citations of green and digital patents, relative to EU baseline (1)



Source: *Authors' calculations based upon PATSTAT (PCT) data in collaboration with ECOOM.*
Note: *Number of forward citations to digital and green patents (shaded line) and number of forward citations per digital and green patent with forward citations (solid line), relative to the EU base (solid blue line).*

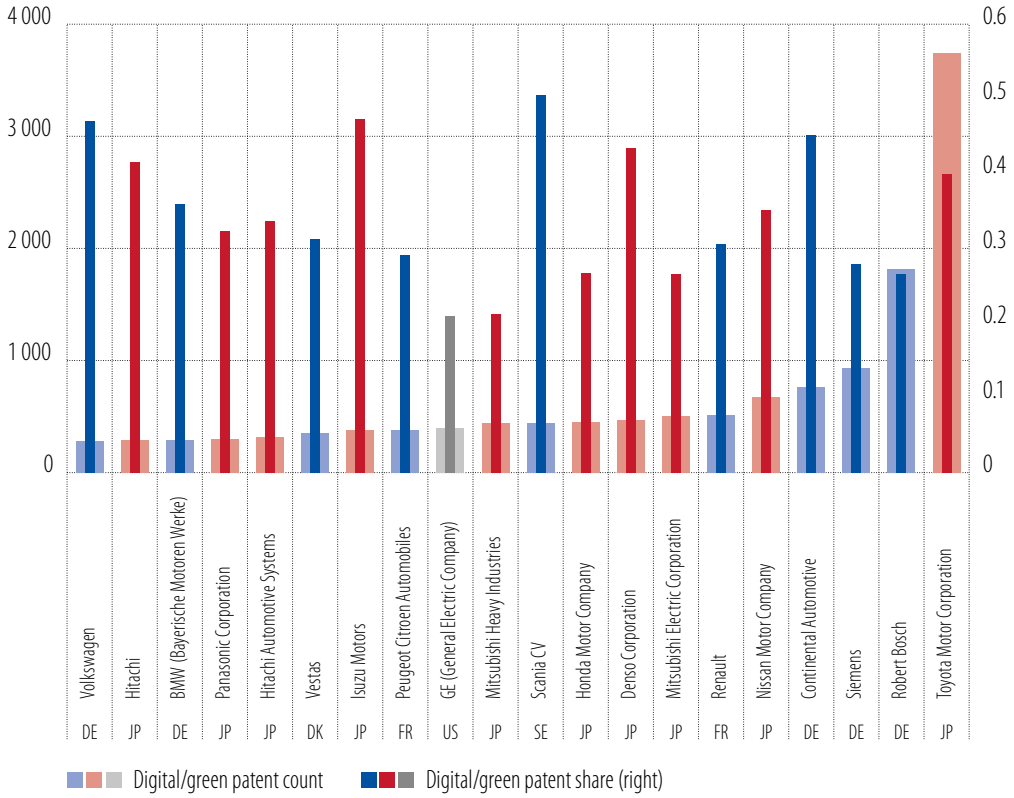
Competition and concentration as key forces in the green and digital sector

The relationship between the diffusion of knowledge and competition is strongly debated. Some economists argue that market power is necessary to foster innovation, while others fear that market concentration leads to a general slowdown of the economy and innovation (for instance, Philippon, 2019). Competition is an important force that determines the cost of goods and therefore overall public welfare. Utterback et al. (2018) emphasise that one technology may either enhance or inhibit another technology's growth. They describe cases of pure competition, but also of symbiosis (where both the new and older technologies mutually enhance growth) and predator-prey interaction (where one technology enhances the other's growth rate but the second inhibits the growth rate of the first). A core question within this debate is the extent to which the high concentration in the digital market is affecting the development of sectors that focus on digital and green technologies.

Nine out of the top 20 players developing digital-green patents are European. Top companies can be measured by the share digital-green patents represent in total patents and by the absolute count of digital-green patents. Figure 33 presents these measures for the top patent applicants (those with the highest number of digital-green patent applications). Besides the clear dominance of Japan and Europe, the list also shows the strong presence of automotive companies. The bars in the figure also reveal that both measures – patent share and absolute count – are important, with many European companies holding an

exceptionally high share of digital-green patents. The same pattern holds in green technologies, where many European firms dominate.

Figure 33
Top green and digital players, patent count (left axis) **and share of digital and green patents** (right axis)



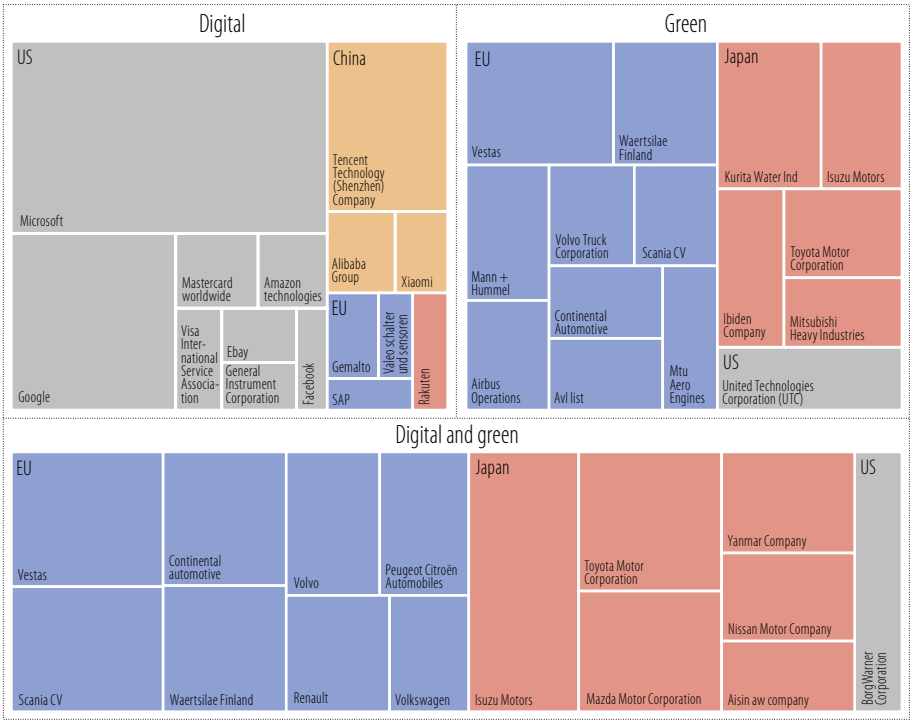
Source: *Authors' calculations based upon PATSTAT (PCT) data in collaboration with ECOOM.*
Note: *The bars reflect the number of digital and green patents for each company from 2000 to 2018. The colours refer to the different regions (blue = European Union; red = Japan; grey = United States).*

In digital technologies, the United States dominates. Google, Amazon, Facebook, Apple and Microsoft (also known as GAFAM) confirm their digital supremacy based on patent data (Figure 34). However, none of these famous top companies in the digital sector end up at the top of the "green" or "green and digital" categories. The top companies in green and digital-green technologies are from Europe and Japan.

The digital sector is often criticised for a lack of competition, which allows some companies to profit from winner-takes-all dynamics. It is important to look closely at whether similar trends are afoot in green and digital-green domains. Digital integration in green technology is expected to offer immense opportunities for progress and should lead to stronger symbiosis between both technologies. However, Akcigit and Ates (2019) signal that as soon as a leading technology is successful, it is rapidly implemented by leading firms. The rapid adoption by leading firms may discourage smaller or less pervasive firms from innovating, thereby slowing down the innovation process.

Environmental innovators are more likely to be embedded in dynamic markets (Figure 35). In the EIB Online Survey on Environmental Innovations, we asked firms about the impact of the transition to a carbon-neutral economy on their competitive positions. Companies that have already introduced an innovation with environmental impacts are more likely to say that they think competitors will exit or enter the market. In addition, they feel – slightly more than other firms – that they may face a loss of competitive advantage. Digital and environmental innovators in particular feel that competitors may enter their market. These concerns clearly show that environmental innovators feel their markets are more dynamic. At the same time, the innovators are less concerned about losing their competitive advantage, a potential signal that they still believe in their innovation potential. The assertion that competition is a potential trigger for innovation is also supported by Aghion et al. (2020), who found that the combination of sustainable consumer behaviour and competition has increased innovative activity in the automotive sector.

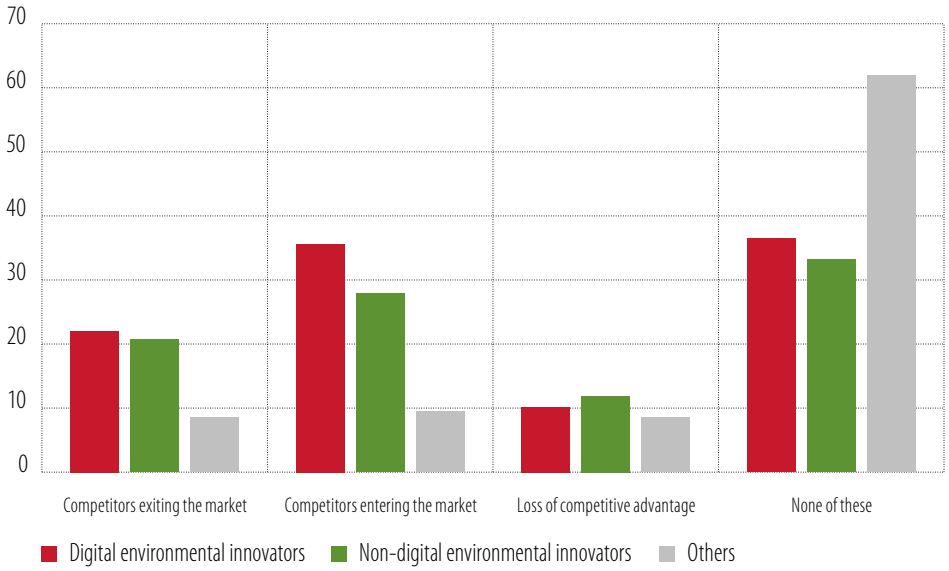
Figure 34
Top players in the different sectors



Source: *Authors' calculations based upon PATSTAT (PCT) data in collaboration with ECOOM.*
Note: *The top players in the different technologies are measured by their patenting intensity in the respective group. The size of the areas reflect the patent count in the respective technology.*

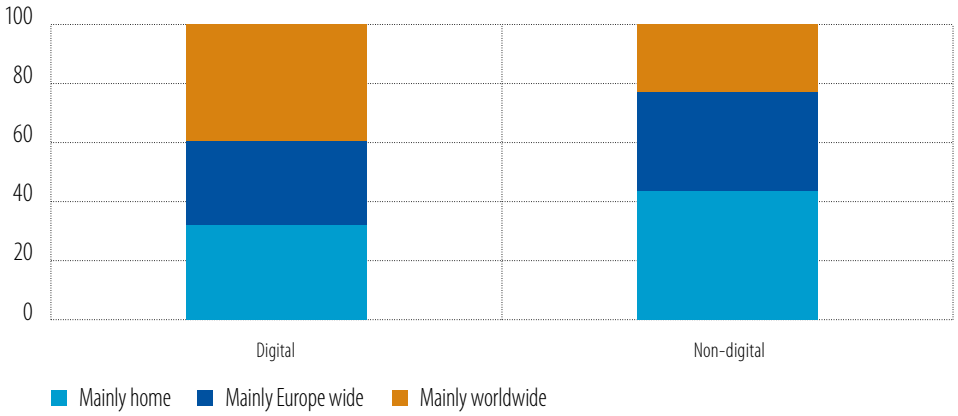
In addition, digital environmental innovators are more likely to enjoy a bigger playing field – likely competing on a global scale (Figure 36). The potentially large market holds enormous potential for digital and green innovators. At the same time, however, the digital and green sector risks replicating the winner-takes-all dynamic witnessed in the digital sector, where just a handful of firms dominate the global market. How the digital and green sector evolves is strongly dependent on competition policy, an area that must be an integral part of policy design, as will be discussed further in Section 3.

Figure 35
Competitive environment of environmental innovators (% of firms)



Source: *EIB Online Survey on Environmental Innovations.*
Base: *All firms.*
Question: *Looking ahead over the next five years, do you think the transition to a carbon-neutral economy will impact your company in any of the following ways?*

Figure 36
The markets of environmental innovators, share of environmental innovators (in %)

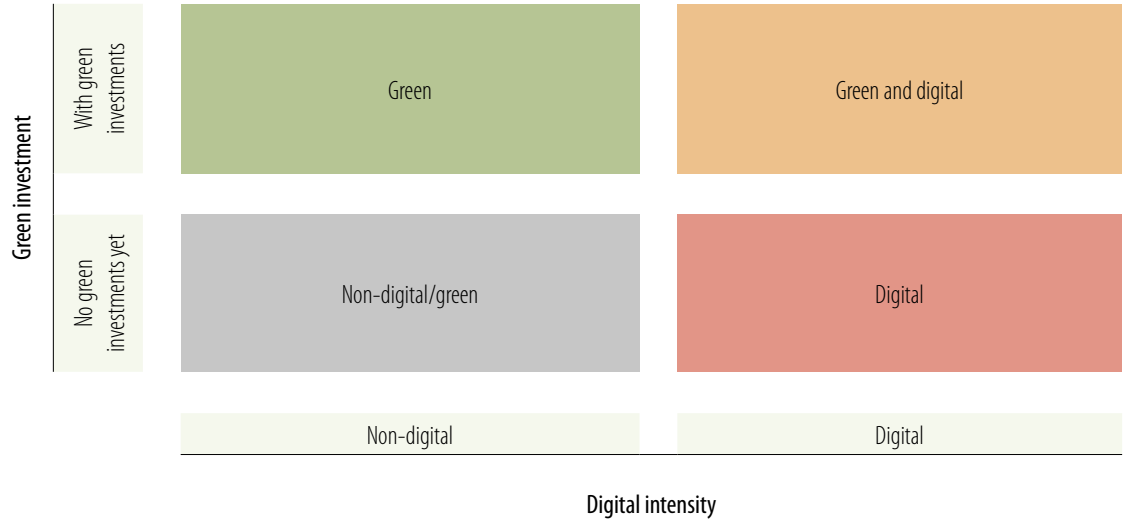


Source: *EIB Online Survey on Environmental Innovations.*
Base: *All environmental innovators having introduced innovations generating environmental benefits for customers.*
Question: *In which geographical markets do you mainly operate for your products, services or processes intended to generate environmental benefits for customers?*

Firms' uptake of green and digital technologies

The patent data provided valuable insights into innovation activities, while the EIBIS data shed additional light on the extent to which firms embrace both digital and green technologies. More specifically, our data allow us to compare firms that are investing in green while also implementing digital technologies with firms that are purely green, purely digital or have no investment in green innovations and no digital technologies. (Figure 37).

Figure 37
The four digital and green profiles

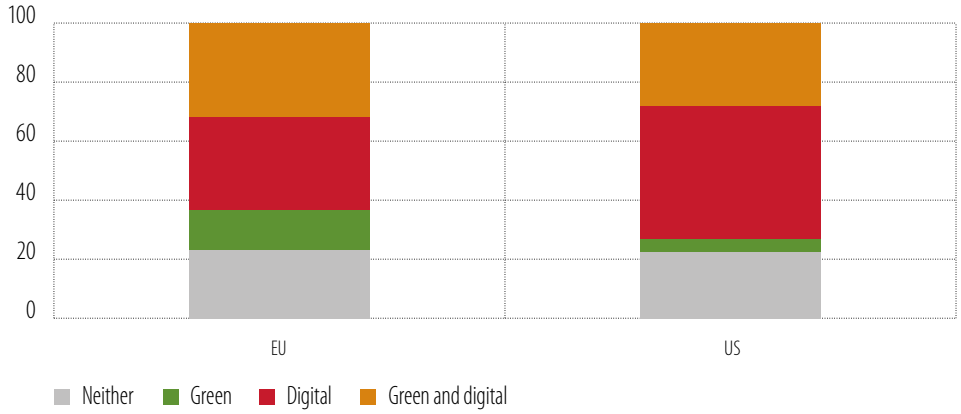


Source: *EIBIS 2020.*
Base: *All firms*
Question: *Green: Now thinking about investments to tackle the impacts of weather events and reduction in carbon emissions, which of the following applies?*
Digital: Can you tell me for each of the following digital technologies if you have heard about them, not heard about them, implemented them in parts of your business, or whether your entire business is organised around them?

While the United States clearly has a higher share of digital firms than the European Union, Europe is stronger in green firms and those embracing green and digital at the same time. With 14%, the share of green firms in the European Union is nearly three times as high as in the United States, where the share is 5% (Figure 38). The European Union also outpaces the United States for the share of digital-green firms (32% vs. 28%).

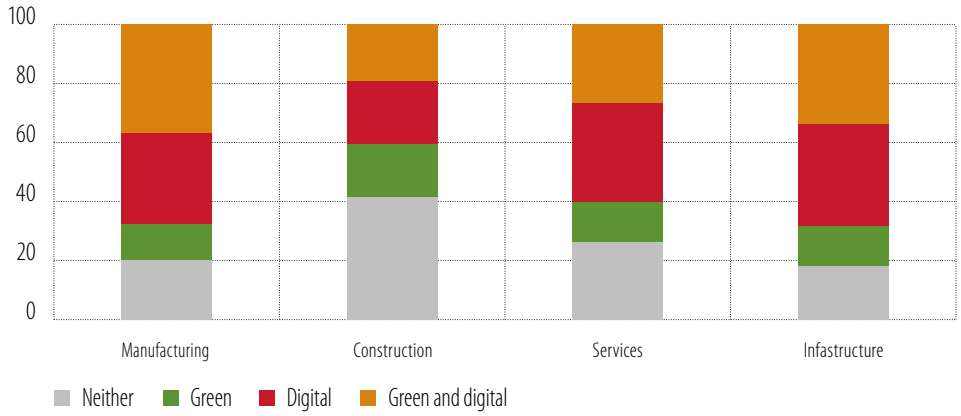
Most of the green and digital firms are active in the manufacturing (37%) and infrastructure (34%) sectors. The high share of these firms in manufacturing may be partly explained by the greening of the transportation sector. The construction sector has the highest share of firms that did not invest in either the green or digital segments (42%), followed by the service sector with 27% (Figure 39).

Figure 38
Digital and green profiles by region, share of firms (in %)



Source: *EIBIS 2020.*
Base: *All firms.*
Note: *The different profiles are defined as in Figure 37. Firms are weighted by value added.*

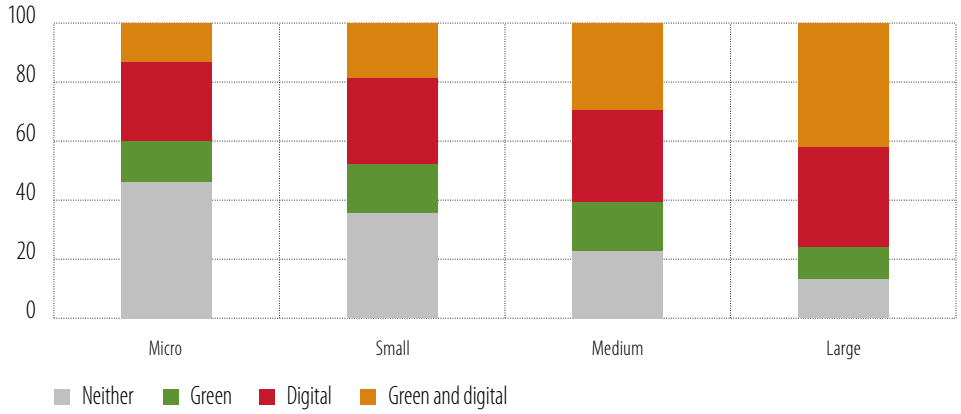
Figure 39
The four digital and green profiles, by sector, share of firms (in %)



Source: *EIBIS 2020.*
Base: *All firms in the European Union.*
Note: *The different profiles are defined as in Figure 37. Firms are weighted by value added.*

Larger firms are more likely to be both digital and green than small ones (Figure 40). While only 13% of microfirms and 18% of small firms are green and digital, this share increases markedly for medium-sized (29%) and large firms (42%). The share of purely digital firms also increases with firm size. The relationship between firm size and digitalisation and green activities can be explained by the fact that investments in digital and green technologies can be risky and involve high fixed costs. Costs and risks are easier to bear if they are spread over larger revenue streams.

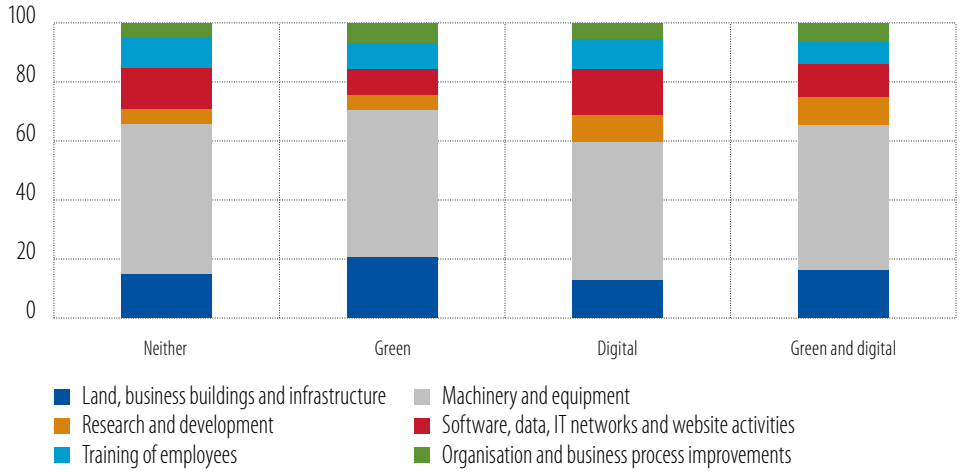
Figure 40
The four digital/green profiles, by firm size, share of firms (in %)



Source: *EIBIS 2020.*
Base: *All firms in the European Union.*
Note: *The different profiles are defined as in Figure 37. Firms are weighted by value added.*

Digital-green firms invest more. If we compare the distribution of investment intensity (defined as investment spending per employee) of firms that are green and digital to other companies, we consistently observe higher investment intensity in green and digital firms. In addition, zooming in on the different areas of investment shows that both digital-green and digital firms tend to invest relatively more in R&D and intangibles in general (Figure 41). The stronger focus on intangible investments is particularly pronounced for digital firms.

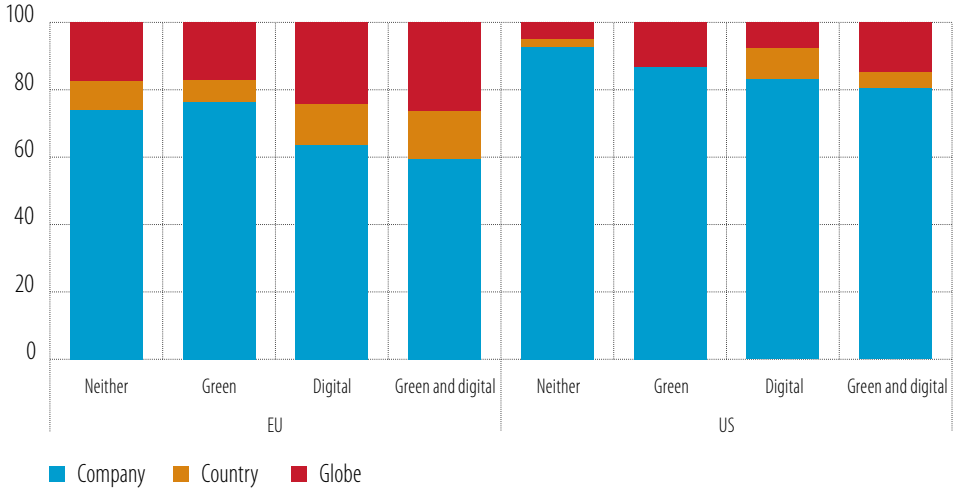
Figure 41
Composition of investment of the four digital/green profiles, share of investment (in %)



Source: *EIBIS 2020.*
Base: *All firms in the European Union.*
Note: *The different profiles are defined as in Figure 37. Firms are weighted by value added.*
Question: *How much did your business invest in each of the following with the intention of maintaining or increasing your company's future earnings?*

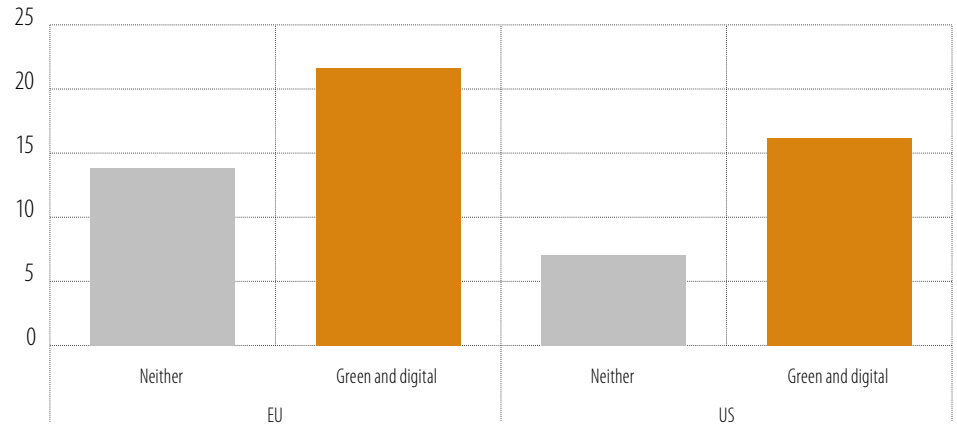
Going forward, it is crucial that Europe maintains its competitive advantage in green and digital. The innovativeness of digital-green firms plays a particularly important role in dealing with climate change. All in all, European firms do not seem to be suffering from any slowdowns in innovation. As EIBIS data show, a large share of firms investing in green and digital are highly innovative (Figures 42 and 43) and more likely to introduce new products, processes or services to their country or the global market. This implies that these firms are not only heavily building upon other innovations but that they also have the potential to further diffuse their own innovations within their country or the global market.

Figure 42
Innovativeness of the four digital/green profiles, share of firms (in %)



Source: *EIBIS 2020.*
Base: *Innovative firms.*
Note: *The different profiles are defined as in Figure 37. Firms are weighted by value added.*
Question: *Were the new products, processes or services...*

Figure 43
Share of innovation (in %) **that is new to the country/global market**

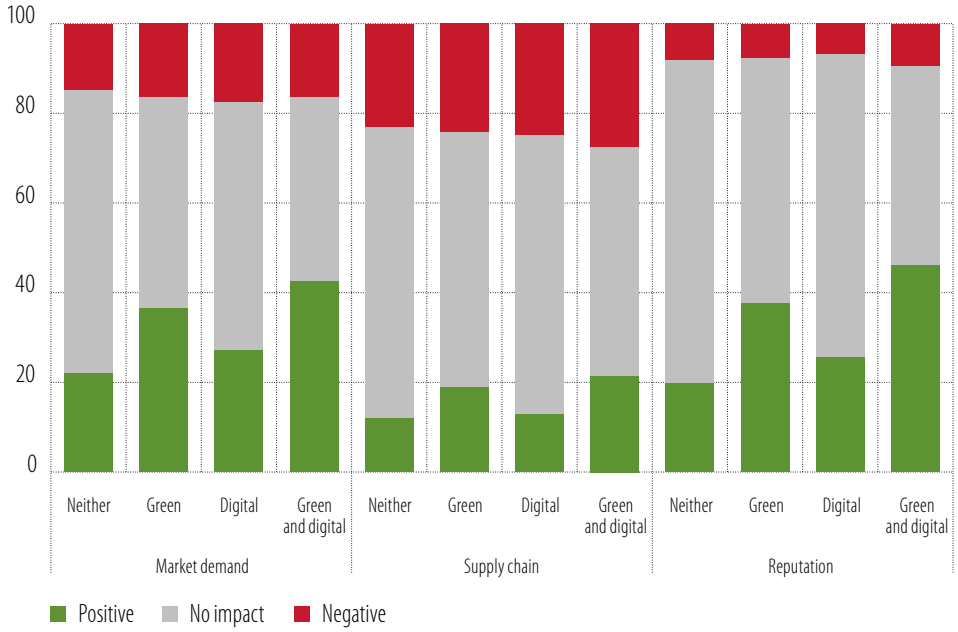


Source: *EIBIS 2020.*
Base: *All firms.*
Note: *The different profiles are defined as in Figure 37. Firms are weighted by value added.*
Question: *Were the new products, processes or services...*

Being green and digital is a game changer for resilience and reputation

Digital-green firms expect decarbonisation to affect market demand and their reputation. We asked firms about the expected impact of climate change on their markets. Specifically, we wanted to know how they assess the effect of decarbonisation on market demand, supply chains and their reputations. Overall, green and digital-green firms are relatively similar in their assessment. Their most common perception is that their reputation will be positively affected (Figure 44).

Figure 44
Impact of the climate change transition for the four digital/green profiles (in %)



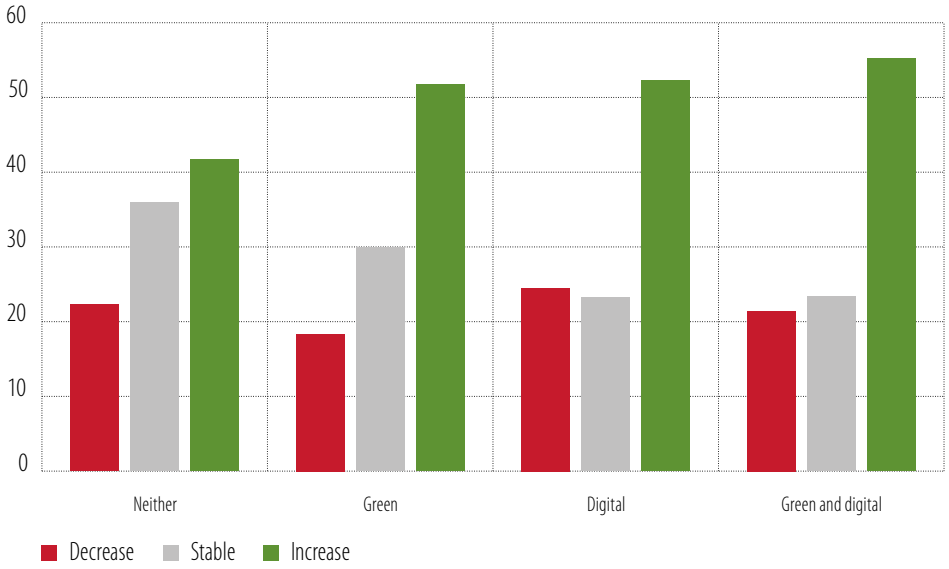
Source: *EIBIS 2020.*
Base: *All firms in the European Union.*
Note: *The different profiles are defined as in Figure 37. Firms are weighted by value added.*
Question: *Limiting global warming requires a reduction of carbon emissions over the upcoming decades. What impact, if any, will this transition to a reduction in carbon emissions have on the following aspects of your business over the next five years?*

Being green and digital has clear upsides. Digital-green firms have higher productivity than other firms and are more likely to have hired new employees over the past three years, suggesting that they are more dynamic. On balance, 35% of digital-green companies stated that they increased employment, compared with 30% of digital firms, 26% of green firms and 21% of firms that are neither green nor digital (Figure 45).

With COVID-19 hitting society and the economy extremely hard, firms at the digital-green crossroads seem less likely than others to translate the short-term job losses into permanent ones (Figure 46). Firms whose staffing has been impacted by the pandemic in the short term were asked whether this would result in permanent job losses. Digital-green firms were the least inclined, indicating that they at least intend to keep employee levels relatively stable in the long term. This might indicate that digital-green investors actually create jobs. As digital and green skills are generally lacking, re-training and re-skilling in those segments might help bring about a more inclusive transition (see Chapter 10). The increased use of digital technologies by already highly digitalised firms was discussed in Chapter 4 and could signal a "winner-takes-all" dynamic.

Figure 45

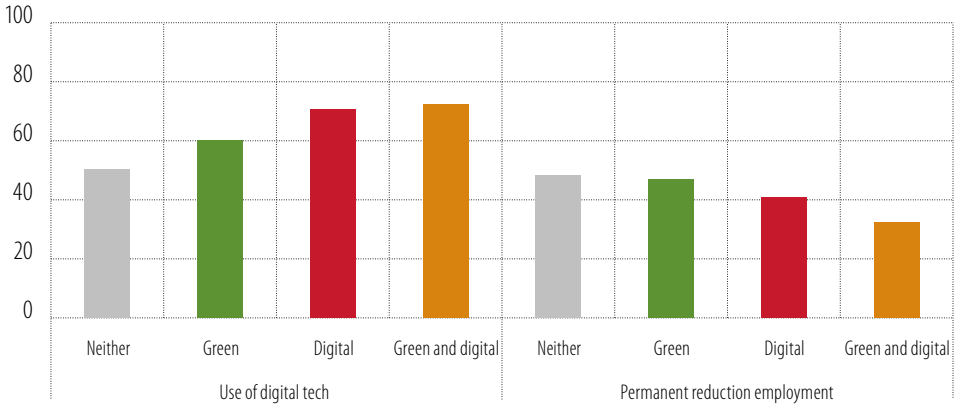
Share of firms having hired new employees over the past three years (in %)**, for each digital and green profile**



Source: *EIBIS 2020.*
Base: *All firms in the European Union.*
Note: *The different profiles are defined as in Figure 37. Firms are weighted by value added.*
Question: *How many people did your company employ either full or part-time at all its locations three years ago? How many people does your company employ either full or part-time at all its locations, including yourself?*

Figure 46

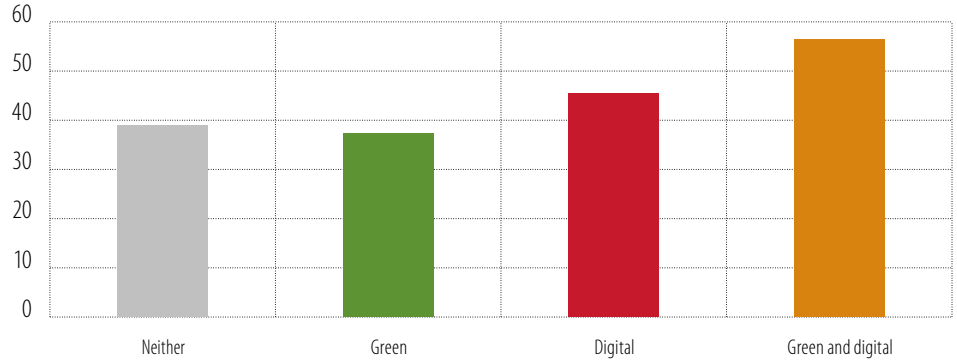
Long-term impact of COVID-19, share of firms (in %)



Source: *EIBIS 2020.*
Base: *All firms in the European Union.*
Note: *The different profiles are defined as in Figure 37. Firms are weighted by value added.*
Question: *Do you expect the coronavirus outbreak to have a long-term impact on any of the following?*

Green and digital companies are most likely to state that COVID-19 has them rethinking the scope of their projects (Figure 47). This does not bode well for a market segment in which Europe currently holds a commanding lead.

Figure 47
Share of firms planning to change the projects' scope due to COVID-19 (in %)



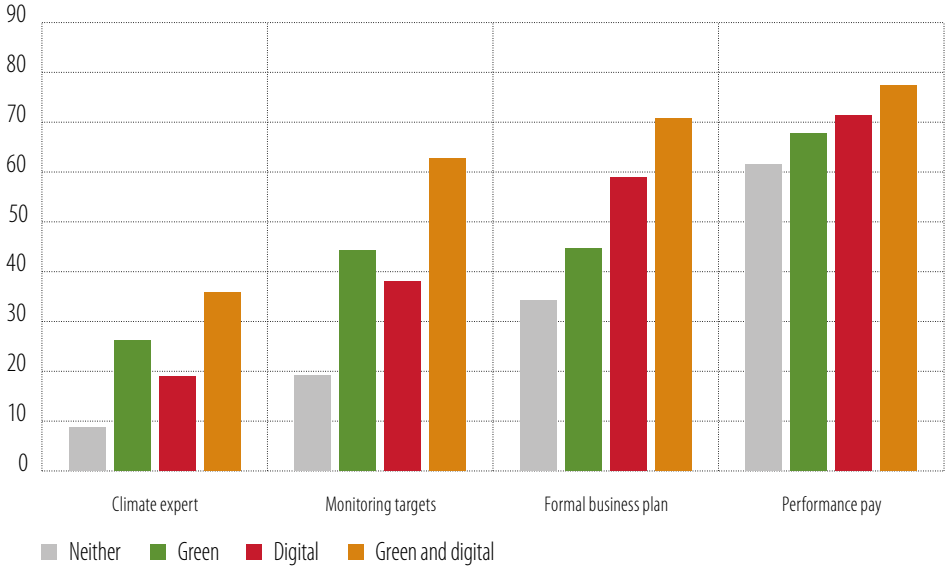
Source: *EIBIS 2020.*
Base: *All firms.*
Note: *The different profiles are defined as in Figure 37. Firms are weighted by value added.*
Question: *Has your company's overall investment expectations for 2020 changed due to coronavirus? Will your company … You just said you will invest less due to coronavirus. Can I just check which of the following actions your company will undertake?*

What is holding firms back and what can we do?

Small firms and firms in the construction sector are less likely to be green and digital. Small firms across all sectors are significantly less likely to have invested in green and digital technologies. In addition, these firms are less likely to be innovative, less likely to create new jobs and less likely to compete internationally. Digital-green firms perform much better and seem to be coping with the current crisis more successfully. Encouraging firms to digitalise and invest in green technologies should therefore be high on the policy agenda.

In addition, innovations are not only needed in technology, but also in business practices and consumer behaviour. The results from EIBIS clearly indicate that firms investing in both green and digital not only score better in management practices in general, but are also more likely to embrace climate change in their company culture (Figure 48).

Figure 48
Management practices, by digital/green profile, share of firms (in %)



Source: *EIBIS 2020.*
Base: *All firms.*
Note: *The different profiles are defined as in Figure 37. Firms are weighted by value added.*
Question: *In 2019 and under normal conditions, did your company… …?*
… use a formal strategic business monitoring system
…reward individual performance with higher pay
…have a designated person responsible for defining and monitoring climate change strategies
…set and monitor internal targets on carbon emissions and energy consumption.

The role of policy

Fostering green and digital innovations should be a policy priority. Reducing carbon emissions sufficiently only seems feasible if clean technologies are successfully adopted. Patent data, data on start-ups and the EIBIS and the EIB Online Survey data all highlight the importance of innovation. In addition, scientific research suggests the urgent need for policy intervention. It is also crucial that we reassess not only the negative consequences of carbon emissions, but also investment in green and digital innovations. Furthermore, investment in key infrastructure will help the European economy transition rapidly.

Global interaction

It is an understatement to say that the role of policymakers is extremely important. Without policy intervention, the green innovation market will not regulate itself. In climate change (a global public issue), problems arise because individual nations enjoy only a small fraction of the rewards of their actions (Nordhaus, 2019; for a comprehensive overview on the topic, Cramton et al., 2017) – which also creates problems for private investments. In other words, nations acting purely in their own interests would only take minimal action because most of the benefits from cooperation spill over to other nations. It is only by designing, implementing, and enforcing cooperative multinational policies that nations can ensure climate change policies are effective.

With its European Green Deal, the European Union is on track for achieving a common policy goal for a large region. That being said, even if a common strategy at the European level could be drawn up, the global community – and often more polluting regions – would not necessarily follow it. Therefore, Europe should not only avoid unfair competition in its own region, but also ensure that the enormous efforts made can actually filter through to other continents. To protect climate investments, a global consensus and a common understanding of how to reach climate targets must be attained. Multilateral compensation funds or border-carbon adjustments are policies that make sense in this respect (Chancel and Piketty, 2015).

The coronavirus recovery efforts underway represent an opportunity to form a consensus on what needs to be done to support the transition to a more sustainable economy. In spite of the apparent urgency, policymakers have not succeeded – so far – in turning the climate tide. To meet the ambitious – and necessary – climate goals, adopting promising technological advancements is crucial. Policymakers can play an important role in promoting innovations that would help achieve climate targets.

If the European Union is to remain a global leader in the green and digital-green fields, preventing investments in these areas from stalling is primordial. While global interaction should stay high on the policy agenda, ensuring that Europe remains in pole position in green and digital-green innovations is also crucial. At the same time, action needs to be taken sooner rather than later. There is not only urgency with climate change, but also from a purely accounting perspective. Given that the lifespan of newly built factories, housing or power plants stretches far beyond the 2050 target (Pfeiffer et al., 2018), it is important that we implement the necessary changes today.

Green investments from the private sector

Policymakers should create incentives for private investors to develop and adopt climate-friendly innovations. Because the negative effects of pollution and climate change are not priced into markets, private investors (consumers included) have very little incentive to take sufficient action. As long as the market failure for these innovations remains unaddressed, it will be difficult to make progress.

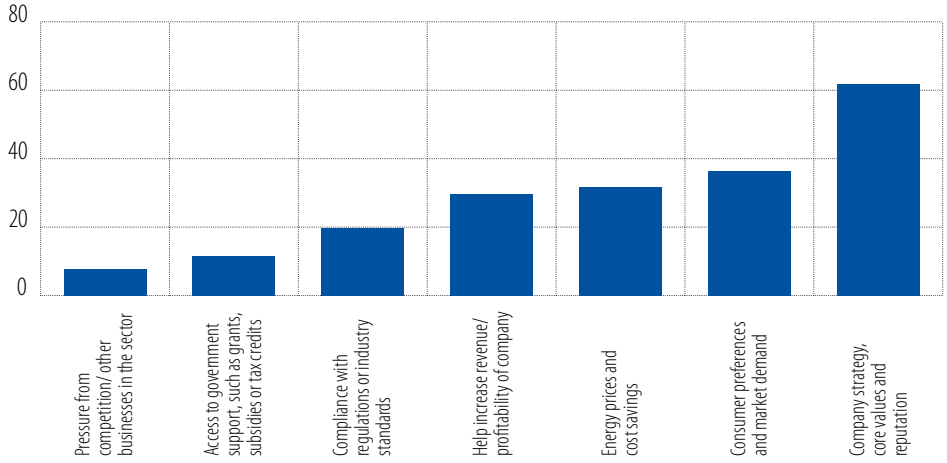
The importance of consumer preferences and market pressure clearly motivates firms to introduce environmental innovations (Figure 49). A large share of firms react to consumer preferences, market demand, energy prices and cost savings. The finding is in line with the trend in patent applications and fossil fuel prices discussed in Section 1. Firms that introduce an environmental-friendly innovation most often state that they have done so because of their company's strategy, core values and reputation. This focus is likely related to consumer preferences and market opportunities.

At the same time, scientific policy should push companies to invest in innovation. Even if innovations address a sufficiently big market, private investors may still hold back for fear of spillovers. In addition, the possibility of other companies benefitting from the technology and the high sunk costs of R&D investments could make it extremely difficult for firms to find the necessary funding. These so-called knowledge market failures are not new in the innovation literature and can be addressed by a variety of measures. Nevertheless, the novelty and often experimental nature of green innovations suggest that they may be more prone to these failures (Rodrik, 2014; Dechezleprêtre et al., 2017).

Green investments are hampered by high costs and a lack of support (external finance and government support). Respondents of the online survey (Figure 50) mention these barriers the most frequently. Furthermore, respondents signal that regulation and industry standards are real obstacles to introducing innovations intended to generate environmental changes.

Figure 49

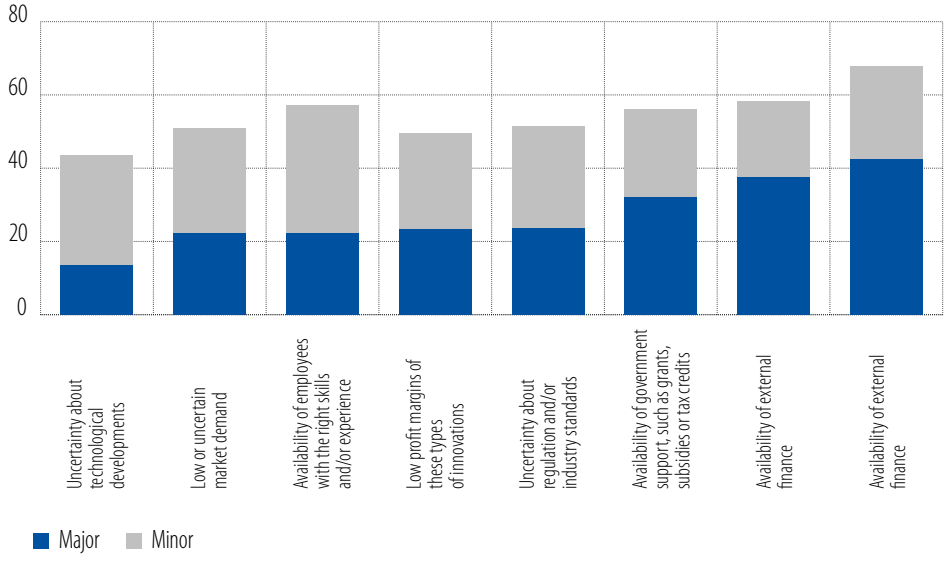
Motivation for making changes to respond to environmental effects share of environmental innovators (in %)



Source: *EIB Online Survey on Environmental Innovations.*
Base: *All environmental innovators.*
Question: *To what extent, if at all, are each of these factors obstacles to making changes in your own company to respond to environmental impacts AND/OR offering products, services or processes intended to generate environmental impacts for your customers?*

Figure 50

Obstacles to making changes to respond to environmental effects, share of environmental innovators (in %)



Source: *EIB Online Survey on Environmental Innovations.*
Base: *All environmental innovators.*
Question: *To what extent, if at all, are each of these factors obstacles to making changes in your own company to respond to environmental impacts AND/OR offering products, services or processes intended to generate environmental impacts for your customers?*

The direction of innovation may be even more important than its pace – notwithstanding the pressing need to deal with climate change. Even though innovation is a top priority on policymakers' agendas (see also Chapter 4), additional innovation in technologies that do not necessarily contribute to carbon neutrality may actually make the problem worse (Acemoglu et al., 2016). It is fundamental to have well-directed innovations introduced to the market that reduce the costs of clean technologies to a level below those of environment-harming technologies.

Getting the prices right

Fully internalising the risks of climate change is impossible, and a consequence is that climate change effects are seriously underpriced from a societal perspective. Carbon prices are a very useful lever for most countries. These policy measures are highly efficient and can achieve a great deal. They provide incentives across the economy and can generate useful public revenue, which can in turn be invested in the transition to a green economy. Importantly, these prices can trigger investments, including in research and development, which can spur economic growth, especially in periods of inadequate aggregate demand.

Using carbon prices to stimulate innovation, as also shown in this chapter (Figure 9), could also counteract the impact of wide swings in fossil fuel prices (Figure 8). Some technologies displaying a serious downturn in patenting might have fared better if carbon prices had not dropped so sharply. However, while increases in the price of fossil fuels – either due to market forces or carbon-pricing policies – may affect which energy technology is cheapest, they are not yet at a level that would encourage producers or consumers to choose green technologies that may be more expensive. To promote these costlier but often more promising technologies, more targeted policy measures are necessary (Popp, 2019).

Indirect policies, such as carbon prices, risk stalling investments in technologies further from market launch. The fact that these policies favour technologies that will soon come on to the market is not necessarily problematic or inefficient. The climate change crisis is a complex problem for which action has to be undertaken urgently. If all environmental externalities are internalised, the cheapest technology is more likely to be an environmentally beneficial one. As policy can hardly take all environmental externalities into account, policymakers can impact innovation even when they adopt a technology-neutral policy. At the same time, specific technologies may need to be supported, even if they are not cost competitive in the short term.

Direct policies, such as targeted grants or early-stage deployment policies, could be useful tool to foster innovation in technologies that have not yet become cost-effective. This was the case with solar PV in the early 2000s (Johnstone et al., 2010). New clean technologies (such as energy storage and carbon capture and storage, to name just a few) exhibit strong learning-by-doing effects and increasing returns to scale in production and R&D (Farmer and Lafond, 2016). Prices for solar PV modules, for example, fell by approximately 20% each time the total cumulative installed capacity was doubled.

It is still debatable whether support should be this targeted. This might bring success for the specific technology being targeted, but may not be the most effective use of public funds and could prevent other promising technologies from being developed.

Even if direct policies can direct resources to specific areas that need government intervention, it is difficult to identify projects that will necessarily produce successful outcomes. Innovation is highly uncertain. A portfolio approach – providing support to numerous projects and technologies to reduce the overall funding risk – is likely to be most effective. Governments with deep pockets especially are in an excellent position to support a diversified portfolio of projects.

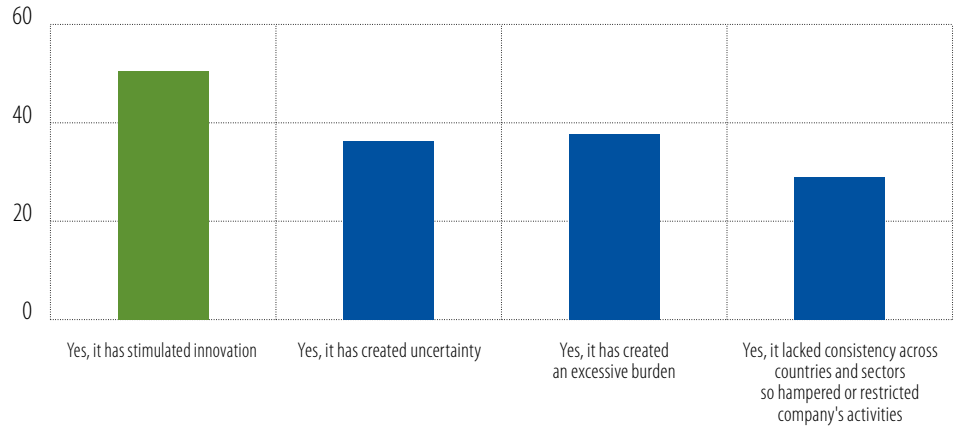
For early-stage technologies, policies are needed to help cross the bridge from research and development to market launch (Howell, 2017). In this context, the European Union's flagship research and innovation programme Horizon Europe will direct EUR 100 billion to research and innovation, making it one of the biggest initiatives in the world. Climate-related projects will account for 35% of

Horizon Europe. In addition, specific innovation programmes and prize-based challenges could benefit innovation. Palage et al. (2019) find supporting evidence that advanced biofuel patenting increases after investments in demonstration projects in EU countries. In addition, extending technology transfer and lab-to-market programmes could help European companies push promising early-stage technologies. Similar initiatives would also make research and innovation an integral part of the European Green Deal, which could itself have an important signalling effect.

The probability of success in the green transformation depends largely on finding the ideal policy mix. It is critical that the full set of available policies is employed to encourage innovators to act throughout the entire value chain of technologies. In addition, the different policies, such as carbon prices, should be extended to different sectors – albeit in different formats (see below).

Companies that feel affected by environmental legislation or regulations are more likely to innovate. Half of the companies that say legislation or regulations have had an impact on them also say that impact has stimulated innovation (Figure 51). At the same time, the current legislative and regulatory framework is creating a lot of uncertainty and excessive burdens while lacking consistency across countries and sectors, which may therefore hamper or restrict a firm's activities. Even if policy measures are going in the right direction, they should tilt more towards stimulating innovation.

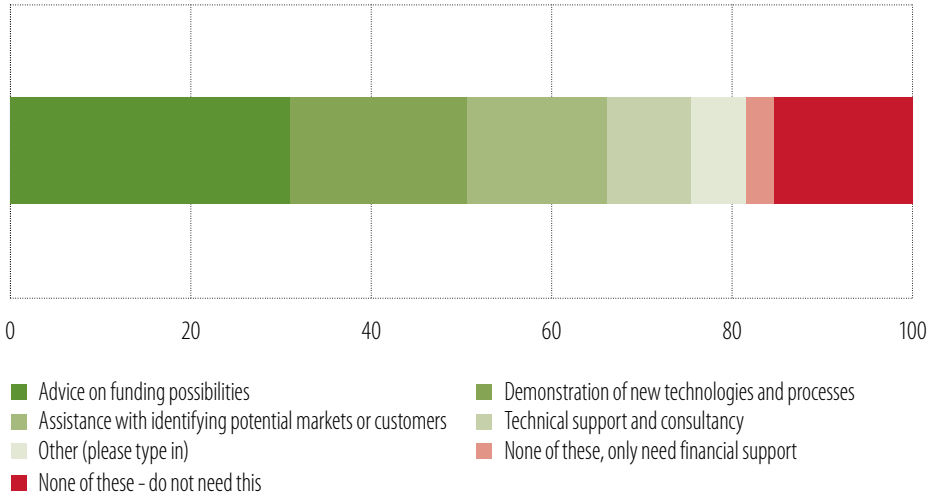
Figure 51
Perception of environmental legislation or regulation, share of environmental innovators
(in %)



Source: *EIB Online Survey on Environmental Innovations.*
Base: *All environmental innovators.*
Question: *To what extent, if at all, are each of these factors obstacles to making changes in your own company to respond to environmental impacts AND/OR offering products, services or processes intended to generate environmental impacts for your customers?*

In addition, firms say that advice on funding possibilities and the demonstration of new technologies and processes provide them with the most support. In the online module on environmental innovations, we asked companies if there was one type of support that would encourage them to introduce or develop environmental projects. The respondents clearly signalled that they need advisory support, advice on funding possibilities and demonstrations of new technologies and processes (Figure 52).

Figure 52
Policy preference, share of environmental innovators (in %)



Source: *EIB Online Survey on environmental innovations.*
Base: *All environmental innovators.*
Question: *From the following, which one type of support would encourage you the most to introduce or develop projects intended to generate environmental benefits?*

Conclusion and policy recommendations

Public support and government action to tackle climate change had increased prior to the pandemic, but it remains to be seen if that support will continue in the future. One risk is that we will leap from the COVID-19 frying pan into the climate fire, as Hepburn et al. (2020a) memorably put it. On the other hand, the pandemic proves that if public support is there, emergencies on a global scale can trigger decisive interventions from governments.

Changing public behaviour will require policy choices that support a green recovery. Aghion et al. (2020) for example found supporting evidence that both pro-environment attitudes and interaction with competition have a significant positive effect on the probability that a firm will focus on cleaner patents.

The set of different policies described in this chapter could be used intelligently to counteract any negative effects on energy innovation. One example are carbon prices, which can be designed in a way that makes prices inversely correlated to international oil prices. That inverse correlation could in turn balance out the negative impact declining oil prices have on innovation. Carbon markets could also generate useful income, giving governments the means to gradually steer the economy in a new direction. In line with Stiglitz (2019), carbon prices should be different "across time, over space, and with different uses." In Europe, the "market stability reserve" of the EU Emissions Trading System should at least ensure a more responsive effective supply (by removing permits from the market when there are too many).

Counter-cyclical stimulus worked during the financial crisis and might work again. The enormous surge in energy patents during the financial crisis, in spite of a decline in total patents, shows that public policy can play an important role. However, the counter-cyclical movement was within a sector that already had a head-start before the crisis hit.

Investments in infrastructure projects could prove largely beneficial in keeping the green innovation engine running. Infrastructure is a critical component of the innovation system and largely determines the feasibility of the adoption and diffusion of new technologies. In addition, recent calculations suggest that public infrastructure investments have the potential to offer high returns by driving down the costs of the clean energy transition. Infrastructure investments are also good for the workforce by curbing job losses resulting from the coronavirus pandemic. Infrastructure investments require specific policies because they only respond weakly to marginal price changes (Hepburn et al., 2020b).

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Chapter 9

Infrastructure investment in the face of digital, climate and cohesion challenges

A large share of EU municipalities still identify infrastructure gaps, even though investment in municipal infrastructure is increasing. These gaps are particularly frequent in Southern and Central and Eastern Europe, and pertain to infrastructure critical to facing the challenges of climate change and digitalisation. The findings of this chapter are based on the EIB Municipality Survey 2020, which queries 685 municipalities throughout the 27 EU Member States. Looking ahead, municipalities intend to increase investment, focusing on climate change and digitalisation. However, investment barriers – notably limited funding and regulatory red tape – are acting as a break. The first wave of the coronavirus pandemic reinforced the demand for more digital investment, while rekindling the need for social infrastructure.

How municipalities address green and digital challenges affects their outlook on climate change and is also related to local corporate innovation in these areas. Municipal digital sophistication (such as providing public services online) and green administrative capacity (such as adherence to green budgeting) are associated with greater assuredness towards economic transition risks. Municipalities that have jointly developed these attributes are also less pessimistic about the physical risks posed by climate change. Furthermore, combining results from the EIB Municipality Survey with the EIB Investment Survey (EIBIS) shows that, on a national level, the share of firms innovating and adopting technologies in digital and green areas rises with the share of municipalities that are digitally sophisticated and have developed green administrative capacities.

Municipalities are less able to close investment gaps if they are more reliant on capital transfers or grants. This poses a challenge for EU cohesion, since this inability to close investment gaps primarily affects municipalities in regions whose economic performance has been below par.

Introduction

This chapter looks at municipal infrastructure and capacity, focusing on the challenges of the digital transformation, climate change and economic cohesion. The results presented here rely chiefly on the EIB Municipality Survey 2020, which was conducted over the summer of 2020 and which includes 685 municipalities across EU Member States.[1] The survey specifically asks municipalities to assess their infrastructure gaps, investment needs and constraints. The survey also delves into the impact of the COVID-19 crisis and challenges related to climate change, decarbonisation and digitalisation.

The surveyed municipalities perceive a need to adapt their infrastructure to the challenges related to digitalisation, climate change, and economic cohesion as well as the coronavirus pandemic. Despite rising infrastructure investment, a large share of municipalities identified gaps in critical areas – especially concerning climate change and digitalisation. Funding, regulatory red tape and a lack of technical capacity are inhibiting investment. Regional differences are important, however, with Western and Northern Europe generally enjoying relatively more investment, fewer infrastructure gaps and investment barriers, as well as better-developed administrative capacities to engage with green and digital challenges. The unfolding coronavirus pandemic has reinforced demand for more digital investment and has rekindled the need to invest in social infrastructure.

Policy action needs to support municipalities in tackling these challenges. In the face of climate change, municipalities with greater digital sophistication (for instance the online provision of public services) and better developed green administrative capacities (such as green budgeting[2]) tend to be more assured. What is more, merging the EIB Municipality Survey 2020 and EIBIS firm-level data shows that the share of firms that are advanced digitally and environmentally rises in countries with large shares of municipalities with better digital and green credentials. Cohesion is also at stake. Municipalities in regions with sub-par economic performance tend to face more infrastructure challenges. What is more, the more those regions depend on capital transfers and grants for investment, the more difficulty they have in closing infrastructure gaps, notably in urban transport.

The remainder of the chapter is structured as follows. Section one provides a summary view of municipalities' assessment of their infrastructure, investment barriers, expected investment and the impact of the coronavirus pandemic. Section two digs into the municipal challenges emanating from climate change. In this context, we construct measures of municipalities' digital sophistication and green administrative capacity. Box A looks at how investment gaps and financing obstacles affect buildings' energy efficiency. Section three explores whether the state of municipal infrastructure in Europe is an obstacle to firms' investment activities. Section four looks at the relationship between municipalities' ability to close investment gaps and funding, focusing on municipalities dependent on state transfers and taking into account regional economic performance. Box B looks at the findings in more detail. The final section concludes with some considerations for policy implications.

1 The 2020 survey follows an inaugural run conducted in 2017.

2 Green budgeting seeks to align expenditure and revenue processes with climate and other environmental goals.

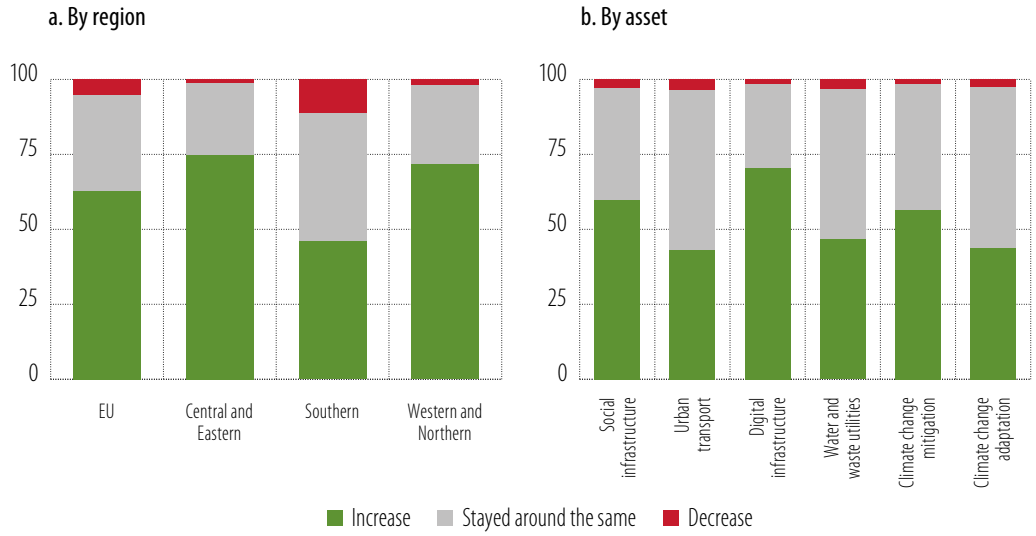
Municipal infrastructure investment: Gaps, barriers and outlook

Municipalities' assessment of local gaps

Nearly two-thirds of EU municipalities have increased their investment in infrastructure in the past three years. The outlier is Southern Europe, where over half of municipalities decreased investment or kept it constant. Northern Europe contrasts with other EU regions, with nearly three-quarters of municipalities increasing infrastructure investment (Figure 1b).[3]

Municipal investments predominantly targeted digital and social infrastructure as well as climate change mitigation (Figure 1a). Municipalities were asked about investment for six categories of infrastructure: social, urban transport, digital, water and waste, climate change mitigation and climate change adaptation. Investment increased most frequently in digital infrastructure (70%), social infrastructure (60%) and climate change mitigation (55%).

Figure 1
Infrastructure investment over past three years (share of municipalities, %)



Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/refused responses).*
Question: *Thinking back to between 2017 and 2019, did the overall investment spend on infrastructure in your municipality increase, decrease or stay around the same?*

Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/refused responses).*
Question: *Still thinking back to between 2017 and 2019, did investment in your municipality increase, decrease or stay around the same in each of the following areas? Please consider all infrastructure investment in your municipality, irrespective of who is responsible for the investment.*

The majority of municipalities said infrastructure investment in recent years was lacking, especially for climate change, digitalisation and urban transport. Respondents were asked about the adequacy of infrastructure investments in their municipalities over the past three years for each of the infrastructure assets mentioned above. Overall, the majority of municipalities said investment has been lacking, with only 40% saying it was broadly adequate. Perceptions about the adequacy of investment vary between

3 This picture is consistent with a general uptick of EU infrastructure investment since 2017. For more information, see Chapter 2 of this report.

regions and by the type of infrastructure. Investment is most frequently said to be lacking for: i) climate mitigation and adaptation, with three-quarters of municipalities not satisfied with the level for at least one of these areas; ii) digitalisation, with the majority of municipalities dissatisfied; and iii) urban transport, which roughly 45% of municipalities said was lacking (Figure 2b). Broad discrepancies exist between regions, however. Municipalities in Western and Northern Europe were more positive, with 55% saying they were broadly satisfied with recent levels of investment, while only 30% of municipalities in Central and Eastern Europe and in Southern Europe thought that investment was sufficient. (Figure 2a).

Figure 2

Adequacy of infrastructure investment over the past three years
(share of municipalities, %)

Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/ refused responses).*
Question: *Would you say that within your municipality the level of investment in infrastructure projects between 2017 and 2019 was broadly adequate, slightly lacking or substantially lacking in each of the following areas?*

Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/refused responses).*
Question: *Would you say that within your municipality the level of investment in infrastructure projects between 2017 and 2019 was broadly adequate, slightly lacking or substantially lacking in each of the following areas?*

Questions on municipal satisfaction with social and transport infrastructure reveal gaps, notably in affordable housing and electric charging stations for vehicles. Respondents were asked to evaluate the adequacy of their local infrastructure assets. These assets were grouped according to whether they serve either transport or social purposes. For transport, the group of infrastructure assets included: cycling lanes and footpaths, urban public transport, inter-urban and urban-rural transport connectivity, as well as electric charging stations for vehicles. Only 25% of municipalities said electric charging infrastructure was adequate. For social infrastructure, the underlying infrastructure assets included health and care, education and training, as well as social housing. Social housing stands out, with every second municipality identifying a lack.

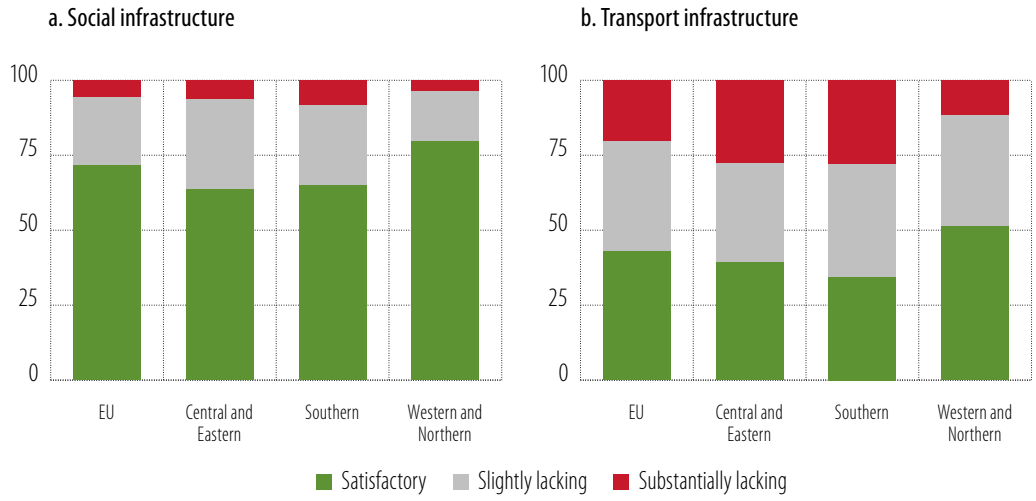
Aggregating over the assets in each group yields two measures of adequacy of municipal infrastructure: one for social infrastructure and the other for transport infrastructure. Figure 3 displays these measures of satisfaction with social (Figure 3a) and transport (Figure 3b) infrastructure by region.

Overall satisfaction with transport and social infrastructure confirms regional differences, while also showing that transport infrastructure is a source of discontent for the majority of municipalities.

Figure 3 shows that regions outside of Western and Northern Europe are more likely to say that social and transport infrastructure was inadequate. Comparing satisfaction between social and transport, satisfaction with social infrastructure is relatively frequent (70%) whereas the majority of municipalities identifies transport infrastructure as deficient (55%). Indeed, 20% of municipalities identify a severe gap in transport infrastructure.

Figure 3

Adequacy of stock (share of municipalities, %)



Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/ refused responses).*
Question: *For each of the following would you say that the quality of infrastructure is satisfactory, slightly lacking or substantially lacking? i) healthcare; ii) childcare; iii) care for elderly; iv) education and training; v) social and affordable housing.*

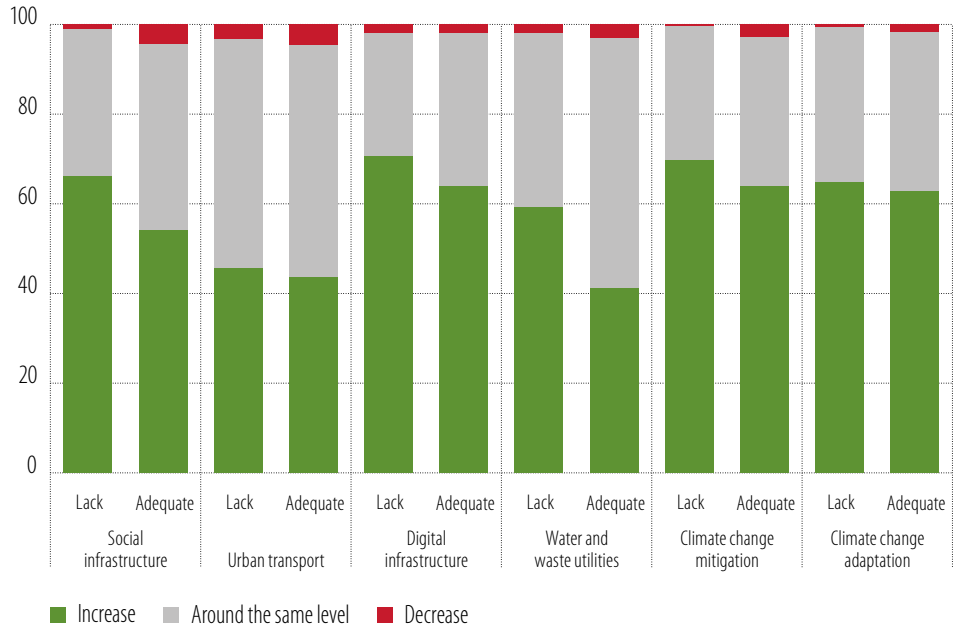
Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/refused responses).*
Question: *For each of the following would you say that the quality of infrastructure is satisfactory, slightly lacking or substantially lacking? i) Cycling lanes & footpaths; ii) Urban public transport; iii) including vehicles and related infrastructure; iii) inter-urban and urban-rural transport connectivity; iv) Electric charging stations for vehicles.*

Municipalities plan to increase investment over the next five years, looking to close gaps and prioritising digital and social infrastructure and climate change mitigation and adaptation (Figure 4). Three-quarters of municipalities plan to keep infrastructure investment at least stable over the same period. About 50% indicate they will increase investment, especially climate and digital investment. The share of investment in digital and climate infrastructure is even higher for municipalities that said recent investment in these two areas was insufficient.

With infrastructure investment set to increase, municipalities plan to focus on modernisation. As Figure 5 shows, over the past three years maintenance and repair has accounted for the largest share of municipal investment all over Europe. Southern European municipalities, in particular, spent nearly half of their investment on maintenance and repair, leaving little for new building or modernisation. Taken together with the relatively low levels of infrastructure investment and the inadequacy of both infrastructure stock and investment in Southern Europe as shown in Figures 1-3, the focus of investment on maintenance and repair indicates that investment gaps have continued to grow here. Municipalities expect, on average, to increase the share of infrastructure investment dedicated to modernisation to 40% over the coming five years. Municipalities in Central and Eastern Europe generally follow the same levels of investment for modernisation, while the share of investment dedicated to maintenance and repair is likely to remain high in Southern Europe.

Figure 4

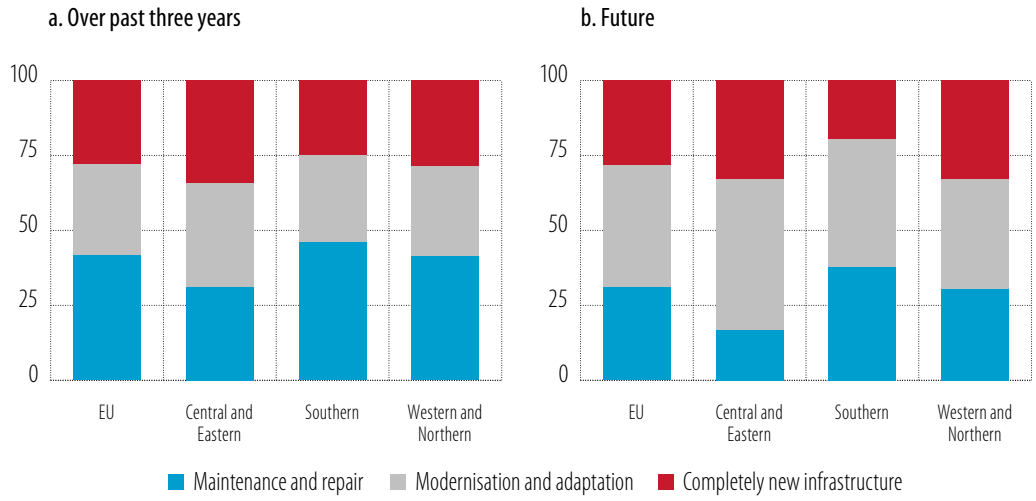
Expected composition of investment over the next five years, by adequacy (share of municipalities, %)



Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/refused responses).*
Question: *And for each of the following areas, over the next five years, does your municipality expect to increase, decrease or have around the same level of spending on infrastructure investment?*

Figure 5

Orientation of infrastructure investment (share of municipalities, %)



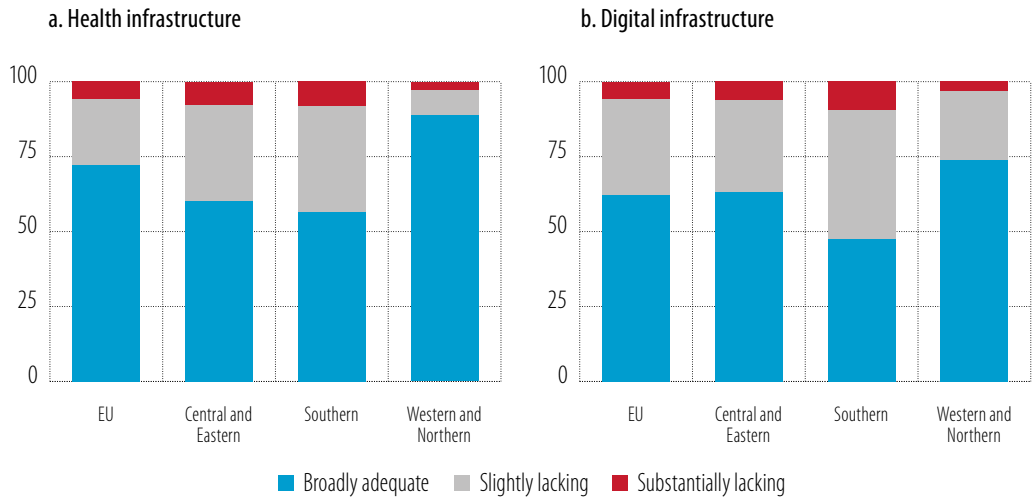
Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/refused responses).*
Question: *Over the past three years, what proportion of the investment was for…?*

Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/refused responses).*
Question: *And looking ahead to the next five years, do you expect the largest required share of investment on infrastructure to be for…?*

Impact of COVID-19

Faced with the coronavirus pandemic, a lack of digital and health infrastructure stifles the ability of a large share of Central and Eastern, and especially, Southern European municipalities to deal with the crisis (Figure 6). Everywhere it hit, the pandemic strained health and care infrastructure. Even where the spread of the virus had, by the time of the survey, been contained, the pandemic forced municipalities to reassess the resilience of their health infrastructure. At the same time, measures to contain the spread of the virus placed demands on other infrastructure, primarily digital infrastructure, for instance to facilitate teleworking. Even though the survey was conducted at a time when the first wave of the pandemic was still unfolding, many municipalities were already certain their municipal infrastructure would face problems dealing with the crisis. Of the municipalities in Southern Europe, more than 50% considered their digital infrastructure to be lacking, while 40% considered their health infrastructure to be insufficient. In Central and Eastern Europe, around 40% considered overall infrastructure lacking, with a greater share concerned about health infrastructure. In Western and Northern Europe, infrastructure deficiencies were less of an issue. One-quarter of municipalities were concerned about digital infrastructure, with a mere 10% expressing concern about their health infrastructure. Of course, a more complete assessment of responses will need to take into account the severity of the pandemic in the relevant regions.

Figure 6
Ability to cope with COVID-19 (share of municipalities, %)

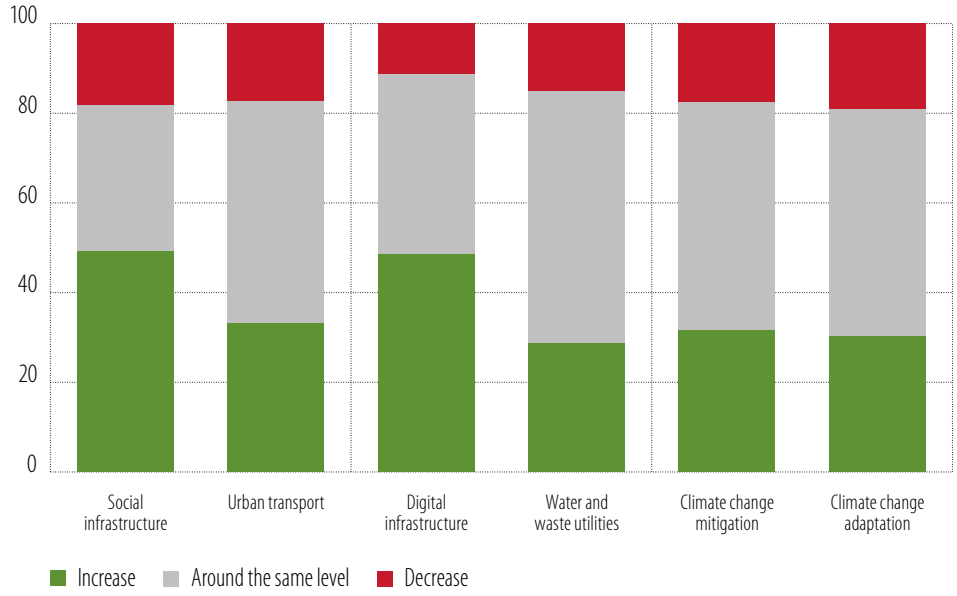


Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/ refused responses).*
Question: *To what extent is your health infrastructure able to cope with the current COVID-19 situation in your city?*

Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/refused responses).*
Question: *To what extent is your digital infrastructure able to cope with the current COVID-19 situation in your city?*

Already by the summer of 2020 some 40% of municipalities had determined that their investment plans would need to change as a result of the pandemic, with an emphasis on digital and social infrastructure (Figure 7). Nearly every second municipality said they expected to increase both social and digital investment – in Southern Europe this rises to 60%. In Western and Northern Europe it was still 50% for digital and 40% for social infrastructure. In Central and Eastern Europe, the pandemic's impact on investment plans is more evenly spread out across infrastructure categories.

Figure 7
Impact of COVID-19 on investment plans, by asset (share of municipalities, %)



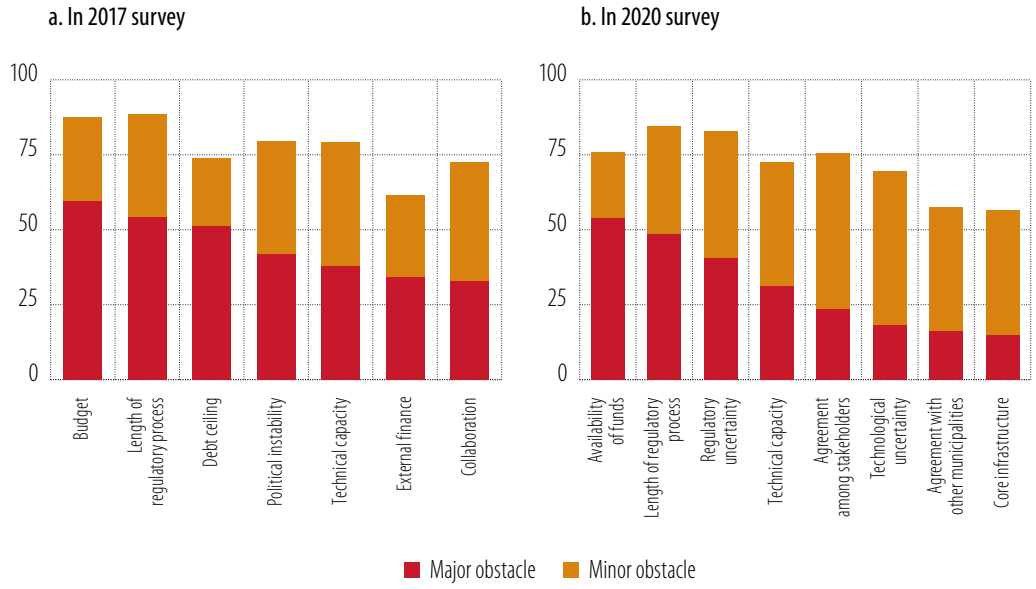
Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/refused responses).*
Question: *For each of the following areas will your municipality increase or decrease spending on infrastructure investment due to coronavirus, or have around the same level of spending on this area?*

Barriers to investment

Regulatory red tape and limited availability of funding remain the most frequently cited obstacles to investment, with limited funding commonly cited as a major obstacle (Figure 8). Municipalities were asked to indicate whether each of the following pose a major, minor or no obstacle to their infrastructure investment: i) funding; ii) technical capacity; iii) access to core infrastructure; iv) agreement with other stakeholders; v) agreement among stakeholders; vi) length of regulatory processes; vii) regulatory uncertainty; and viii) technological uncertainty. Municipalities most commonly cited regulatory red tape[4] (over four-fifths), and lack of funding (three-quarters of municipalities). In addition, every second municipality identified a lack of funding as a major obstacle. Other common barriers were stakeholder agreement, technological uncertainty and technical capacity. Though the categories have not remained entirely the same, the overall picture remains similar to that found in the 2017 edition of the EIB Municipality Survey, with funding and length of regulatory processes topping the list at the time.

4 Red tape lumps together the individually flagged obstacles of regulatory uncertainty and length of the regulatory process.

Figure 8
Municipal barriers to investment (share of municipalities, %)



Source: *EIB Municipality Survey 2017.*
Base: *All municipalities (excluding don't know/ refused responses).*
Question: *To what extent is your health infrastructure able to cope with the current COVID situation in your city? 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 2020.*
Base: *All municipalities (excluding don't know/refused responses).*
Question: *To what extent is your health infrastructure able to cope with the current COVID situation in your city? 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?*

Infrastructure financing

Given the prevalence and severity of lack of funding as a barrier to investment, a deeper understanding of the underlying issues is important. Municipal investment can be financed through internal resources, transfers (from central or regional government or EU funds) or from direct access to external finance (such as bank loans and bond issuances). The composition and magnitude of municipal investment funding is related to a number of factors, including municipality size, national governance structures and laws and regulations or the relative level of regional gross domestic product (GDP), which may affect revenue streams or entitlements to receive transfers and grants.[5] National laws and regulations can specify a number of criteria, including the types of revenue accruing to municipalities or the modalities of access to capital transfers and grants. Similarly, externally sourced municipal financing is often regulated at the national or regional level, including stipulations of which entities are entitled to borrow and for what purpose as well as debt ceilings. Aside from these factors, the structural economic features of the region or the municipality is important to determining the composition of funding, such as development of capital markets or the extent to which certain types of revenue are included in regional economic performance.

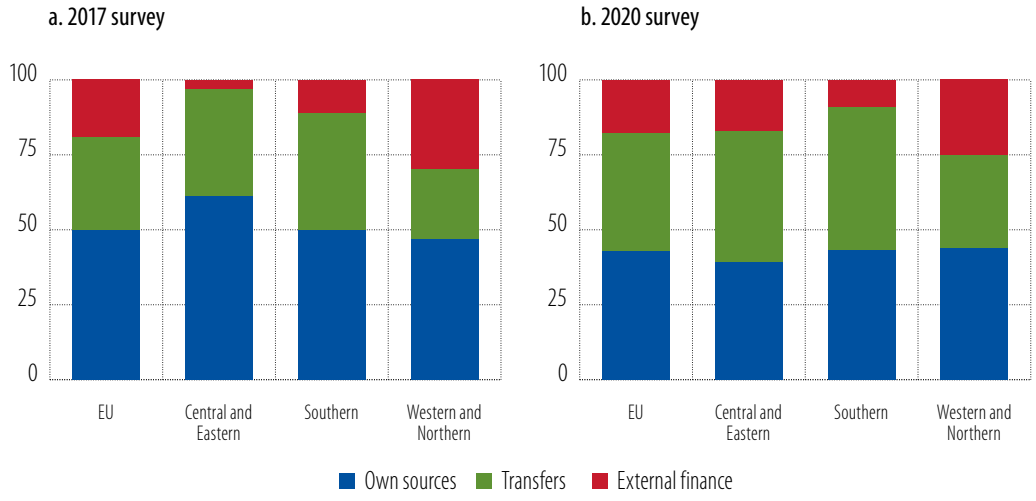
On average, 43% of municipal investments were funded from current income or their own resources; 39% by capital transfers; and 18% through external financing. Figure 9 shows the respective average

5 For a more general discussion on subnational funding, the reader might consider Organisation for Economic Co-operation and Development (OECD)/United Cities and Local Governments (UCLG) (2016), Subnational Governments around the world: Structure and finance.

breakdowns of funding as reported for the 2017 and 2020 editions of the EIB Municipality Survey.[6] The average reported reliance on capital transfers has increased in all regions from the 2017 poll to the one conducted in 2020. Of course, this increase can be due to a number of issues, including the composition of samples and responses, or a decline in municipal revenues or more difficult access to external financing. Still, it is noteworthy that the increase has been strongest in Central and Eastern Europe, where capital transfers now account for 43% of funding. Capital transfers are also dominant in Southern Europe, where they fund nearly half of activities. By contrast, in Western and Northern Europe, the share remained below one-third. Municipalities have traditionally relied more on external finance, particularly in Western and Northern Europe (now accounting for 25%). Lately, the share of external financing has increased to 18% in Central and Eastern Europe, but not in Southern Europe.

Figure 9

Financing composition (share of investment funding, %)



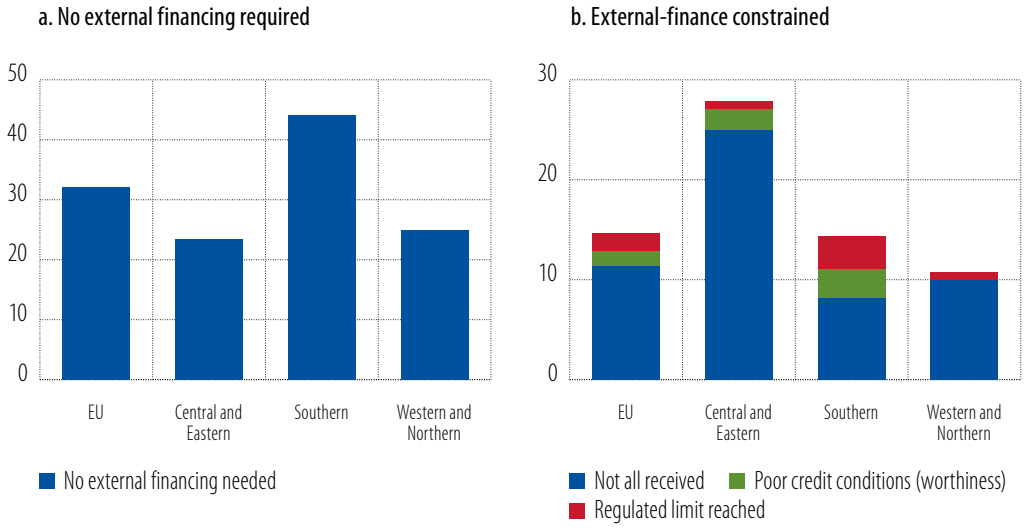
Source: *EIB Municipality Survey 2017.*
Base: *All municipalities (excluding don't know/refused responses).*
Question: *Can you tell me approximately what proportion of your infrastructure investment activities in the last three years were financed by each of the following?*

Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/refused responses).*
Question: *Can you tell me approximately what proportion of your infrastructure investment activities in the last three years were financed by each of the following?*

Survey results show that one in seven municipalities have difficulties accessing external finance. The survey defines external financing as financing raised – for the purpose of investment – via capital markets or in the form of loans obtained from commercial banks or promotional banks and institutions operating at the local, regional, national or international level. Of the respondents eligible to apply for external financing[7], more than 50% received all the financing requested and one-third had no need for external financing (Figure 10a). The remaining 15% can be considered finance-constrained, because either they did not receive all the funding they would have desired (11.5%); they already reached statutory debt limits (2%); or, based on their credit worthiness, they considered credit conditions prohibitive (1.5%) (Figure 10b). External credit-constrained municipalities are clearly more prevalent in Central and Eastern Europe, where this constraint affects every fourth eligible municipality. External finance constraints are least prevalent in Western and Northern Europe (10%).

6 85 municipalities did not report on the composition of their financing, with more than half of these from Central and Eastern Europe.
7 11 respondents indicated that their municipality is not entitled to borrow.

Figure 10
External financing in past three years, by region (share of municipalities, %)

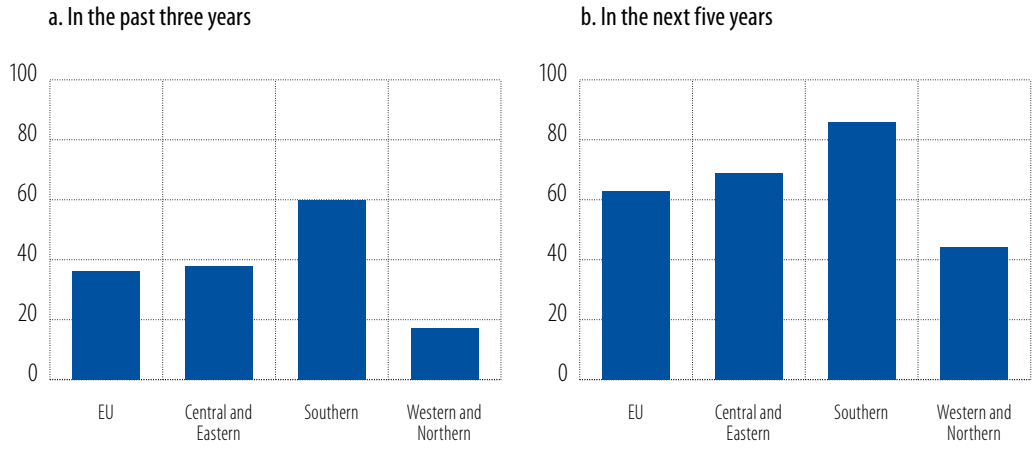


Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/ refused responses).*
Question: *Share of municipalities that did not use any external financing because no borrowing was required.*

Source: *EIB Municipality Survey 2020.*
Base: *Municipalities that didn't use external financing.*
Question: *Your municipality did not use any external financing, i.e. financing raised via capital markets or in the form of loans obtained from commercial banks or promotional banks and institutions operating at local, regional, national or international level. Was this because…?*
Looking back at the investments you had planned over the last three years, did you receive all of the external finance that you sought in order to execute the planned investments, or only some of the external finance you sought?

The share of municipalities reporting to have benefitted from EU financial instruments continues to rise, with more than one-third of municipalities saying they benefitted from such instruments – particularly in Southern Europe and in Central and Eastern Europe. (Figure 11). In terms of regional shares of municipalities having benefited from EU financial instruments over the past three years, nearly 60% of those in Southern Europe declared having done so compared to 38% of those from Central and Eastern Europe. In Southern Europe, the frequency of the use of financial instruments increases with municipal size. The share of municipalities benefitting from these instruments has doubled from that reported in the 2017 survey. Looking ahead, nearly two-thirds of EU municipalities expect to benefit from EU financial instruments (Figure 11b). More than two-thirds of those in Central and Eastern Europe and 86% in Southern Europe expect to take advantage of these instruments.

Figure 11
Use of EU financial instruments, by region (share of municipalities, %)



Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/refused responses).*
Question: *In the last three years, has your municipality benefited from EU-funded financial instruments such as subsidised loans, guarantees and other risk bearing mechanisms?*

Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/refused responses).*
Question: *In the next five years, in order to finance planned investment projects, does your municipality plan on benefiting from EU-funded financial instruments such as subsidised loans, guarantees and other risk bearing mechanisms?*

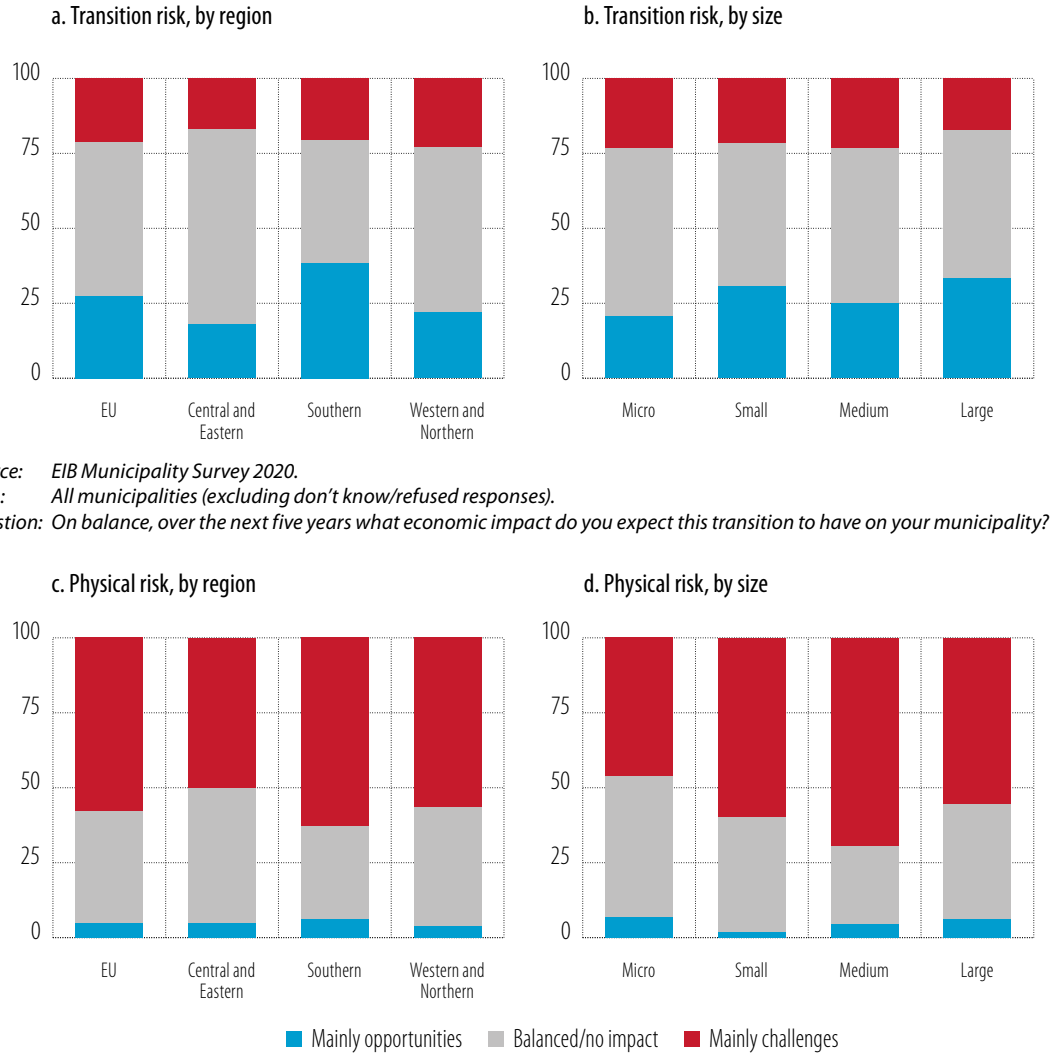
Climate change and municipalities' development of green administrative capacity and digital sophistication

Municipalities tackle the challenges of climate change

Municipalities are, on balance, more concerned about the physical risks of climate change, while adopting a more neutral view on transition-related risks. Municipalities were asked to evaluate their exposure to climate risk, distinguishing between physical risks and risks associated with the EU plans for a transition to a net-zero carbon economy. For each of these risks, respondents were asked to assess, on balance, whether they pose more of a challenge or opportunity, or whether the risks were broadly balanced or not relevant. The outlook on the transition risk is relatively balanced, with the neutral view prevailing, whereas concerns about the physical risks related to climate change dominate (Figure 12). Some 60% of EU municipalities consider physical risks to be a challenge, with slightly higher ratios in Southern Europe and in medium-sized municipalities. When requested to assess the economic impact of the EU transition towards a zero-emission economy, on the other hand, municipalities expressed rather balanced views, with 27% pointing to opportunities and 21% to challenges. Southern European municipalities, in particular, and especially large municipalities, tend to perceive some economic upside in the transition risks.

Finance constraints are the most frequently noted barrier to green and climate-related investment (Figure 13). Asked to identify the two principal barriers to green or climate-related investment, nearly 70% of municipalities flag finance, with a large majority identifying it as the primary obstacle. The next three categories are each cited by one-quarter of municipalities as among their principal constraints, namely length of regulatory process, regulatory uncertainty and lack of technical capacity.

Figure 12
Municipal perception of the impact of risks emanating from climate change (share of municipalities, %)



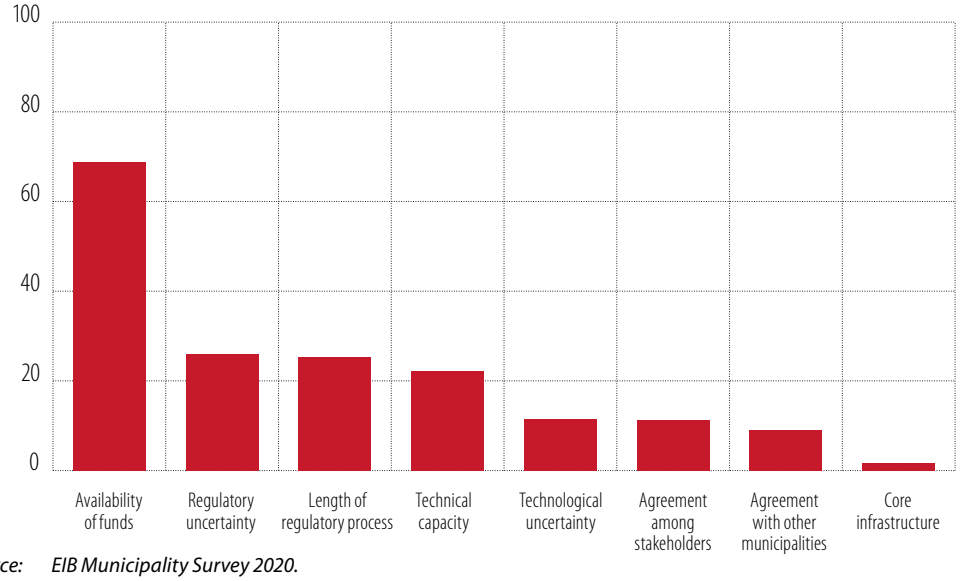
Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/refused responses).*
Question: *On balance, over the next five years what economic impact do you expect this transition to have on your municipality?*

Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/refused responses).*
Question: *Thinking about perceived climate change and changing weather patterns: over the next five years, what impact do you expect the physical risks associated with these weather events to have on your municipality?*

The negative impact of funding obstacles is particularly evident for infrastructure investments focused on climate change. As already discussed in the first section of the chapter, the perceived adequacy of infrastructure investment varies by infrastructure asset class (Figure 2). Since financing is a major obstacle to investment, Figure 14 juxtaposes groups of municipalities that perceive funding to be an obstacle against those that do not. For investment related to climate change, there is a clear difference between these groups. For municipalities that do not flag funding as an obstacle, a higher share consider climate investment to be adequate than for municipalities that experience funding obstacles. Digital, transport and social infrastructure also show differences between municipalities highlighting a slight lack of investment.

Figure 13

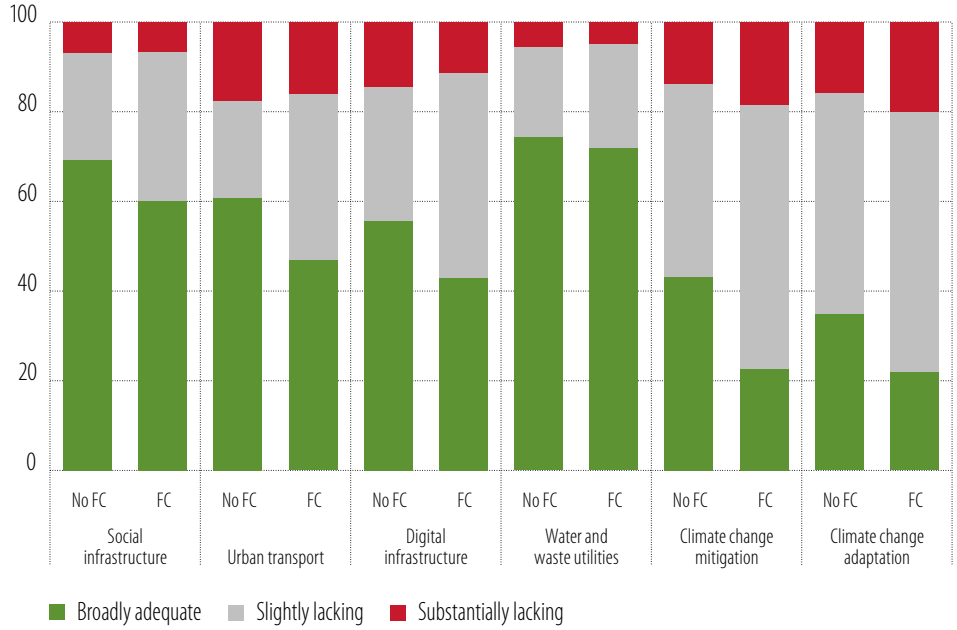
Municipal barriers to green or climate-related investment (share of municipalities, %)



Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/refused responses).*
Question: *Thinking of green or climate-related infrastructure investment, which are the two main obstacles to this type of investment?*

Figure 14

Adequacy of infrastructure investment for different asset classes, by perception of funding obstacle (share of municipalities, %)



Source: *EIB Municipality Survey 2020 and EIB staff calculations.*
Base: *All municipalities (excluding don't know/refused responses).*
Note: *Funding a major constraint (FC) vs. not (not FC).*
Question: *Would you say that within your municipality, the level of investment in infrastructure projects between 2017 and 2019 was broadly adequate, slightly lacking or substantially lacking in each of the following areas?*

Box A

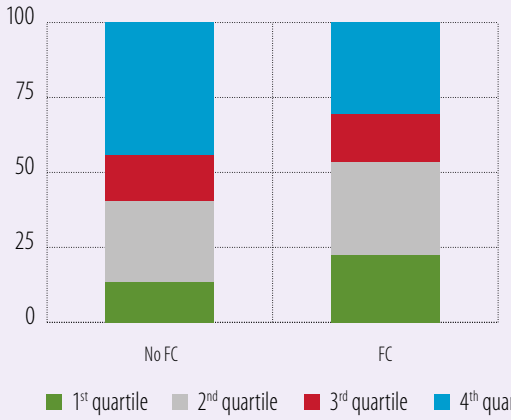
How does green matter? The case of energy-efficient buildings and the role for public finance

A positive relationship exists between adequate climate change-related investment and the energy efficiency of buildings – funding obstacles, however, limit those investments. To examine the issue further, this box draws on municipalities' estimates of the share of public buildings that meet the highest national norms on energy efficiency.[8]

Municipalities that do not identify funding as an obstacle to investment tend to have higher shares of energy-efficient public buildings. Figure A.1a reports the quartiles of shares of energy-efficient buildings, juxtaposing those facing funding as an obstacle against those that do not. Clearly, the higher share of energy-efficient buildings (the fourth quartile) is found in the group that does not face financing constraints.

Figure A.1a

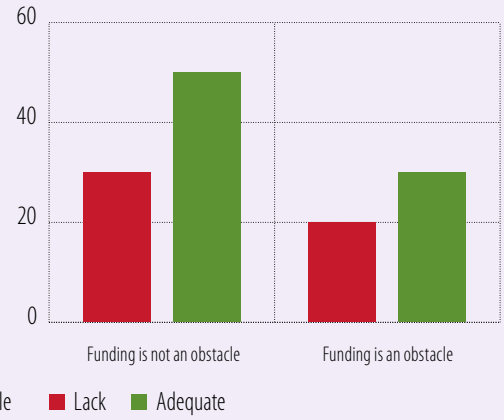
Share of energy-efficient public buildings, quartiles by funding obstacle (share of municipalities, %)



Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/ refused responses).*
Note: *Share of public buildings out of all public building stock whose energy rating meets the current national energy efficiency standards.*

Figure A.1b

Share of energy-efficient public buildings, by adequacy of investment in climate change mitigation and funding obstacle



Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/refused responses).*
Note: *Share of public buildings out of all public building stock whose energy rating meets the current national energy efficiency standards.*

Even where climate-related investment is considered adequate, funding barriers have a major impact on energy efficiency. For the 344 municipalities that say recent investment in climate change infrastructure was inadequate, the mean share of energy-efficient buildings is 29%, and the median is 20%. On the other end, for the 105 municipalities that indicated this type of investment was adequate, the mean and median are 40%. Figure A1b shows how funding obstacles push down the average. It shows the median shares of energy-efficient buildings by adequacy of investment and presence of funding constraints. For municipalities with adequate climate investment, the share of

8 Survey responses are not audited, and so their exactness cannot be guaranteed. It is worth noting, however, that municipalities that commissioned energy audits reported a higher average share of energy-efficient buildings compared to those that had not undertaken an energy efficiency audit.

energy-efficient buildings depends on whether financing is an obstacle. Those municipalities that face funding obstacles record a mean of 36%, and median of 30%. By contrast, those municipalities that do not face this barrier report a mean share of 47% and a median share of 50%. For municipalities that deem climate investment to be inadequate, on the other hand, the impact of financial constraints is less palpable.

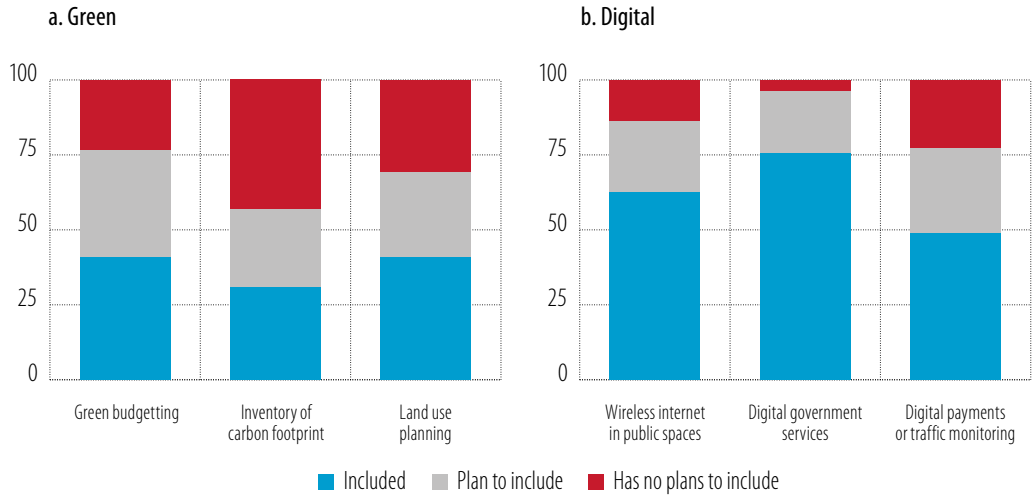
Municipal digital sophistication and green administrative capacity

As climate change and the digital transformation unfold, municipalities are becoming more sophisticated and adapting their administrative capacity. Climate change and digitalisation present paradigm shifts. They demand that economic participants, including municipal authorities, acquire new ways of operating. The EIB Municipality Survey 2020 detects whether certain underlying capacities have been developed. These capacities are split into two sets: green and digital.

- **green underlying capacities** are i) green budgeting or procurement; ii) the existence of an inventory of the carbon footprint; and iii) land-use planning, including to deal with extreme weather events;
- **digital underlying capacities** are i) the provision of wireless internet in public spaces; ii) the provision of digital or online government services; and iii) and digital payment systems or real-time traffic monitoring for public transport.

Figure 15 provides a summary view of how these capacities are distributed across municipalities.

Figure 15
Municipal administrative capacity and sophistication (share of municipalities, %)



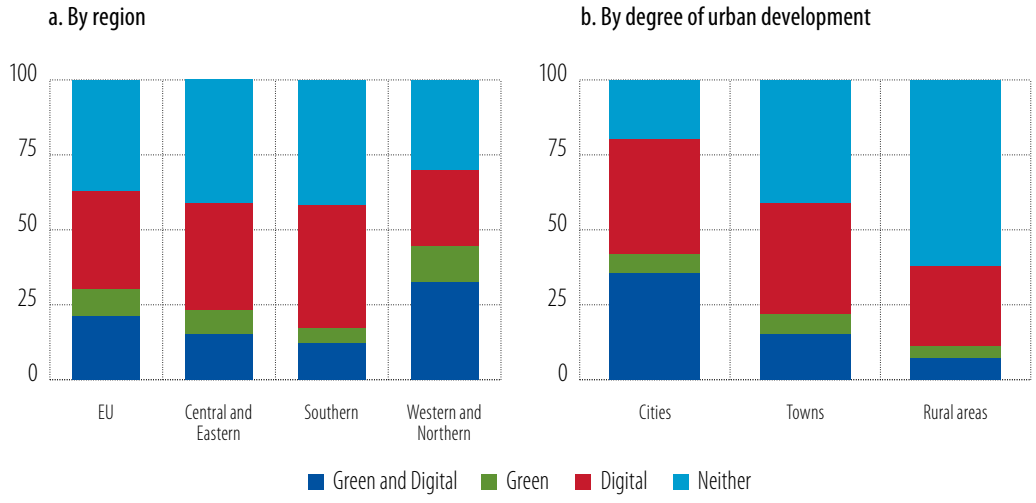
Source: *EIB Municipality Survey 2020 and EIB staff calculations.*
Base: *All municipalities (excluding don't know/refused responses).*
Question: *For your municipality's infrastructure investments, have you included, do you plan to include or do you have no plans to include in the next five years, any of the following considerations or types of projects?*

Aggregating the data for each category allows us to measure municipal digital sophistication and green administrative capacity. We introduce two indicators based on the survey responses, one for green capacity and the other for digital sophistication, which serve as a proxy for the degree to which

municipalities are developing their ability to meet the challenges of climate change and digitalisation.[9] Each of these indicators represents an aggregate of a set of underlying capacities. For the purposes of this chapter, each measure of underlying capacity is rendered dichotomous: either it is in place or it is not. Pairing the dichotomous variables yields four possible combinations. Municipalities are therefore labelled according to a binomial classification for green and digital capacity: i) green and digital; ii) green (and not digital); iii) digital (and not green); and iv) neither green nor digital.

Measures of municipal digital sophistication and green administrative capacity suggest disparities exist between and within regions – and are also influenced by the degree of urbanisation. Over one-third of EU municipalities have poorly developed green administrative capacity and digital sophistication, whereas one-fifth are well developed in these respects. The remainder have developed one of the capacities. Digital sophistication is clearly more frequently developed than the green capacities being considered. At the regional level, Western and Northern Europe lead in green and digital capacities. Yet, even within Northern and Western Europe there is a clear divide, with one-third of municipal capacities being poorly developed against one-third being well developed. That being said, other regions see a degree of specialisation. Southern Europe is quite advanced in terms of digital sophistication. Central and Eastern Europe, on the other hand, is slightly ahead in green. Both of these regions have large shares of municipalities with poorly developed green and digital capacities (Figure 16a). The degree of urbanisation appears to be an important factor in developing these capacities. Rural municipalities exhibit a low share of both green and digital capacities, whereas towns have a similar share of digitally enabled capacities as cities (Figure 16b).

Figure 16
Municipal development in digital and green capacities (share of municipalities, %)



Source: *EIB Municipality Survey 2020 and EIB staff calculations.*
Base: *All municipalities (excluding don't know/refused responses).*
Question: *See Figure 15 for the definition of digital sophistication and green capacity.*

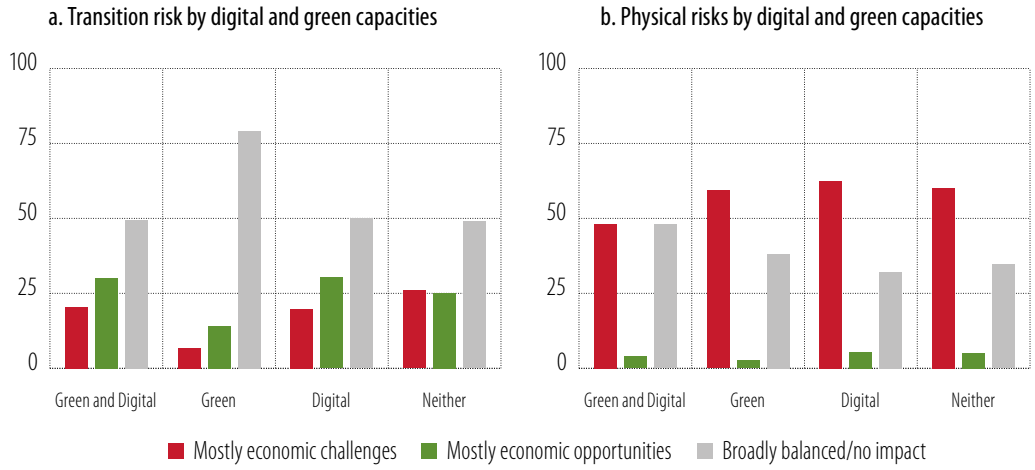
9 The concepts of green administrative capacity and digital sophistication are, of course, complex and multi-dimensional, with different development paths chosen based on a number of factors. The European Committee of the Regions and European Commission have various publications that highlight their importance, including the importance of service delivery and digitalisation and its implication for implementation and innovation as well as business environment. See, for instance, Administrative capacity of local and regional authorities, Committee of the Regions, 2018, or Quality of Public Administration – A Toolbox for Practitioners, European Commission, 2017. Adequately capturing the extent to which a municipality has developed these capacities is therefore challenging. Two remarks for the interested reader: i) an important question is whether the existence of an underlying capacity relates to local capacity or is simply a reflection of a national wave. Clearly national and regional factors matter. The reader may take some comfort from the fact that the national distributions suggest that deployment is far from uniform. ii) Administrative capacity is a broad concept and alternative specifications are, of course, legitimate. One might consider audits on energy efficiency or exposure to climate change. The survey allows for this. Initial results based on such specifications find the same general trends as in this chapter.

Municipalities that do not have well-developed green administrative capacity or digital sophistication tend to be less optimistic about the economic transition (Figure 17a). For the most part, municipalities without either green or digital capacities view transition risks neutrally. This deviates from the more optimistic overall outlook displayed in Figure 12a. As Figure 16b shows, municipalities without developed green capacity or digital sophistication tend to be located in rural areas. Figure 12b shows that the smallest municipalities tend to be more pessimistic. On the other hand, the remaining municipal groupings have developed either green capacity or digital sophistication. For these, the net balance of perceptions is tilted towards seeing opportunity and away from perceiving challenges. A balanced outlook dominates among these more optimistic groups, particularly for municipalities focused on developing green capacities. Several factors could be at play here. Future research could control for more objective assessments of transition risks for the area as well as for economic development. Still, digital sophistication and green administrative capacity could be important factors in helping municipalities deal with climate change.

Concerns about physical risks tend to be less pronounced in municipalities that have developed both green administrative capacity and digital sophistication (Figure 17b). This finding supports the potentially complementary nature of green and digital capacities for municipalities facing the physical risks posed by climate change. As Figure 16 shows, these municipalities tend to be located in Western and Northern Europe, and are often cities.

Figure 17

Perception of climate change-related risks by infrastructure adequacy and administrative capacity (share of municipalities, %)



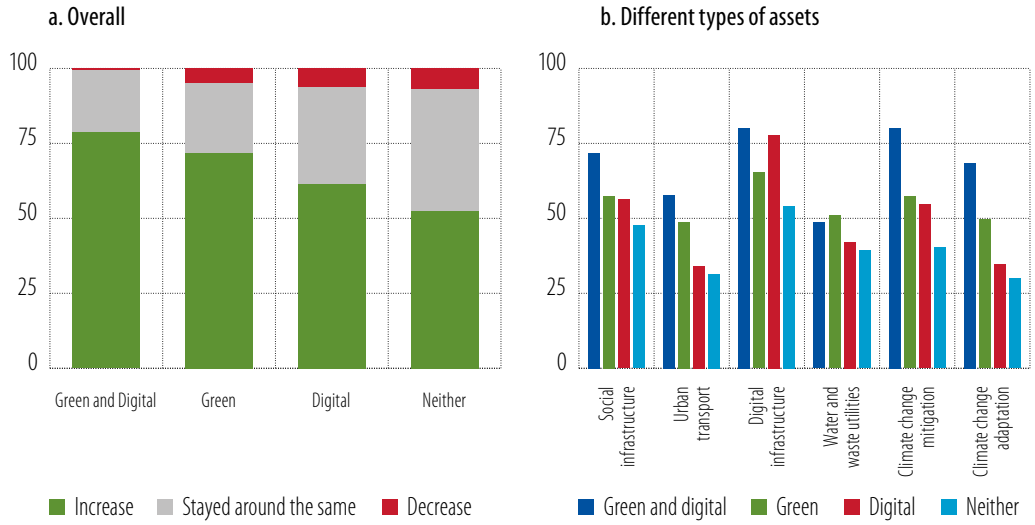
Source: *EIB Municipality Survey 2020 and EIB staff calculations.*
Base: *All municipalities (excluding don't know/refused responses).*
Note: *See Figure 15 for the definition of digital and green capacity.*
Question: *On balance, over the next five years what economic impact do you expect this transition to have on your municipality?*

Source: *EIB Municipality Survey 2020 and EIB staff calculations.*
Base: *All municipalities (excluding don't know/refused responses).*
Note: *See Figure 15 for the definition of digital sophistication and green capacity.*
Question: *Thinking about perceived climate change and changing weather patterns: over the next five years, what impact do you expect the physical risks associated with these weather events to have on your municipality?*

Digital sophistication and green capacity appear to have grown with recent municipal investments (Figure 18). Municipalities that have invested in recent years tend to have more developed green and digital capacities, in general and across infrastructure type. Where both digital and green capacities are advanced, the share of municipalities that invested was highest across infrastructure types[10], followed by green and digital.

10 The high share of municipalities with digital as well as digital and green capacities suggests that some overlap exists between digital sophistication and digital infrastructure. This is not surprising, since elements of digital sophistication might be considered as intangible digital infrastructure, for example digital public services, online payments or real-time traffic monitoring.

Figure 18
Infrastructure investment over past three years, by digital and green capacity
(share of municipalities, %)



Source: *EIB Municipality Survey 2020 and EIB staff calculations.*
Base: *All municipalities (excluding don't know/refused responses).*
Note: *See Figure 15 for the definition of digital sophistication and green capacity.*
Thinking back to between 2017 and 2019, did the overall investment spend on infrastructure in your municipality increase, decrease or stay around the same?

Source: *EIB Municipality Survey 2020 and EIB staff calculations.*
Base: *All municipalities (excluding don't know/refused responses).*
Note: *See Figure 15 for the definition of digital sophistication and green capacity.*
Still thinking back to between 2017 and 2019, did investment in your municipality increase, decrease or stay around the same in each of the following areas?

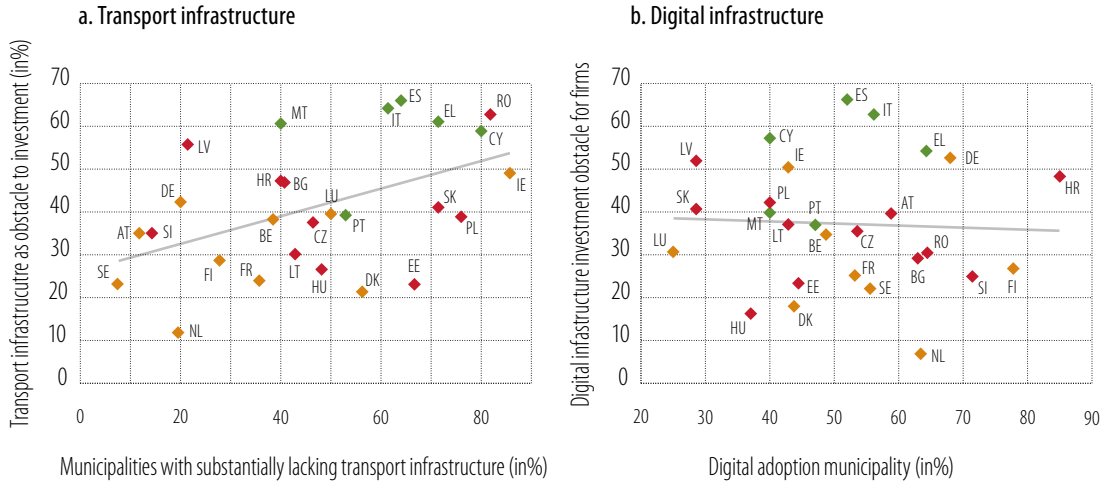
Green and digital orientation: Synthesising municipal and corporate data

Is the state of municipal infrastructure in Europe an obstacle to firms' investment activities? This section aims to explore this question by combining EIBIS firm-level data and the EIB Municipality Survey 2020. To this end, the datasets are aggregated to the national level. The EIBIS records firms' perception of whether inadequate access to infrastructure poses an obstacle to their investment activities. As explained in the previous section, the municipality survey provides insight into the state of municipal transport and digital infrastructure as well as municipal digital sophistication and green administrative capacity. These indicators are cross-referenced with firm data from the EIBIS that was collected in different EU countries. Additionally, patent data are used to draw basic inferences about innovation.

The quality of transport and digital infrastructure is correlated with firms' investment decisions (Figure 19). Firms complain more frequently about transport being an obstacle to investment in countries where a high share of municipalities claim to severely lack transport infrastructure. The better the transport infrastructure, the less an impact it has on firms' general investment activities. The link between digital infrastructure and investment activities is weaker. In countries where a higher share of municipalities say digital capacity is low, firms complain slightly more often about digital infrastructure being an obstacle to investment.

Figure 19

Perceived municipal infrastructure quality and firms' investment barriers
(share of municipalities, %)



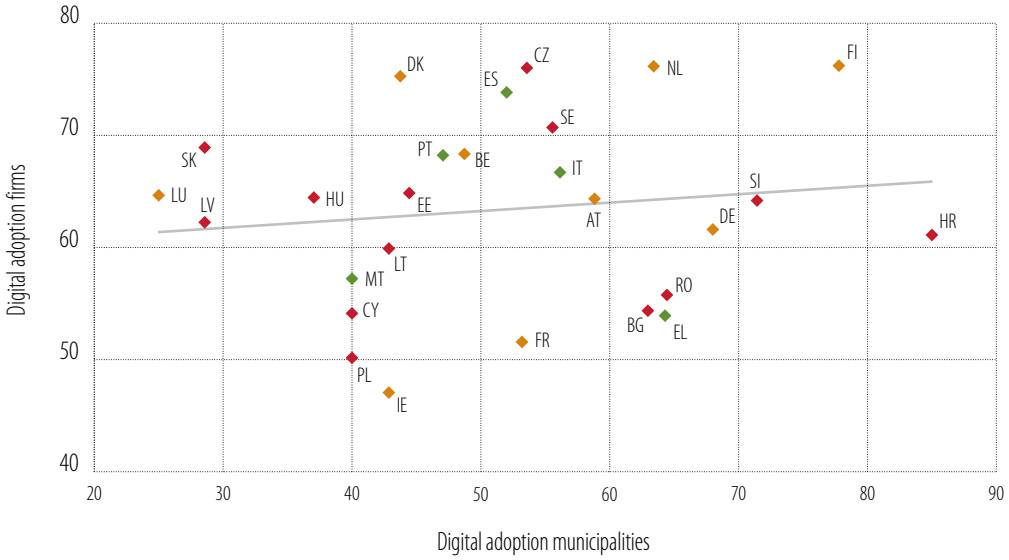
Source: *EIBIS 2020 and EIB Municipality Survey 2020.*
Note: *See note to Figure 3b for the definition of municipal transport infrastructure.*
Question: *Is the availability of adequate transport infrastructure an obstacle?*

Source: *EIBIS 2020 and EIB Municipality Survey 2020.*
Note: *See Figure 15 for the definition of municipal digital sophistication.*
Question: *Is the access to digital infrastructure an obstacle?*

Municipal digital sophistication is positively correlated with firms' uptake of digital technologies. Firms have higher rates of digital adoption in countries where a high share of municipalities are digitally sophisticated. Figure 20 displays a positive correlation between municipal adoption of digital technologies and digital adoption rates of firms.

Figure 20

Digital adoption



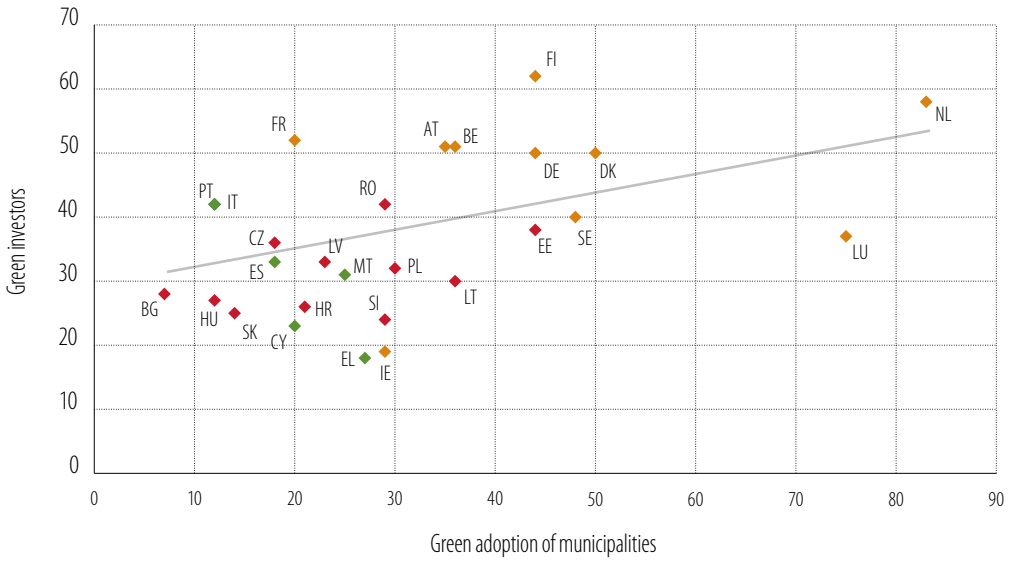
Source: *EIBIS 2020 and EIB Municipality Survey 2020.*
Note: *See Figure 15 for the definition of municipal digital sophistication.*

Firms made more green investments in countries where a high share of municipalities have good green administrative capacity – firms in those countries also cited the cost of an investment as less of an obstacle. Figure 21a plots green municipal capacity against the share of firms making green investment. It illustrates a clearly positive relationship between the two, highlighting the importance of putting in place the right infrastructure for firms' investments. What is more, in countries where a high share of municipalities have good climate capacity, firms complain less about cost being an obstacle when investing to prepare for weather events or to cut emissions.

Figure 21

Municipal green capacity vs. firms' perceptions and behaviour (share of municipalities, %)

a. Climate adoption

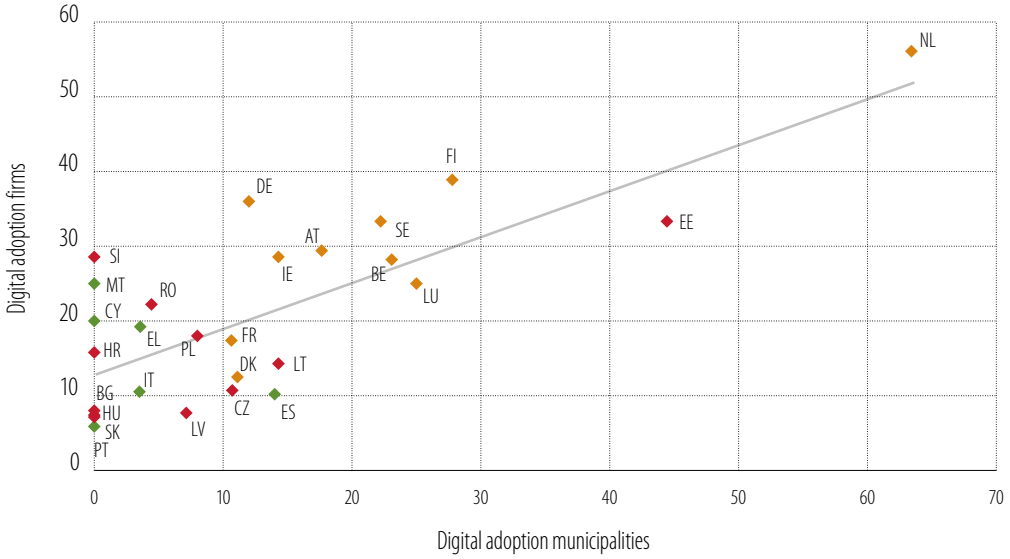


Source: *EIBIS 2020 and EIB Municipality Survey 2020.*
Note: *See note to Figure 15 for the definition of municipal green administrative capacity.*
Question: *Has your company already invested to tackle the impacts of weather events and reduction in carbon emissions?*

b. Cost as obstacle

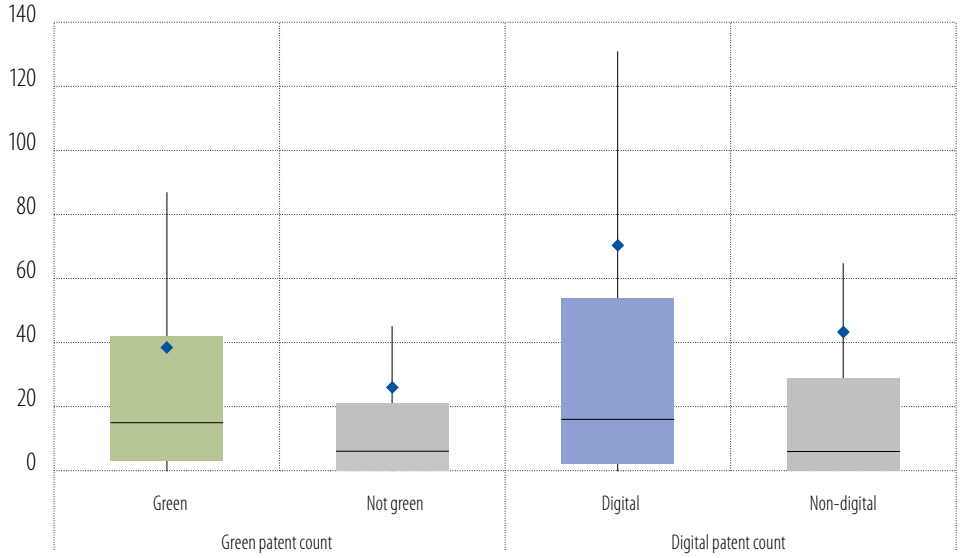
Source: *EIBIS 2020 and EIB Municipality Survey 2020.*
Note: *See note to Figure 15 for the definition of municipal green administrative capacity.*
Question: *Are costs an obstacle to investing in activities to tackle the impacts of weather events and emissions reduction?*

Figure 22
Digital and green adoption (share of municipalities, %)



Source: *EIBIS 2020 and EIB Municipality Survey 2020.*
Note: *See note to Figure 15 for the definition of municipal green capacity and digital sophistication.*

Figure 23
Digital and green patents (share of municipalities, %)



Source: *Authors' calculations based upon European Patent Office PATSTAT data in collaboration with the Centre for Research and Development Monitoring (ECOOM) in Belgium.*
Note: *The figure shows the distribution of – and average count of – green or digital patents in the NUTS3 region, for green and digital municipalities and their counterparts.*

Though driven by the developed regions in Western and Northern Europe, a strong relationship exists between municipalities with strong green capacities and digital sophistication and firms that have a competitive advantage in the green and digital domains (Figure 22). EU governments have made efforts to invest in green and digital infrastructure in recent years. In Central and Eastern Europe, as well as in Southern Europe, it seems that firms' green and digital investment is racing ahead of efforts by municipalities.

The shares of green and digital municipalities and of firms that are innovative in green and digital domains appear to develop in tandem (Figure 23). The number of green patent applications is clearly higher in regions with green municipalities. A similar picture emerges for digital innovation. This finding suggests that there is a clear link between the development of regional infrastructure and innovation activities. While further research is needed to assess the link, academic research supports the idea that infrastructure helps determine the innovative capacities of regions (see Porter and Stern (2001) for one of the seminal papers on this topic).

Cohesion

Regional characteristics

For decades, EU cohesion policy has focused on the disparities between low-income and high-income regions and the convergence among them. This focus has motivated institutional development on a historic scale by creating expectations about prosperity in countries in Central and Eastern Europe. It is reckoned to be only part of regional development strategies in recent contributions to the academic literature on regional policy (Barca, 2009; Barca, McCann, and Rodríguez-Pose, 2012; OECD, 2009). Attention should also be paid to social inequality and economic underperformance, even in higher income regions.

Economic performance varies across regions, within Member States and across the European Union. To study these discrepancies more closely, we compared NUTS3 regions based on their economic growth over the past 20 years, conditional on their initial income per capita, instead of simply grouping them based on income per capita.[11] The approach makes it possible to focus on economic underperformance and how it relates to infrastructure and investment.

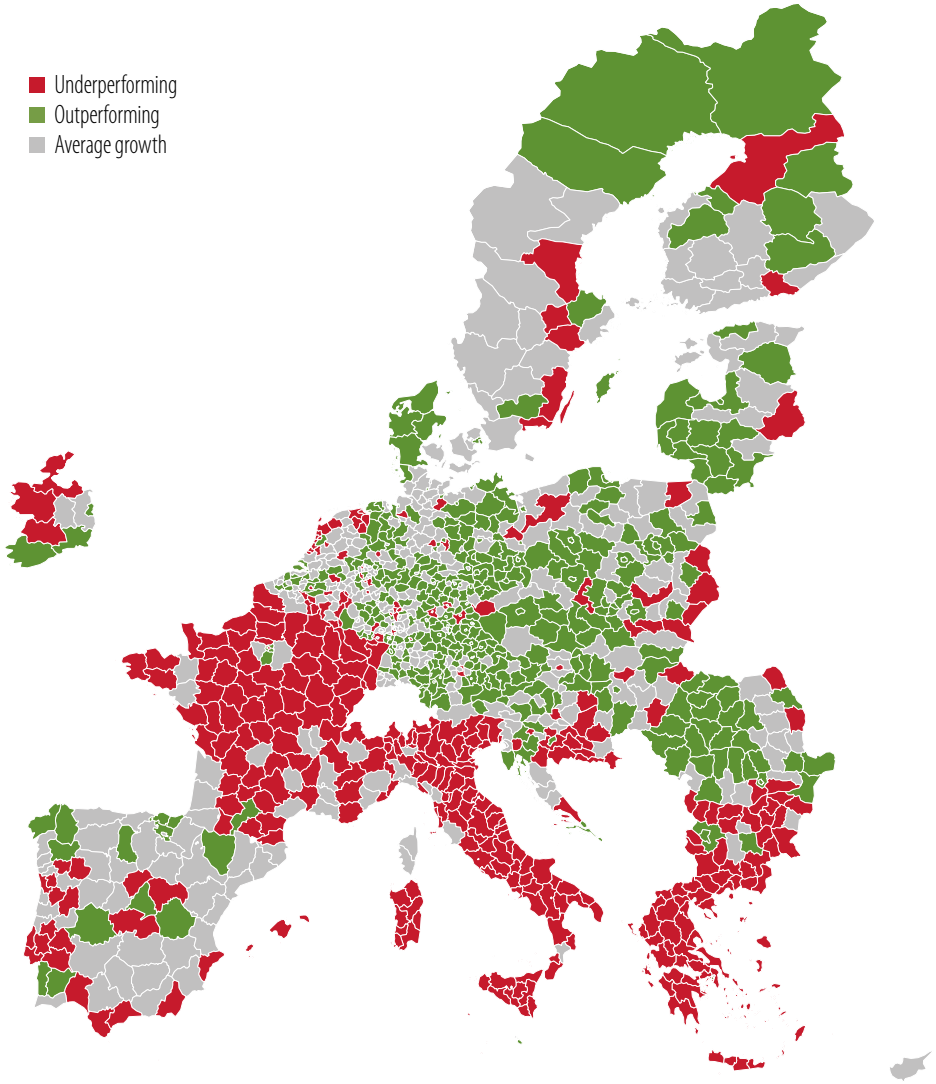
The analysis contrasts the results of the EIB Municipality Survey 2020 for regions that have grown at about the EU average, against those that have grown rapidly and those that have grown slowly. If a region grows too slowly relative to the rest, conditional on its initial income in 2000, then it is classified as a region in relative decline, or underperforming. Regions growing faster than the average are grouped into a category of relative growth, or outperforming. Regions close to the average are classified as average growth regions.[12] Not all regions in relative decline are poor regions. For instance, the GDP per capita (in purchasing power standards, or PPS) of the Italian NUTS3 Reggio nell'Emilia was 122% of the European Union average in 2017. It is nevertheless classified as a region in relative decline, as it has grown too slowly from 2000 to 2017 compared to peers, with 1% average annual growth.[13] Figure 24 shows the geographic distribution of regions classified according to this categorisation.

11 The nomenclature of territorial units for statistics, abbreviated NUTS (from the French version Nomenclature des Unités territoriales statistiques) is a geographical nomenclature subdividing the economic territory of the European Union into regions at three different levels: NUTS 1, 2 and 3 respectively, moving from larger to smaller territorial units. See also the Data annex of this report.

12 Too little here means that the average annual growth rate of a region from 2000 to 2017 results in GDP per capita in 2017 that is in the lower third of growth rates in the population of NUTS3 regions, conditional on its GDP per capita in purchasing power standards (PPS) in 2000. Very rapid growth is used when the average annual growth rate is in the top third of the regional growth distribution, conditional on GDP per capita in PPS in 2000. The middle third defines average growth.

13 The estimated average annual growth of GDP per capita of this region in 2000 is 2%. Because of its sub-par growth, GDP per capita of this region fell from 162% relative to the EU27 average in 2000 to 122% 17 years later – a decline of 40 percentage points.

Figure 24
EU NUTS3 regions classified according to their relative economic growth, 2000-2017



Source: *Eurostat and EIB staff calculations.*

Outperforming regions account for about 36% of the EU population (Table 1). Underperforming regions are home to 30% of the EU population. They are more sparsely populated compared to the rest and their population is ageing faster. The employment rates of underperforming regions are smaller and were stable from 2000-2017, in contrast to the average growth and outperforming regions. Employment rates have increased 2.1 percentage points for average-growth regions and 4.8 percentage points for outperforming regions over the period (Table 1).

Table 1

Demographic labour market characteristics of EU NUTS3 regions

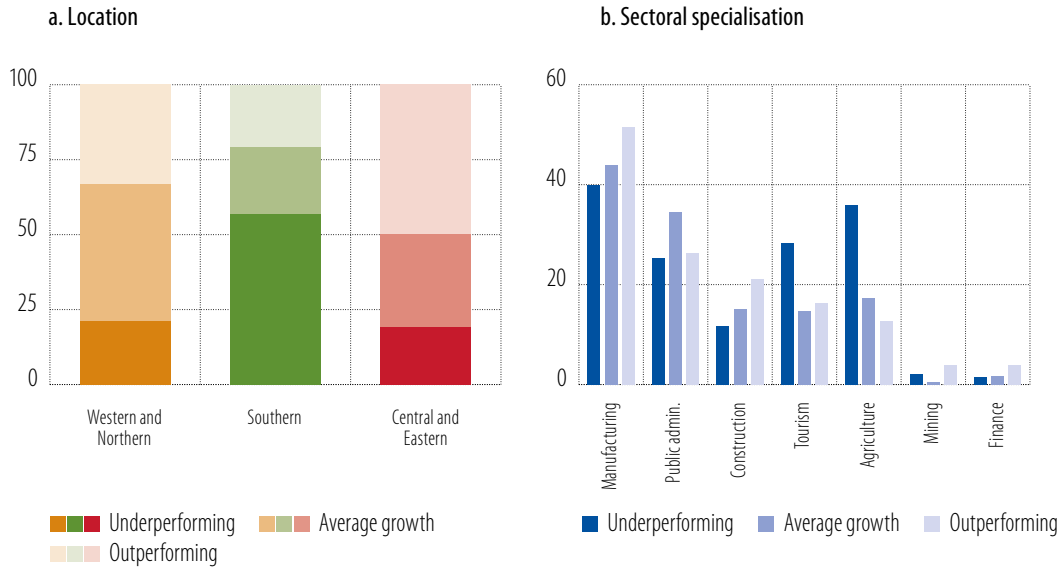
Enabling technologies	Underperforming regions	Average-growth regions	Outperforming regions
		Demographics	
Share of total population, %	30	34	36
Population density, persons/km^2	91	131	157
Old dependency ratio, %	34	32	31
		Labour market	
Employment rate, %	39	44	48
Employment rate, p.p.	0.1	2.1	4.8

Source: *Eurostat and EIB staff calculations.*
Note: *Old dependency ratio is the population over 65 years as a share (in %) of the population of 15-64 years. The employment rate is the percentage of total employment to total population. Employment rates are not necessarily bounded by 100 due to workers commuting across NUTS3 regional borders. The change in the employment rate is the within-group median of the total change over 2000-2017 in percentage points. All measures, except the share of population, use the median within the group.*

In the EIB Municipality Survey 2020, Central and Eastern Europe contains more regions in relative growth than in relative decline (Figure 25a).[14] The share of outperforming regions in Western and Northern Europe is about one-third. In Southern Europe, on the other hand, nearly 60% of the regions have grown slowly from 2000 to 2017 and are classified as underperforming. Regions that grew relatively rapidly are home to significantly more manufacturing, construction and finance (Figure 25b). In turn, the slow-growth regions rely much more on agriculture and tourism.[15]

Figure 25

Location and sectoral specialisation of regions (share of municipalities, %)



Source: *EIB Municipality Survey 2020, Eurostat and EIB staff calculations.*

14 The regional performances gleaned from the EIBIS Municipality Survey 2020 are broadly similar to the shares in the population of NUTS3 regions for Western and Northern Europe and for Central and Eastern Europe. In Southern Europe there is a significant difference, however. According to Eurostat, the share of the population living in underperforming regions is 73%, higher than the 57% in the EIBIS Municipality Survey 2020.

15 Farole, Goga, and Ionescu-Heroiu (2018) observe that, on current trends, mostly low-income regions in Central and Eastern Europe will surpass mostly low-growth regions in Southern Europe by 2025.

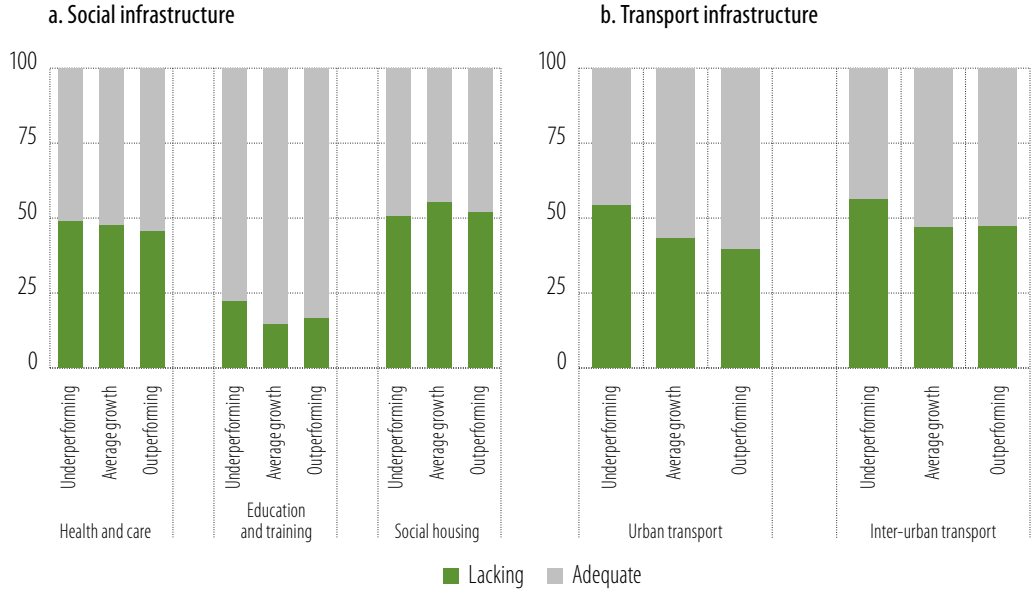
The locally available and required infrastructure will vary with socioeconomic characteristics. The different demographic and industrial structures require, to some extent, different infrastructure. Regions with a greater share of elderly people may need more health care and retirement facilities and less childcare and educational infrastructure. Higher shares of manufacturing require transport infrastructure that facilitates the supply and distribution of goods. Greater shares for tourism might mean a higher share of recreational infrastructure.

Assessment of infrastructure stocks

The regional groups assess the adequacy of social infrastructure slightly differently (Figure 26a). Nearly half of interviewed municipalities assess their health and care infrastructure as adequate, and this assessment does not vary a lot across groups with different growth rates. The finding is similar for social and affordable housing. Respondents in underperforming regions are more likely to assess education and training infrastructure as lacking than the other two groups, but the level is relatively low at only 22%, against 78% who think that such facilities are adequate. The responses for outdoor and recreational areas are very similar. Underperforming regions are more likely to think such infrastructure is lacking – 20% against 13% in high-growth regions.

Assessments of transport infrastructure vary significantly across regions with different rates of growth (Figure 26b). Municipalities and cities in underperforming regions are significantly more likely to say transport infrastructure is lacking. The share of respondents who think urban transport infrastructure is lacking is 15 percentage points higher in underperforming regions than in outperforming regions. The difference for inter-urban and urban-rural transport infrastructure is about 10 percentage points.

Figure 26
Assessment of adequacy of infrastructure stocks in EU regions (share of municipalities, %)



Source: *EIB Municipality Survey 2020, Eurostat and EIB staff calculations.*
Question: *For each of the following would you say that the quality of infrastructure is satisfactory, slightly lacking or substantially lacking? i) healthcare; ii) childcare; iii) care for elderly; iv) education and training; v) social and affordable housing.*

Source: *EIB Municipality Survey 2020, Eurostat and EIB staff calculations.*
Question: *For each of the following would you say that the quality of infrastructure is satisfactory, slightly lacking or substantially lacking? i) Cycling lanes & footpaths; ii) Urban public transport; iii) including vehicles and related infrastructure; iii) inter-urban and urban-rural transport connectivity; iv) electric charging stations for vehicles.*

Infrastructure investment and finance

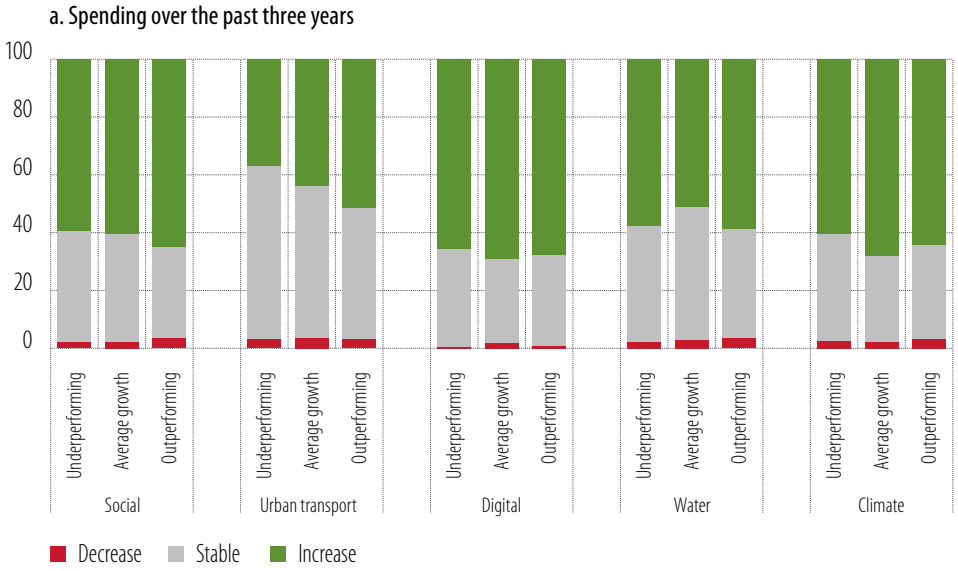
Underperforming regions are less likely to adjust their investment to address infrastructure deficiencies, creating a mismatch between needs and actual investment. While 55% of respondents in underperforming regions find their transport infrastructure lacking, only 37% have increased investment in transport infrastructure over the past three years (Figure 27b and Figure 28a). Of these respondents, 53% say transport investment is lacking. A similar pattern is observed for social infrastructure in underperforming regions, where 70% of respondents say social infrastructure is lacking. Yet, only 59% have increased investment in these assets. However, for those that have invested, 61% said social infrastructure investment was adequate.

The pattern differs in municipalities located in more dynamic regions. While 55% of average-growth regions think social housing is lacking, investment in these assets has increased commensurately (60%) over the past three years and about 67% of municipalities think their investment is adequate. Likewise, 40% of respondents in high growth regions say urban transport infrastructure is lacking, but 51% have increased transport investment over the past three years and 62% now see this investment as adequate.

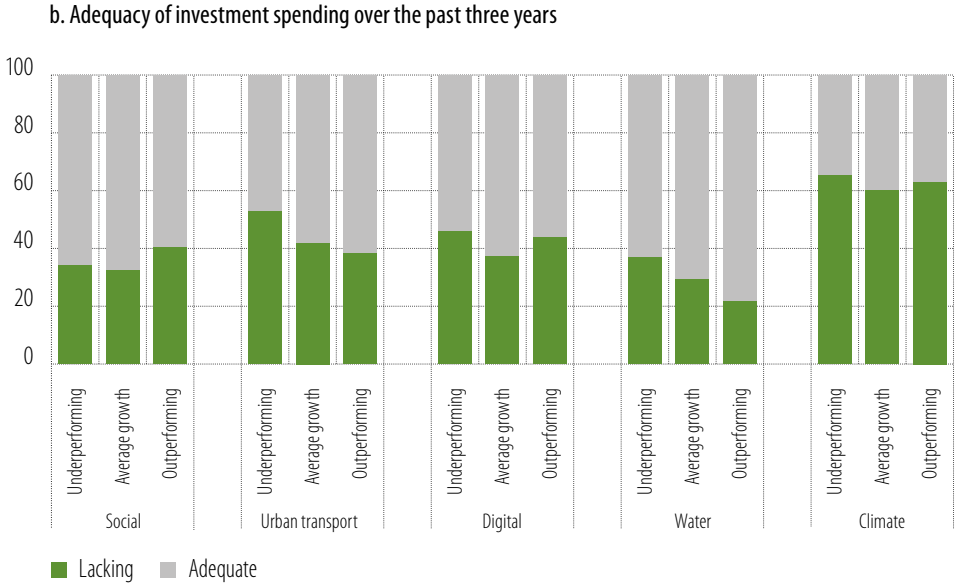
Future investment plans in underperforming regions do not fully address perceived infrastructure deficiencies (Figure 28). Less than 50% of underperforming regions plan to increase investment in urban transport and only about 60% plan increases in social infrastructure. In more dynamic regions, the share of respondents planning to increase investment in urban transport (about 48%) exceeds the share of those assessing urban transport infrastructure as lacking – by 5 percentage points in regions with average relative growth and by 8 percentage points in outperforming regions.

These observations suggest that infrastructure investment in underperforming regions is more constrained than elsewhere. The EIB Municipality Survey 2020 provides a battery of questions aimed at identifying likely constraints to infrastructure investment by cities and municipalities. These include questions about perceived barriers to investment, questions about administrative capacity to promote and assess investment projects and questions on investment finance. The reason for lower-than-needed infrastructure investment seems to be a limited availability of internal funds to invest – at least that reason correlates best empirically (Figure 29). Underperforming regions have the highest (median) reliance on transfers, subsidies and grants from national or supra-regional governments or the European Union to finance their investments. Underperforming regions rely less on their funds and external financing than more dynamic regions. These regions' reliance on transfers, subsidies and grants may significantly constrain investment because the granting of these funds is notoriously discretionary, as was observed in the wake of the global financial crisis.

Figure 27
Adequacy of recent infrastructure investment (share of municipalities, %)



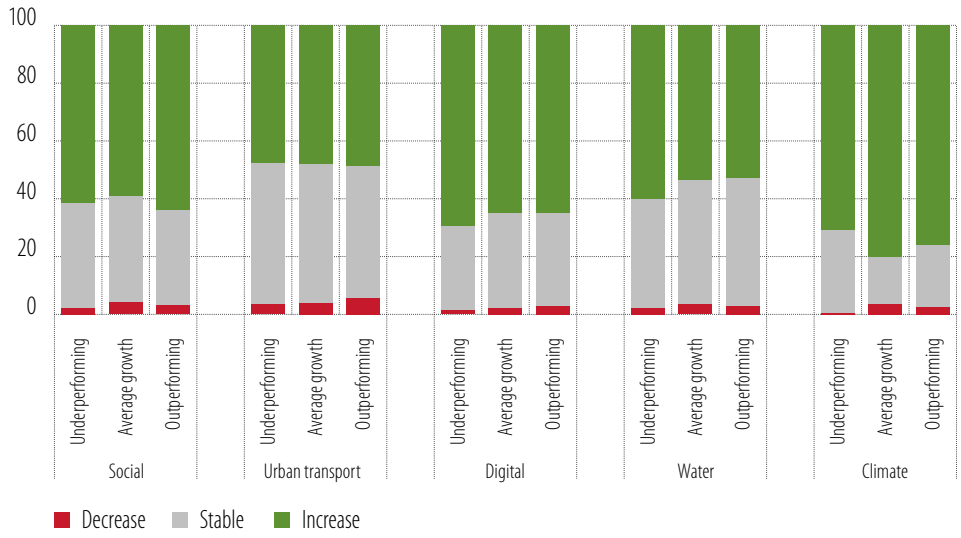
Source: *EIB Municipality Survey 2020, Eurostat and EIB staff calculations.*
Question: *Still thinking back to between 2017 and 2019, did investment in your municipality increase, decrease or stay around the same in each of the following areas? Please consider all infrastructure investment in your municipality, irrespective of who is responsible for the investment.*



Source: *EIB Municipality Survey 2020, Eurostat and EIB staff calculations.*
Question: *Would you say that within your municipality the level of investment in infrastructure projects between 2017 and 2019 was broadly adequate, slightly lacking or substantially lacking in each of the following areas?*

Figure 28

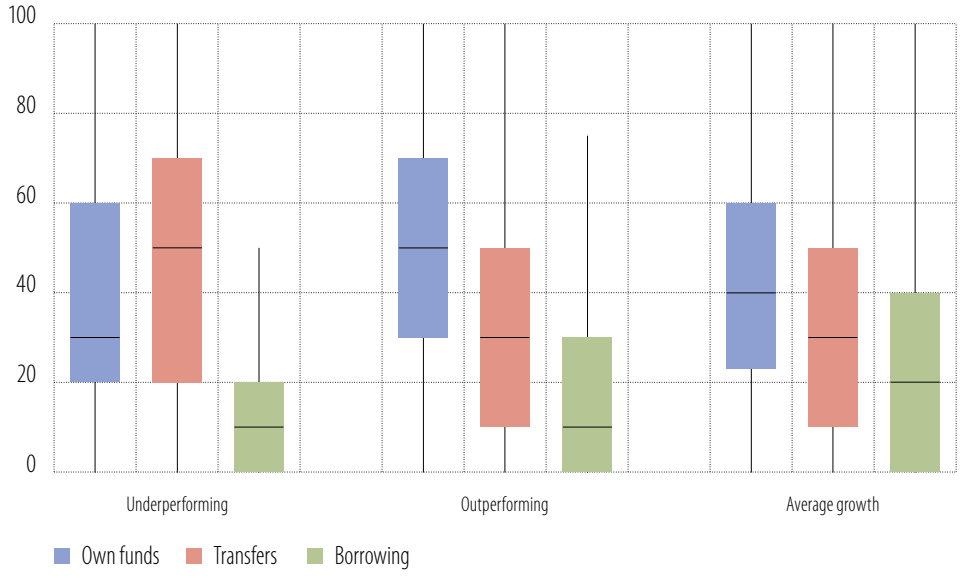
Investment plans over the next five years (share of municipalities, %)



Source: *EIB Municipality Survey 2020, Eurostat and EIB staff calculations.*
Question: *And for each of the following areas, over the next five years, does your municipality expect to increase, decrease or have around the same level of spending on infrastructure investment?*

Figure 29

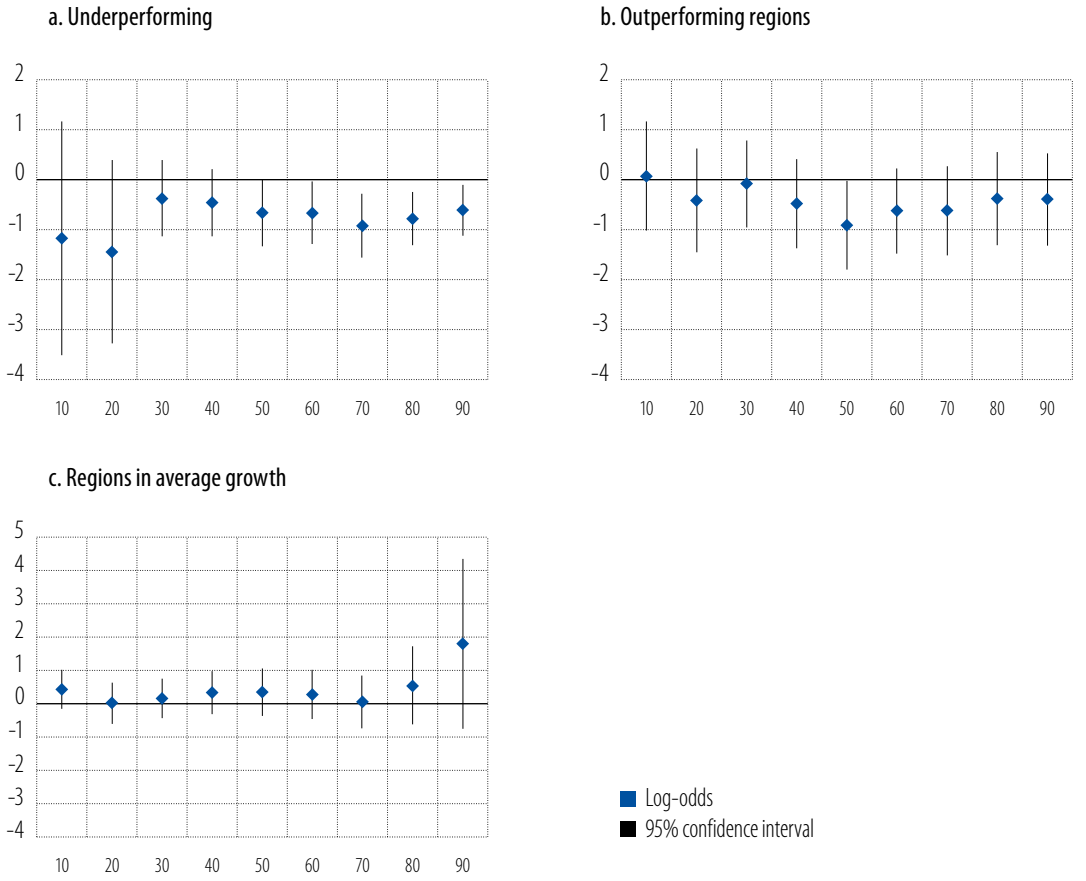
Sources of municipality and city investment finance



Source: *EIB Municipality Survey 2020, Eurostat and EIB staff calculations.*
Question: *Can you tell me approximately what proportions of your infrastructure investment activities in the last three years were financed by each of the following?*

Figure 30

Probability of having increased investment over the past three years by share of transfers and grants in investment financing (log-odds)



Source: *EIB Municipality Survey 2020, Eurostat and EIB staff calculations.*
Note: *Calculations are based on the estimated regression in Table B.1 in Box B and on an identical regression with an alternative definition of the variable Transfer. In Table B.1, this variable is defined as 1 if transfers and grants account for investment financing of 50% or more and 0 otherwise. Each point estimate on this chart corresponds to a different definition of Transfer. The horizontal axis records the cut-off value for the share of transfers and grants, above which Transfers equal 1.*

We consider the importance of transfers in addressing suboptimal investment in the less dynamic regions in a formal statistical analysis (Box B). The analysis quantifies the effects of constraints on local governments' propensity to increase investment in urban transport over the past three years. We mainly find that financially constrained municipalities in less dynamic regions suffer from a large investment mismatch in the sense that real investment does not address perceived infrastructure deficiencies. Figure 30 plots the change in the likelihood (log-odds ratios) of increasing investment if a city or municipality relies on transfers and grants above a certain threshold compared to peers that rely on transfers and grants below this threshold. Thresholds vary along the horizontal axis. Thus, the point corresponding to 70 on panel a, for example, plots the change in the odds (in logarithm) of increasing the investment of a city or municipality that relies on transfers and grants to finance 70% or more of its investment vs. a city or municipality that relies on transfers and grants for less than 70% of its investment. In this case the probability of investing decreases by about 30 percentage points.[16]

16 The estimated difference in log-odds is -0.92. Converting this from log-odds to odds yields an odds ratio of 0.4. This translates in to a decrease in probability of about 30 percentage points.

Financially constrained municipalities in regions in decline are significantly less likely to invest in transport than peers in the same region (Figure 30a). This is particularly the case for municipalities that finance 50% or more of their investments with transfers and grants received from supra-local levels of government or the European Union. However, the situation changes in more dynamic regions, where a reliance on transfers does not affect the propensity to invest (Figure 30b and Figure 30c). While more analysis is needed to understand the reasons for differences across the regions, information from Figure 25a provides a tentative explanation. It reveals that each economic performance group is dominated by certain geographical regions. For example, regions from Southern Europe dominate the group of underperforming regions (46%). Regions from Central and Eastern Europe dominate the group of outperforming regions (51%), and regions from Western and Northern Europe dominate the group of average-growth performance (51%).

The fiscal constraints of central governments – particularly prevalent in Southern Europe – are probably at the core of suboptimal municipal investment in regions in relative decline. As central governments struggle to consolidate fiscal positions, they are likely to reduce investment grants and transfers to regional governments and municipalities, consistent with findings in Chapter 2 of this report (see Box B in Chapter 2). On the other hand, regions in Central and Eastern Europe are the main beneficiaries of the European Structural and Investment Funds (ESIF). These funds have likely reduced the financing constraints on local governments in Central and Eastern Europe and especially on those more reliant on transfers. Additional evidence suggesting that ESIF financing goes predominantly to large cities in Central and Eastern Europe might explain the results of the analysis in Box B.

Box B

Internal financing constraints and infrastructure investment in EU municipalities

Local government investment appears to be constrained, especially in less dynamic regions, because investment changes poorly match local governments' assessments of infrastructure gaps. The focus of the analysis is investment in urban transport infrastructure, where the divergence between investment and perceived gaps is the largest. In the statistical model, the decision to increase investment or not is a function of the perceived infrastructure gap. We control for financing constraints, economic performance, size, location and degree of urbanisation. This function is modelled as a logistic regression.

$$\Delta I_i = \alpha + \beta_1 RegClass_i + \beta_2 Transf_i + \beta_3 RegClass_i * Transf_i + \beta_4 InfraQual_i + \gamma X_i + \varepsilon_i$$

The dependent variable takes values of 1 if the i^{th} city or municipality has increased investment in urban transport in the past three years and 0 otherwise. The variable *RegClass* denotes the regional classification adopted in this chapter. The variable *Transf* is also binary and takes values of 1 if 50%, or more, of the investment is financed by transfers or grants from higher levels of government and 0 otherwise. The variable *InfraQual* is also binary and takes a value of 1 if urban transport infrastructure is assessed as adequate and 0 otherwise. *X* gathers several variables to control for size (logarithm of population); geographical location – Western and Northern Europe, Southern Europe or Central and Eastern Europe; degree of urbanisation – city, town or suburb or rural area. The interaction term between regional classification and transfers is intended to address the nexus between economic performance and financial constraints that may affect the propensity to increase investment. In essence, significant reliance on transfers and grants to finance investment is taken to be a sign of financial constraints. Cities or municipalities do not generate enough of their own revenue to finance investment or to borrow against.

The estimation results are included in Table B.1. The first observation is that large, densely populated areas, as well as cities and municipalities located in Central and Eastern Europe, are more likely to have increased investment over the past three years than smaller towns, suburbs and rural areas and cities and municipalities in Southern Europe. Likewise, cities and municipalities located in NUTS3 regions

with high economic growth over the past 20 years are significantly more likely to have increased investment than municipalities in less dynamic regions.

Cities and municipalities in Southern Europe and located in less dynamic regions are less likely to have increased investment in urban transport over the past three years, even though they assessed their stock of urban transport infrastructure as lacking. This multivariate analysis therefore confirms the observations from the simple bivariate analysis above that these municipalities' investment choices are constrained.

The last and most important piece of evidence in Table B.1 relates to the coefficient on the interaction between the type of region and the measure of financial constraints. The statistically significant coefficients mean that cities and municipalities that rely highly on transfers to finance their investment are much less likely to have increased investment than peers that are not so reliant on transfers and grants. This is particularly true for cities or municipalities located in underperforming regions, to some extent, in outperforming regions.

Table B.1

Change in investment in urban transport over the past three years correlates with availability of internal finance in a logistic regression

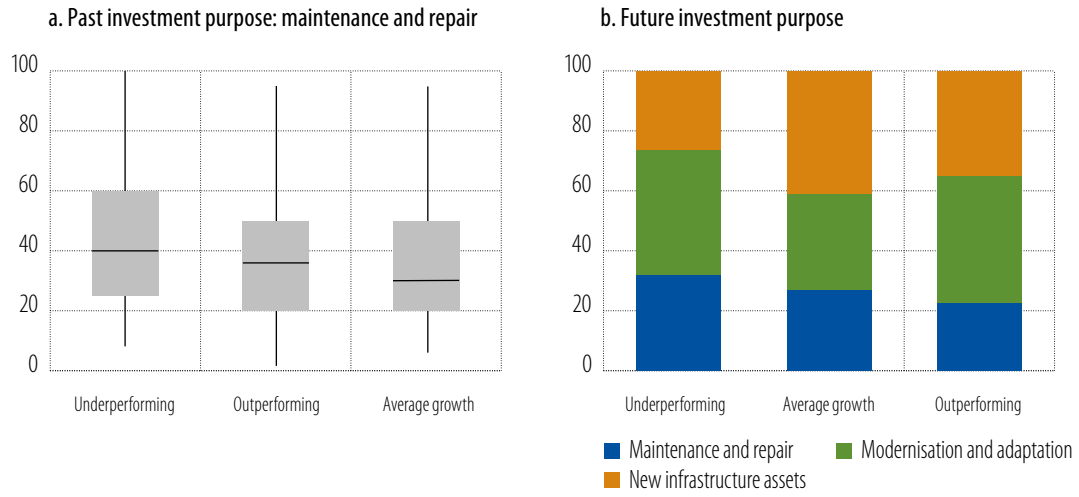
Variables	Coefficient (odd-ratios)	t -stat
ΔI (Urban transport)		
In decline	1.395	1.03
In growth	1.769**	2.14
Transfers > 50%	1.228	0.62
Underperforming#Transfers > 50%	0.385**	-2.02
Outperforming#Transfers > 50%	0.434*	-1.91
Lacking infrastructure	0.687**	-2.04
Central and Eastern Europe	1.857***	3.44
Western and Northern Europe	1.254	0.85
Population size (log)	1.273***	2.78
Towns and suburbs	0.416***	-3.23
Rural areas	0.725	-0.64
Constant	0.117*	-2.26
Observations	573	
Psuedo R^2	0.09	
Wald Chi square (11)	59.05	

Notes: *Logistic regression. Odds ratios reported. T-statistic based on robust standard errors.*
**** p<0.01, ** p<0.05, * p<0.1*

These results confirm the importance of the design of fiscal policies of central governments related to local governments. Such policies may result in underinvestment in infrastructure, even though that infrastructure is deemed very necessary at the local level. These mismatches create inefficiencies in government investment.

Lack of funding constrains investment options, leading to increased focus on maintenance and repair (Figure 31). The evidence of constraints on investment, especially in underperforming regions, may help explain another dimension of the investment choices of cities and municipalities in these regions. Over the past three years, they are more likely to have invested in cheaper and divisible options like maintenance and repair, rather than in capital-intensive, indivisible new assets. Likewise for the next five years, local governments in underperforming regions are less likely to invest in new infrastructure that typically requires large and lumpy investments.

Figure 31
Investment purpose (share of municipalities, %)



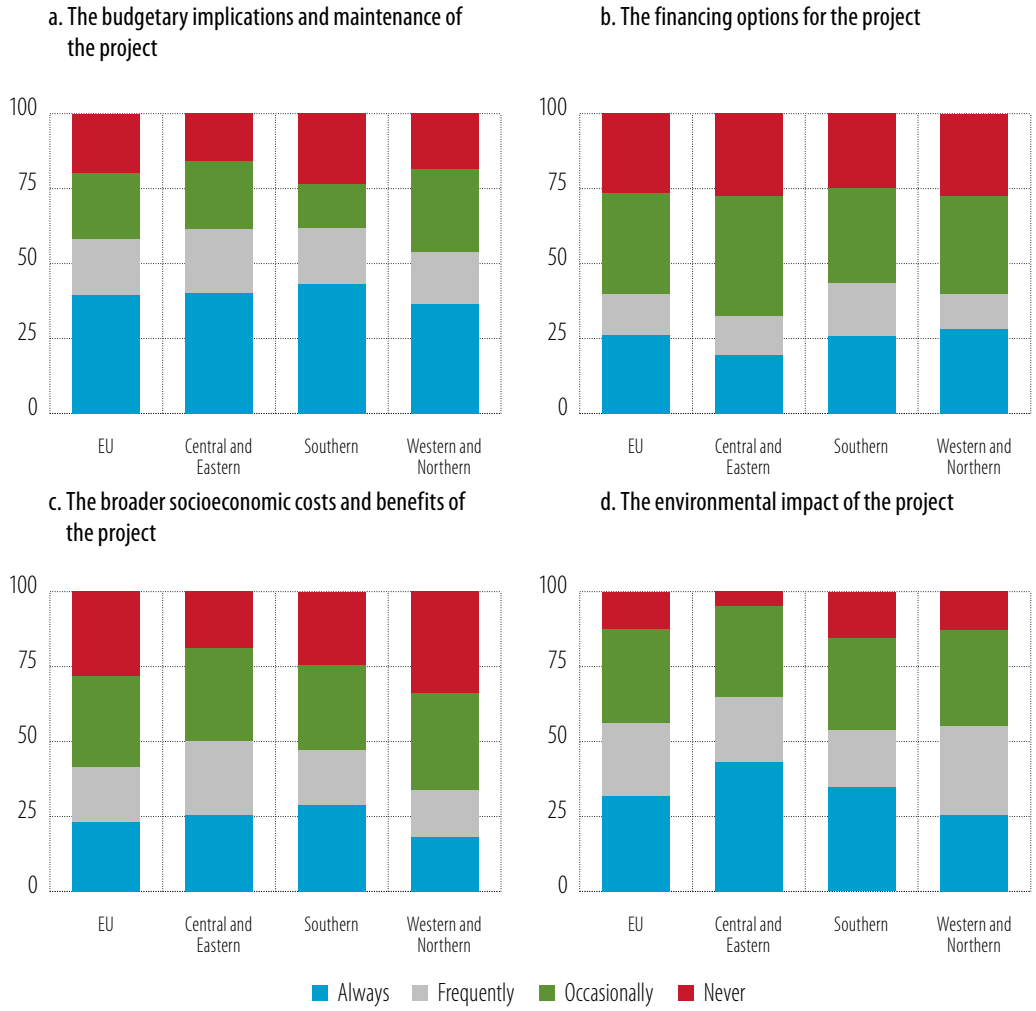
Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/refused responses).*
Question: *Over the past three years, what proportion of the investment was for…?*

Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/refused responses).*
Question: *And looking ahead to the next five years, do you expect the largest required share of investment on infrastructure to be for…?*

Assessing the impact of past projects could result in better infrastructure investment in the medium term. Municipalities do not appear to often independently assess the impact of past projects (Figure 32). Only a quarter of respondents regularly consider the different financing options available (Figure 32b) and about the same share regularly use cost-benefit analysis to assess a project's socioeconomic impact (Figure 32c). The lack of such insight reduces the ability of municipalities to objectively prioritise different investment projects and to find alternative financing for the most pressing projects. Increasing the use of impact assessment could lead to tangible improvements in infrastructure and increase the implementation of the most relevant projects.

Figure 32

Frequency of project assessment by different aspects



Source: *EIB Municipality Survey 2020.*
Base: *All municipalities (excluding don't know/refused responses).*
Question: *Before going ahead with an infrastructure project, does your municipality obtain an independent assessment of any of the following…?*

Conclusion and policy implications

Municipal infrastructure gaps remain prevalent in the European Union, especially for digitalisation and climate change. The EIB Municipality Survey 2020 highlights these gaps, even though municipalities are investing and remain eager to do so. In recent years, municipalities have focused on developing digital, urban transport and social infrastructure. Still, a large share of surveyed municipalities said that their infrastructure investment remained inadequate, especially in critical areas. Over two-thirds of municipalities said investment was inadequate to tackle climate change mitigation or adaptation; nearly 50% said the same about digitalisation, and roughly 45% for urban transport. A lack of investment is also reflected in municipalities' poor assessment of critical aspects of their own social and transport infrastructure, such as affordable housing or electric charging stations for vehicles. Municipalities, however, said they intend to add these investments to the list of priorities. Where the COVID-19 crisis had already buffeted investment plans, municipalities are paying more attention to digital and social infrastructure.

Lack of funding and regulatory red tape are the major barriers to investment. Limited funds are the most important obstacle: every second municipality deems it a major issue and three-quarters cite it as an issue. Limited funds also stand out as the main issue facing climate-related investments. Also important are the length of regulatory process and regulatory uncertainty, which affect 85% of municipalities, and a lack of technical capacity, which is a constraint for 70% of municipalities. Access to funding has real implications for outcomes, such as investment in buildings' energy efficiency, which is better when funding is not an obstacle.

Municipal green administrative capacity and digital sophistication tend to be associated with greater optimism towards the risks associated with climate change. As municipalities take on the challenges of climate change and digitalisation, they are adapting the manner in which they provide public services. These adaptations may have an important role to play in how municipalities master these challenges. For instance, synergies between digital sophistication and green capacity are also related to municipal views of the physical risks posed by climate change.

Policy support should focus on promoting corporate and municipal advancements in the green and digital spheres, and doing so in a manner that maximises potential synergies. The development of municipalities' green administrative capacities and digital sophistication is associated with higher rates of technological adoption rates and innovation by firms in the green and digital domains. This suggests that common factors are at work, while also raising the question of synergies. The analytical results support greater and more targeted policy action to support municipalities in tackling the digital transition and climate change.

Municipalities' ability to close infrastructure gaps appears to be inversely related to their reliance on transfers – notably in regions that economically perform below par – which begs the question whether the effectiveness of transfers can be improved. Municipalities in Central and Eastern as well as Southern Europe report that capital transfers and grants represent, on average, a significant share of their investment funding. For municipalities located in regions whose economic performance has been below par, those that rely heavily on capital transfers and grants tend to be more limited in their ability address gaps in transport infrastructure. Of course, a lack of alternative sources of funding also points to deeper issues facing the municipality. Still, this finding leads us to question whether the effectiveness of capital transfers and grants can be improved to better address investment gaps in regions in decline.

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Chapter 10

The impact of digitalisation and climate change policies on social cohesion

The European Union has a window of opportunity to embark on a recovery that tilts towards a greener economy and stands to generate sustainable benefits for its people. The coronavirus crisis has laid bare existing inequalities among Europeans – for instance, in work, education and housing – and risks opening up new ones as its impact unfolds on labour markets. Before the pandemic hit, many Europeans were already feeling left behind.

An economic transformation is needed to foster recovery and long-term growth. The twin transition towards a greener and more digital economy could stimulate economic growth in the near term and create jobs. At the same time, a successful transition would help strengthen growth prospects, resilience to future shocks and well-being in Europe. Failure to seize the opportunity to turn the European economy around will carry a high cost including a further loss in competitiveness and economic significance in the decades to come and a high risk of exacerbating existing inequalities while new ones emerge.

Building a more digital and green economy while managing the fallout from the pandemic requires strong policy support. The pandemic and structural changes linked to climate action and digitalisation affect people, regions and countries differently. The move to a digital and climate-neutral economy does not inherently promote social inclusion, and the right mix of short-term policies and long-term vision is needed to protect social cohesion.

Digitalisation and the green transition will impact EU labour markets. Both will change the kind of skills required, and create and potentially destroy jobs. Beyond lost jobs, there is a risk that people will not possess the right mix of skills needed for the jobs to be created, which could have profound social and economic consequences.

Some places in the European Union are more likely to experience larger-scale job losses linked to transitions. Many of the regions at high risk of losing jobs are already grappling with other challenges. Many regions vulnerable to both the digital and green transitions are located in Central and Eastern Europe, pointing to a need to re-examine economic growth models for further convergence. Dealing with transition risks will require strong local administrations that can identify future job opportunities, provide adequate support for individuals and devise strategies to transform and revitalise local economies. In the longer term, disparities will be driven by regions' ability to respond to economic changes and to reinvent themselves.

Investments need to focus on people if the green and digital transition is to be successful. A lack of sufficient skills limits the ability of individuals to respond to economic evolution and a changing job market. Reforms to adult learning systems and broader participation is needed to deal with the risks of a growing gap in workers' skills and further labour market polarisation. A renewed focus on adult learning must be coupled with investment in quality education, which forms the basis for the lifelong learning necessary to boost innovation and support the digital and green transitions. Investment in each of the three areas will complement the others and raise the economic and societal returns.

Introduction

The European Union is emerging from an historic economic shock. The coronavirus crisis has laid bare existing inequalities among Europeans – for instance, in work, education and housing – and risks opening up new ones as its impact unfolds on labour markets. Dealing with these inequalities is even more challenging as Europe continues to grapple with the consequences of the financial and sovereign debt crisis, which deepened regional disparities and resulted in surges in unemployment, particularly among vulnerable groups. Before the pandemic hit, many Europeans were already feeling left behind.

Europe has a window of opportunity to embark on a recovery that tilts towards digitalisation and a greener economy, and stands to generate sustainable benefits for its people. The twin transition towards a greener and more digital economy could stimulate economic growth in the near term and create jobs. At the same time, a successful transition would help strengthen long-term growth, resilience to future shocks and well-being in Europe.

Failure to seize the opportunity to turn the European economy around will carry a high cost. Megatrends, for example climate change or the changing nature of work, are here to stay, and new technologies are key to providing environmental and social sustainability. A failure to act now would mean a less healthy planet. Moreover, it would mean a further loss of competitiveness and economic significance for Europe in the decades to come, and a high risk of exacerbating existing inequalities while new ones emerge.

Managing the fallout from the pandemic, while at the same time building a more digital and green economy, requires strong policy support. The pandemic and structural changes linked to climate action and digitalisation affect people, regions and countries differently. The move to a digital and climate-neutral economy does not inherently promote social inclusion, and the right mix of short-term policies and long-term vision is needed to protect social cohesion.

This chapter looks at the twin transition towards a digital and green economy, its impact on social cohesion and the policies needed to ensure no one is left behind. The first section discusses the effects of digitalisation and greening on the EU labour market, highlighting structural implications and recent developments. The second section identifies the regions at a higher risk of losing jobs during the transition. It also discusses different regions' ability to absorb shocks and manage transition risks. The third section focuses on employment opportunities from greening and digitalisation, and how best to unlock those opportunities. The fourth section identifies critical gaps that need to be addressed if Europe is to adequately support the structural transformation or its economy while maintaining social cohesion. The conclusion covers the implications for different policy measures.

Digitalisation, greening and the EU labour market

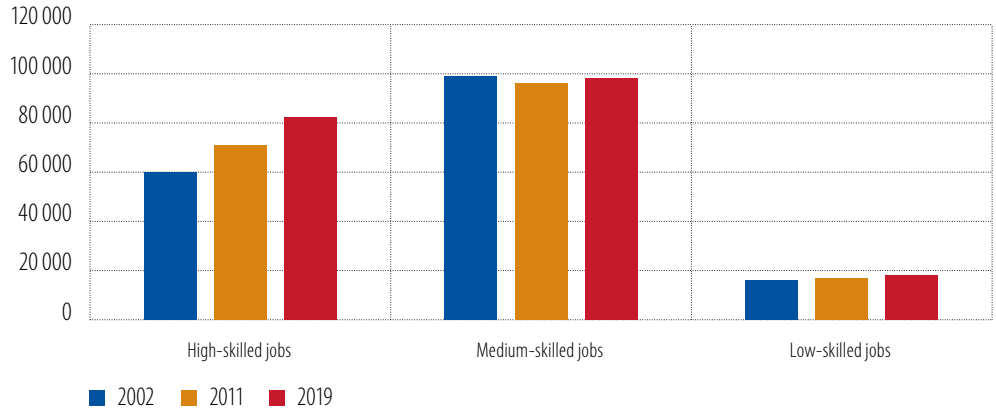
The ongoing digital transformation has spurred profound changes in EU labour markets. Digitalisation has supported the creation of new employment in many firms directly (for instance, by creating new jobs like data analysts, software developers, or digital marketeers) and indirectly (by raising productivity, reducing prices and stimulating demand). However, creation goes hand in hand with creative destruction, putting pressure on routine jobs with little complexity. Recent advances in digital technologies have tended to benefit high-skilled workers and those in less-routine occupations (EIB, 2018, 2019; International Monetary Fund (IMF), 2017, 2018). Since 2002, job polarisation, as measured by wage differences, has increased, with the proportion of middle-wage workers shrinking, albeit at a slower pace in more recent years.[1] Analyses that focused more on job tasks indicate that high-skilled work that is typically more intensive in non-routine cognitive tasks has been rising in most EU countries (European Commission, 2019).

1 It should be noted that studies on labour market polarisation effects linked to technological change for Europe are somewhat sensitive to the different methodologies and data sources used. These difference relate amongst others to the definition of jobs and granularity, job rankings by median (country) wages, and the definition of categories for high/middle/low-paying jobs.

Digitalisation has added to growing spatial disparities. People and businesses have increasingly clustered in favoured urban locations to work and innovate (Moretti, 2012; Rodriguez-Pose, 2017). At the same time, large cities, and capital city regions in particular, have often witnessed a polarisation in the kinds of jobs available, with higher paying jobs growing the most. More broadly, across the European Union, disparities have particularly emerged in Southern and Eastern Europe. In some regions, the structural features of employment are not converging with patterns found in Northern Europe, where low-paid jobs tend to be less frequent (European Commission, 2019).

Rapid technological change raises the risk of skill mismatches and shortages. Technological progress lowered demand for workers doing more routine tasks, and supported the growth of high-skilled employment (Figure 1). Shifting demand can temporarily cause skill mismatches as new employment often requires different and more advanced skills that are not readily available on the market – and educational systems can be slow to respond to changing needs. Data from career networking sites give some indication of the recent shifts in demand. That evidence suggests that specific combinations of technical skills – often directly related to new digital technologies – and soft skills are in particularly high demand.[2] Firms seeking specific (and still rare) talents often have difficulties finding the right people. At the same time, the lack of critical skills can slow down technology adoption and diffusion, weighing on productivity (EIB, 2019; Sekmonkas/European Commission, 2020).

Figure 1
Number of jobs by skill level (in thousands)**, European Union 2002-2019**



Source: *Eurostat, European Commission (2020).*

Digitalisation has changed ways people work, increasing flexibility for some but uncertainty for others. The pandemic showed plainly how polarised "worlds of work" had become. Digital technologies can offer flexibility to employees, for instance by enabling more remote work. High-skilled jobs often involve more tasks that can be done from home. During the pandemic, remote work allowed many highly skilled employees to keep working while limiting their exposure to the virus. Moreover, while COVID-19 boosted digitalisation and remote work, it did so mainly for the jobs that already allowed for more flexibility (Adams-Prassl et al., 2020). At the same time, the pandemic has shone a spotlight on the working conditions of some – typically lower-paid – employees of businesses powered by digital technologies, such as those related to e-commerce or delivery services.

In a worst case scenario, post-pandemic labour markets could see an increase in skill mismatches coinciding with higher unemployment. Digitalisation has increased rapidly over the last few months,

2 Notably, it appears that the demand for soft skills has become more human- centric, including for instance emotional intelligence, in addition to creativity and the ability to collaborate. The most sought-after hard skills are mostly analytical and data-centred, and for 2019 include blockchain technologies, artificial intelligence, business analysis, UX design and cloud computing. See LinkedIn Learning, posted Dec. 2019.

and most EU firms expect this trend to continue (Chapter 1). One in five firms expect the pandemic to lead a permanent reduction in employment, which, in the absence of adequate labour market policy responses, suggests a risk of rising structural unemployment in EU labour markets. Firms are facing pressure to reduce costs, restructure business lines and reassess the degree to which their businesses require human interaction. The ongoing restructuring could accelerate automation, with lower-skilled employment bearing the brunt of the lost jobs (European Commission, 2020; Munro, 2020). In contrast, high-skilled employees are still more difficult to replace with machines. In fact, most firms operating in Europe and many experts expect high-skilled jobs to grow with digitalisation (EIB, 2019; Cedefop, 2018). At the same time, higher-skilled workers are in a better position to adapt to structural shifts in the kinds of work performed, as they are more likely to have jobs that support learning. In contrast, lower-skilled and non-standard workers (self-employed or with temporary or short-term contracts) could find it harder to adapt to structural changes, as they are less likely to benefit from employment-related training (Cedefop, 2020). In addition, many non-standard workers are more vulnerable to the business cycle and are not fully covered by traditional social protections.

Greening the economy requires a major industrial transformation, which will impact employment. Meeting the European Union's goal of neutral carbon emissions by 2050 requires large-scale changes in the production and business models of many firms. Like digitalisation, greening will have implications across different sectors and jobs. The mechanics are similar. Some employment, particularly in energy-intensive and polluting industries, will be lost (job destruction effect). At the same time, new employment opportunities are expected to emerge for example in sectors such as renewable energy, where demand is forecast to expand (job creation effect).[3]

The transition's effect will vary widely, depending on geography and the labour market group. Job gains from greening can be expected in many regions, while job losses are likely to be concentrated in a few. In particular, regions dependent on traditional industries – like fossil fuel extraction or the auto industry – will experience a more extensive transformation. Shifts in the kinds of jobs in demand could widen gender gaps in the labour force as some of the areas most expected to grow with greening, such as construction, currently employ fewer female workers (International Labour Organization (ILO), 2018).

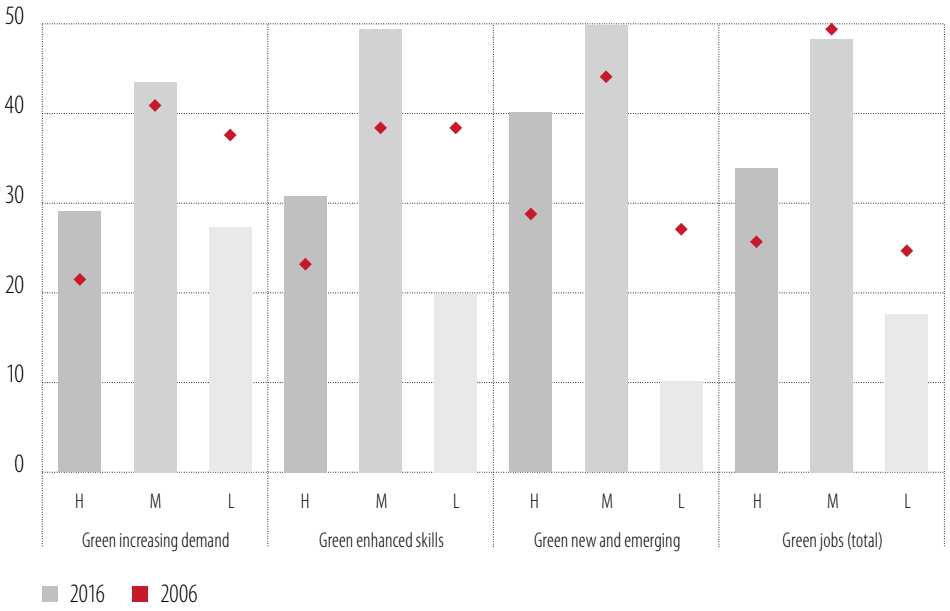
The green transition will change the kinds of skills needed in a number of occupations. For example, architects or engineers well-versed in building renovations or green technology will increasingly be sought after (ILO, 2018; Cedefop, 2018a). Outside of some specific technical skills, the greening of the EU economy more generally requires cross-cutting skills not related to a particular job, including digital skills (European Commission, 2018). Moreover, skills needed for innovation will be in high demand, to advance green technologies and keep up with changes in the decades to come.

The green transition could exacerbate labour market disparities. The skills needed for green(able) jobs have increased more quickly in recent years than for the job market as a whole (Figure 2).[4] Green(er) jobs typically require more education than non-green jobs, and tend to account for a larger share of higher-skilled employees within the same sectors (Cameron et al., 2020; Figure 3). Like digitalisation, the green transition is expected to increase demand for higher-skilled employment. The transition might therefore result in a rise in skill mismatches related to the transition phase and widening polarisation if these were to become entrenched.

3 Examples of direct employment opportunities include reinforcing buildings and infrastructure, construction or development of new climate-friendly technologies.

4 There is no fixed and internationally comparable definition of green jobs. For further discussion and a taxonomy to identify green jobs in the European Union see Griffin et al. (2019).

Figure 2
Change of skill requirements in green(able) jobs, European Union for 2006 and 2016



Source: *Griffin et al. (2019).*
Note: *Shares of employment, total and by qualification, in a given green job category are given as a percentage of total employment (15-64 years). H denotes tertiary education (ISCED levels 5-8), M denotes upper secondary and post secondary non-tertiary education (ISCED levels 3 and 4) and L denotes less than primary, primary and lower secondary education (ISCED levels 0-2).*

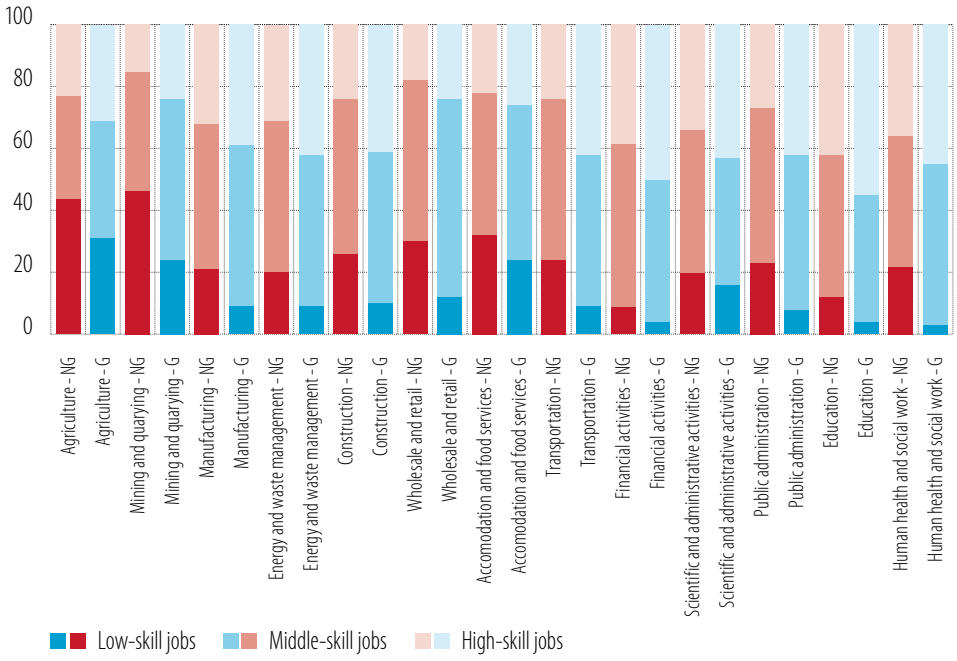
High-skilled jobs from greening may emerge early in the transition. Technological development or transition planning may quickly create high-skilled jobs, for example in research and development or risk analysis. Low(er)-skilled jobs, such as in renewable energy, often depend on decisions being made to shift activities first, with job creation materialising later. There is a risk that low(er)-skilled workers might bear higher costs related to the transition at an early stage, potentially coinciding with more difficult labour market conditions resulting from the pandemic.

Slow action on climate change will also affect social cohesion. Some of the immediate risks of job losses from greening may not be evenly distributed across workers. However, the negative implications of acting slowly on climate change also affect some people more. According to data from the second annual EIB climate survey[5], about a third of Europeans think they will have to move to another region or country because of climate change.[6] The perceived likelihood of having to move differs not only across countries – with the highest shares in those with warmer climates (EIB, 2020) – but also by socioeconomic characteristic. People with higher incomes typically feel safer than those with lower incomes (Figure 4). The difference may stem from people's current living conditions as well as capacities to adapt them (Figure 5). The survey results might also suggest that for those with lower incomes, risks from climate change add to other, generally higher (economic) uncertainties in their lives. This includes potential job changes linked to moving.

5 The EIB climate survey sheds light on citizens' attitudes and expectations on climate change and climate action. The data for the second wave of the survey were collected from 27 September to 21 October 2019 by the polling company BVA. The survey covers all EU member states, the United Kingdom, the United States and China. The sample, some 28 000 respondents from the European Union and 2 000 from the United States and China, is based on gender, age, region and social class quotas from official statistics. For further information see EIB (2020).

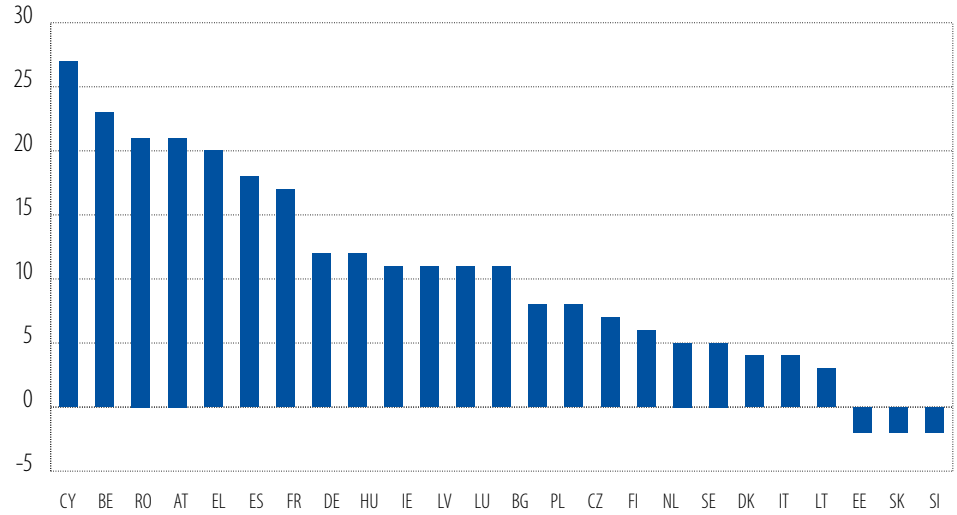
6 While the direct impact of extreme weather and temperature changes in Europe is estimated to be less severe than for other world regions, studies suggest that their local effects, for instance on agriculture or cities' economies, can be quite profound. For example, a warm year can result in depressing the gross economic value added by Bilbao, Spain, by about 9.5%. (Costa et al., 2016).

Figure 3
Skill composition of green and non-green jobs in selected sectors, European Union 2016



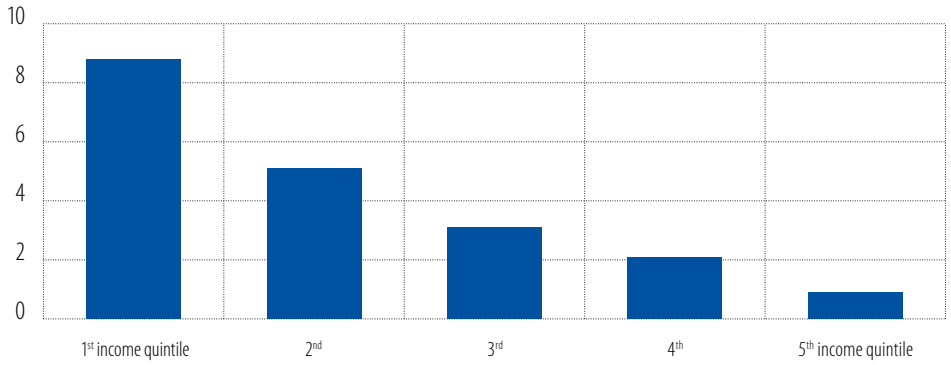
Source: *Griffin et al. (2019).*
Note: *Dark colours indicate low-skilled jobs. Light colours indicate high-skilled jobs.*

Figure 4
Differences in expectations of having to move because of climate change, high vs. low incomes, in percentage points



Source: *EIB Economics Department calculations. EIB.*
Note: *Differences in shares of responses for people who do not think they will have to move. Higher positive values indicate that fewer people with lower incomes expect that they will not have to move compared to people with higher incomes in the same country. Malta is excluded due to a low number of respondents by income group. Small base for Cyprus.*
Question: *Do you think that you will have to move to another country or region in the future because of climate change?*

Figure 5
Severe housing deprivation rate by income quintile, European Union 2018



Source: *European Union Statistics on Income and Living Conditions (EU-SILC).*
Note: *Severe housing deprivation rate is defined as the percentage of the population living in a dwelling that is considered overcrowded, while also exhibiting at least one of the housing deprivation measures, such as leaking roofs, no bath/shower, no indoor toilet or a dwelling considered too dark.*

To manage the transition successfully and support social cohesion, an understanding of who will bear costs and where they will materialise is needed. Analysing concentrated costs and risk exposures makes it possible to put in place policies to provide insurance, compensation or adaptation support. Those kinds of support can help soften the potential negative effects arising from the structural transformation of an economy, such as high inactivity, high structural unemployment, lower incomes and adverse consequences for health, well-being and the social fabric of communities.[7] Understanding costs allows for transition planning to be devised early and communicated in a timely manner, reducing the likelihood that people will feel ignored and left behind.

Assessing EU regions' twin transition risks

This section analyses employment risks arising from the green and digital transition for EU regions. The greening and digitalisation of the EU economy will proceed simultaneously over the next decade. We analyse where local employment is more at risk from both transformative forces and shed light on the ability of regions to cope with change.[8]

Digitalisation risks to employment stem from job automation. The likelihood of jobs being automated differs across occupations, depending on the tasks performed. Employment intensive in routine tasks carries a higher risk of being automated.

Carbon-intensive activities are more at risk of losing jobs during the green transition. Regions with larger shares of employment in carbon-intensive industries are at a higher risk of job losses over the coming years.[9]

Some regions are more likely to face job losses from both automation and greening. We analyse the distribution of twin transition risks across EU regions (Box A).

7 See for example Dorn et. al (2018) for a discussion of wider implications of trade shocks on households.

8 It should be noted that we analyse both transitions from a structural perspective and with a view to identifying effects over a ten-year timeframe. The impact of the COVID-19 shock or recent changes in climate-related policies cannot be accounted for in this framework.

9 Data assistance by Hubert Strauss (Projects Directorate) in the calculation of employment shares of carbon-intensive industries is gratefully acknowledged.

Box A

Assessment of twin transition risk

We estimate risks of job automation for European regions at the NUTS2 level.[10] These estimations are based on job automation risks by occupation as defined by ISCO two-digit categories. Differences in occupational risks reflect different tasks performed at work and the extent to which these tasks can be automated. Information on tasks is based on microdata from the Organisation for Economic Co-operation and Development's PIAAC survey (see Nedelkoska and Quintini, 2018 and EIB 2019 for further discussion). As a robustness check, we also assess automation risks based on estimates by occupation from Pouliakas (2018). Information on task content is based on the European Skills and Jobs Survey. To derive automation risks for EU regions, we use mean probabilities of automation for occupations together with information on the regional employment composition based on the EU Labour Force Survey.[11] Regions with a regional automation risk above the EU median are considered high risk.[12] In addition, we identify high and low-risk regions by country groups and for five larger countries (Spain, Italy, France, Germany and Poland) for country group and intra-country comparisons.

Similar to automation, we then classify regions with higher vs. lower risks of job losses linked to greening. We use a sectoral approach, considering employment in carbon-intensive industries.[13] Regions with employment in carbon-intensive industries above the EU median are considered high risk. The assessment focuses on the medium-term risk of job losses linked to the structural transformation over the next decade.

Regions facing a high twin risk of job losses have a high automation risk and a high share of employment in carbon-intensive industries. The shares cannot be added to each other because a job with a high routine content in a carbon-intensive industry would count double. However, this job would be at risk from both types of transformation, increasing the likelihood it would be eliminated.

The two approaches used to assess the risk to employment from transformation – focusing on job tasks for automation and industry activities for greening – have become the workhorse models used to assess risks from the two transformations separately. While our analysis does not provide a joint estimate for the share of employment at risk from automation and greening by region, it does enable us to gauge differences in the intensity of exposure. We do not provide an indication of net employment effects, but the analysis does help to identify vulnerabilities, providing information needed to better manage labour market risks across the European Union.

10 According to NUTS2 2016 classification.

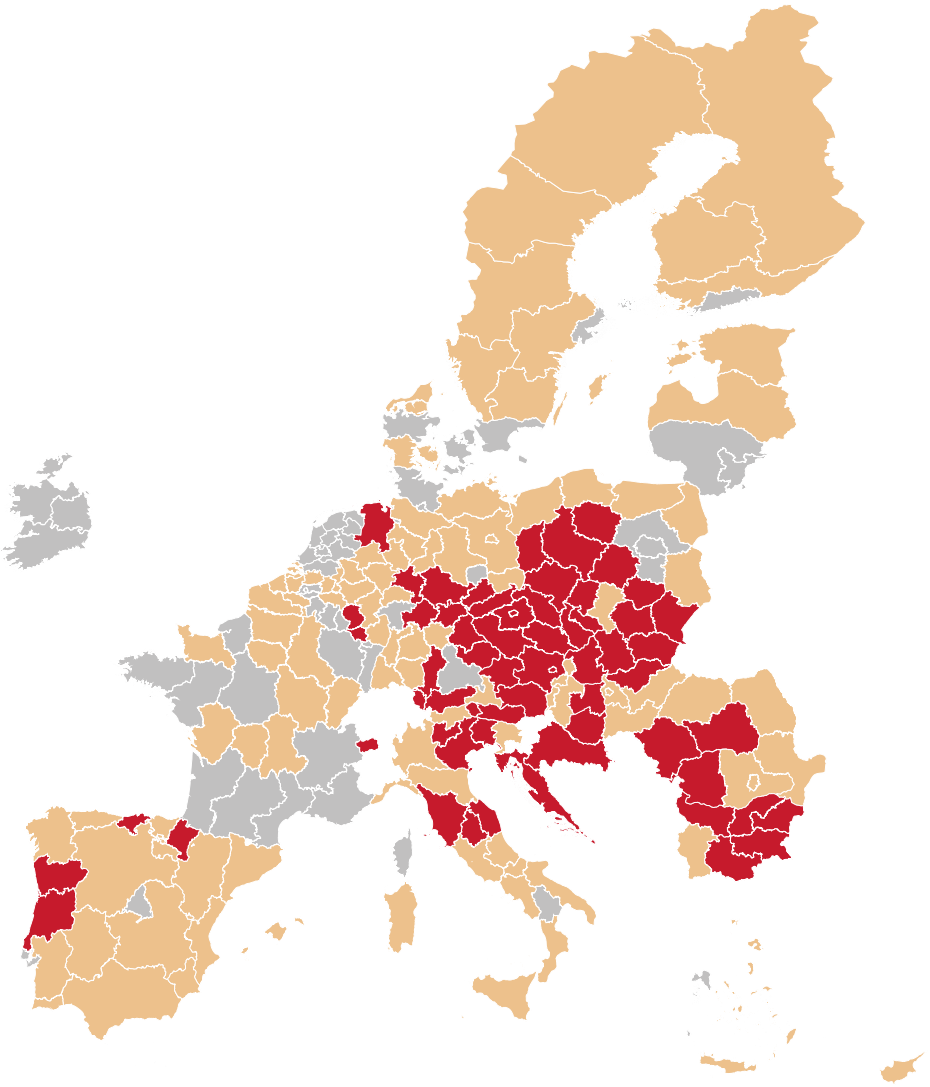
11 Due to limited data availability at ISCO 2 level, automation risks are not available for Malta. For the Netherlands, country level estimates were used due to data limitations.

12 Unweighted medians.

13 This analysis considers the following industries as carbon-intensive: B – mining, C17 – manufacturing of paper and paper products, C19 – manufacturing of coke and refined petroleum, C20 – chemicals and chemical products, C23 – other non-metallic mineral products, C24 – basic metals, C25 – fabricated metal products and D – electricity-steam-cooling. The employment associated is based on Eurostat's structural business statistics. For further discussion of the sectoral approach to estimating job risks from the green transition see Cameron et al. (2020).

A high twin transition risk aggravates the challenges faced by local labour markets. Where job destruction caused by automation and greening coincide, alternative employment will be harder to find, all else being equal. Moreover, high exposure to both risks amplifies challenges for local authorities. For example, taxes may fall while higher spending is needed to retrain workers. These challenges can also include dealing with legacy infrastructure that needs to be cleaned up or redeployed. Twin risks complicate the ability of local authorities to adequately plan. We define regions with high twin transition risks as those with automation risks above the EU median, along with employment shares in carbon-intensive industries above the EU median.

Map 1
Regions with high twin transition risks



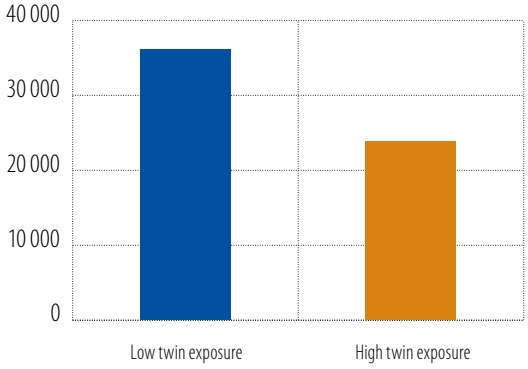
Source: *EIB Economics Department calculations.*
Note: *Red = high exposure to two types of transition risk, linked to automation and potential job losses in carbon-intensive industries. Orange = high exposure to one type of transition. Grey = relatively low exposure to both types of risks. EU outermost regions not shown.*

High double exposure risks cluster in Central and Eastern Europe. Some regions with high twin risks are located in Germany, Austria, Spain, Portugal and Italy. However, some 55% of Central and Eastern European regions are exposed to high twin transition risks, compared with 23% in Southern Europe and 15% in Northern and Western Europe. The difference reflects the regions' industrial structure, with more activities with higher value added, which often create more jobs less susceptible to automation, located in Northern and Western Europe. All of the regions in the "very high risk" group (defined as being in the top quintile for both risk types) are in Central and Eastern and southeastern Europe. In contrast, no Central and Eastern European region is included in the 20% of regions that have the lowest risks from automation and the green transition.

Regions with high exposure to twin risks tend to be poorer, less densely populated and often with labour markets that have some structural difficulties. Comparing the regions with high exposure to both risks to the group of regions facing lower risks suggests that regions with higher risk are already facing more challenges. Income levels are lower in the high risk regions, where a higher share of people are at risk of poverty, the regions are less densely populated, the population is older and fewer people received a higher, or tertiary, education (Figure 6a and 6b). These regions also tend to have more structural difficulties, with lower employment rates, a higher share of people leaving school early, and a higher share of young people that are not employed, in education or in training (Figure 7a and 7b).

Figure 6a

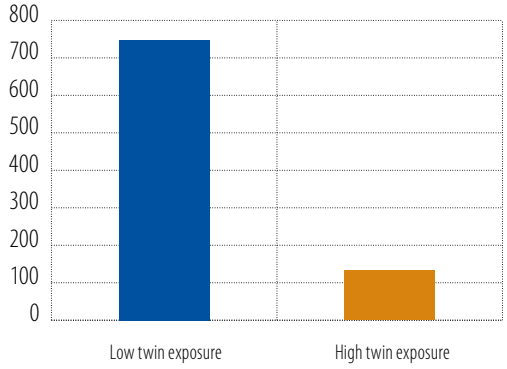
GDP per capita in regions with high vs. low twin exposure



Source: *EIB Economics Department computations, Eurostat.*
Note: *GDP in euros.*

Figure 6b

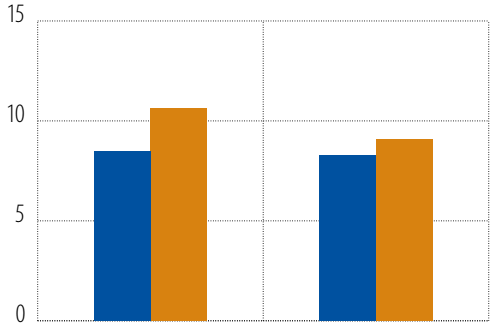
Population density in regions with high vs. low twin exposure



Source: *EIB Economics Department computations, Eurostat.*
Note: *Population density In persons per square kilometre.*

Figure 7a

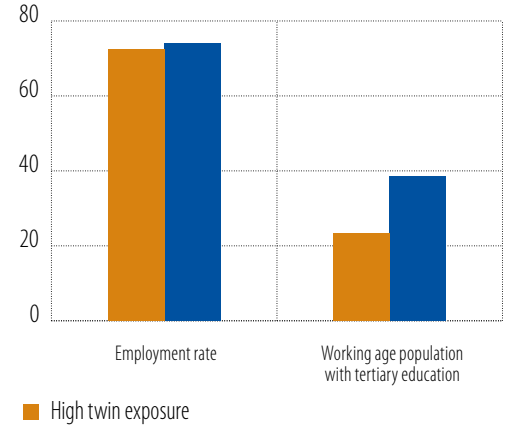
NEET rates and share of early school leavers in regions with high vs. low twin exposure (in %)



Source: *EIB Economics Department computations, Eurostat.*
Note: *NEET refers to not in employment, education or training, for people aged 15-24.*

Figure 7b

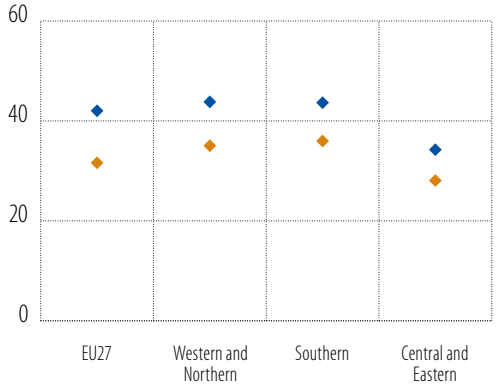
Employment rates and share of people with tertiary education in regions with high vs. low twin exposure (in %)



Source: *EIB Economics Department computations, Eurostat.*
Note: *Employment rates for people aged 25-64. Refers to working age population.*

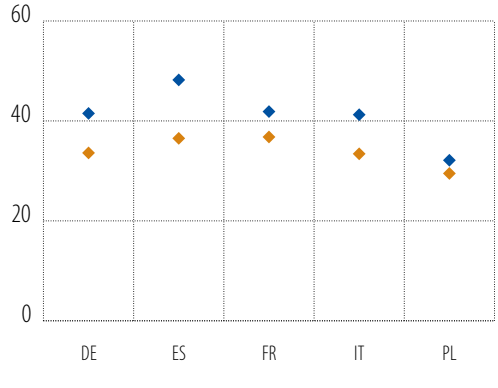
Firms in regions with high twin transition risks invest less in intangibles. Moreover, these firms are more likely to report investment gaps compared to peers in regions with low transition risks. At the same time, more firms in these regions say that limited finance is an obstacle to investment. Differences in intangible investment for firms in high vs. low twin risk regions also emerge when examining the three country groups and when looking at the intra-country differences for larger countries (Figures 8a and 8b).

Figure 8a
Investment shares in intangibles, by exposure to transition risks (in %), **EU and country groups**



Source: EIB Investment Survey (EIBIS) 2016-2019.

Figure 8b
Investment shares in intangibles, by exposure to transition risks (in %), **selected countries**



Source: EIBIS 2016-2019.

Among the regions with the highest twin transition risks, none is among the 30 most R&D intensive regions in the European Union.[14] Jobs linked to innovative activities, such as research and development, are less likely to be exposed to the transformation risks assessed. Regions whose economies are further away from the innovation frontier are likely to have more difficulty moving up the value chain and boosting innovation, particularly if they are in countries whose innovation systems are also lagging behind. Regions in Northern and Western European countries, meanwhile, may benefit from stronger innovation systems. Typically, these regions also have a higher share of the workforce active in science and technology than most regions in Southern and Eastern Europe. While some Southern European countries have stronger intra-country divisions in terms of innovation activity and performance (Italy, for example), in Central and Eastern Europe, innovation remains strongly focused in the capital regions (Kollar et al., 2018; European Commission, 2019, 2020). This divide calls for a more comprehensive approach to strengthening home-grown innovation, particularly for Central and Eastern European economies (Gereben and Wruuck, 2020). Other factors that affect regions' ability to catch up on innovation include their specific industrial structures, existing clusters and differences in interregional linkages (Hollanders et al., 2020).

Twin risks may add to regional differences within countries and hinder convergence among EU members in the future. The economic convergence of Central and Eastern Europe with the European Union is considerable but had started to slow down already after the global financial crisis (European Central Bank (ECB), 2018). Widespread exposure to the twin risks of digitalisation and greening for several countries – such as Bulgaria, Hungary, Slovakia and Romania – might slow convergence and call the viability of the prevalent growth model there into question (Gereben and Wruuck, 2020). In some parts of North Western Europe and Southern Europe, notably Germany, Austria, Italy Portugal and Spain, high twin exposures of some regions indicate risks of divergences within countries. For Germany, Spain, France and Poland for instance, the high double exposure affects regions that are already poorer and have lower shares of people with higher, or tertiary, education.

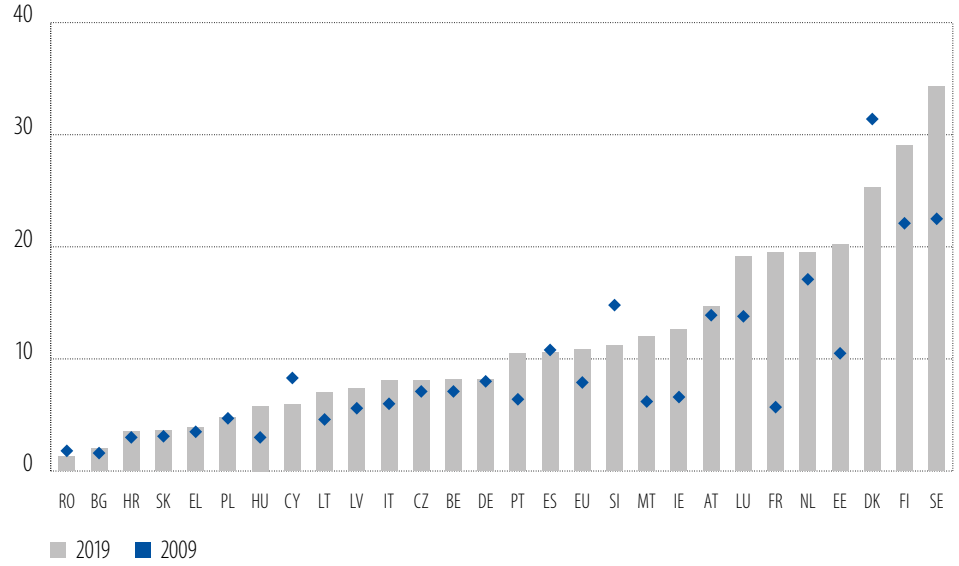
14 Innovation performance and classification based on the European Innovation Scoreboard (2019).

Divergences in regional performance will be more difficult to address in the coming years. European economies will continue to reel from the coronavirus crisis, and (structural) unemployment could remain an issue. This applies for regions that stand to be directly affected by transition risks and for individual countries. A more difficult labour market will limit employment opportunities at the regional and country level. In this respect, parts of Southern Europe face a more challenging situation as local labour markets had not yet fully recovered from the financial and sovereign debt crisis and are experiencing persistent structural difficulties, such as high unemployment. Although average EU unemployment rates were at historic lows before the pandemic, out of the 47 regions with double digit unemployment rates, more than 80% were located in Southern Europe, including every region of Greece, the majority of regions in Spain and approximately one-third of the regions in Italy.[15] Similarly, long-term unemployment has remained particularly prevalent in Greece and Italy. Even if many of these regions are not particularly exposed to the twin transition risks, adapting to the economic transition could be difficult given a more challenging labour market situation to start with. Among the regions with the highest twin exposure, Severen tsentralen (BG), Severozápad (CZ), Swietokrzyskie (PL) and Vychodné Slovensko (SK) stand out as already having structural unemployment rates above the country averages.[16]

High twin risks coincide with differences in regions' ability to adapt. Factors helping to mitigate unemployment risks include quality of governance (country and local level), labour market policies to smoothen transition, and access to (re)training possibilities. Spending on active labour market policies is relatively low in Central and Eastern Europe as is participation in lifelong learning, with the exception of Slovenia (Figure 9). Moreover, most regions highly exposed to the twin transition risks lag behind other countries when it comes to lifelong learning. Participation rates in education and training in high risk regions are less than half (6.3%) those of regions with low twin exposure (15.9%). The low participation in education and training will make it even more difficult for high-risk regions to adapt.

Figure 9

Participation in lifelong learning, EU27 (in %)



Source: *Eurostat.*
Note: *Participation of population aged 25-64.*

15 Based on 2019 unemployment rates (15-74 years) at NUTS2 level (Eurostat).
16 Based on 2019 long-term unemployment rates at NUTS2 and country levels (Eurostat).

Part of these learning gaps are linked to differences in training among firms. Firms are the main financial sponsors of adult learning in the EU27. Workers in high-skilled jobs, which are typically less susceptible to automation, regularly receive more training than those in low-skilled jobs.[17] Industries that stand to be affected strongly by the green transition invest comparatively little in their workforce (European Commission, Cameron et al., 2020). Firms in Central and Eastern Europe also spend less on training compared to their Northern and Western European peers (EIB, 2019). This could leave a non-negligible share of the workforce at high risk but with little preparation and support to change jobs.

Some of the risks posed by automation and the green transition for labour markets are similar. Automation and the green transition will both create and destroy jobs. Both stand to change the skills required and are likely to increase demand for higher skilled employees. Beyond risks of job losses, they share risks linked to skill mismatches and labour market polarisation with economic and societal costs beyond the local level.

Automation and greening present different challenges when it comes to managing the transition. Regions with high twin transition risks potentially face larger job losses and a more complex challenge to manage adaptation. The complexity arises because the digital transition and the green transition also differ in some aspects. From a local perspective, the needs of regions to adapt to automation are somewhat uncertain, particularly in terms of their scope and timeline. It is less clear what jobs will really be replaced by machines and what jobs will "only" be transformed. The speed of these developments depends on multiple factors, such as the pace of innovation, technology adoption, labour market regulation and firms' approaches to human resources management.[18] Some of these factors are beyond local authorities' influence or are only changing very slowly, making it difficult for authorities to devise effective responses. For the green transition, phasing out activities with a clear timeline on the one hand also reduces uncertainties for transition planning. At the same time, it may involve the loss of large employers in a region and leave less room for upgrading jobs within firms or industries. Job losses at mining or some manufacturing sites may also affect workers with similar skills and a distinct professional identity. To deal with these concentrated job losses, transition management requires strong capacity on the ground and an agreement on sharing transition costs beyond the local level.

Past cases of "narrow" industrial transition can offer ideas on how to best manage the transition. Transformation processes with strong (first-round) effects for specific industries and concentrated local job losses include (ongoing) coal transitions in Europe, for example in Germany or Poland, but also in the United States and Canada (Government of Canada, 2018; Sartor, 2018; Tzimas, 2018; BmWi, 2019; Cameron, 2020). While the instruments that worked are specific to the country context, a number of principles supporting a successful transition can be distilled. These include:

- Early preparation of transition plans with binding commitments;
- Communication, cooperation and stakeholder engagement, aligning local constituents and social partners;
- Policy consistency across levels, such as at the regional, national and (supported by) the European level;
- Evaluation of progress and instruments, defining key indicators and monitoring progress.

"Big waves" of technological transformation have triggered broader societal and policy shifts. Broader waves of technological change comparable to digitalisation have typically triggered changes in production processes and the organisation of work, while also affecting social and education policies. For instance with the Industrial Revolution, workers moved from farms to factories, and increasing demand for a skilled workforce helped to broaden access to education and to introduce compulsory primary schooling. Historically, industrialisation was intertwined with the emergence of workers' rights and the welfare state.

17 Participation rates of high-qualified employees of private companies in adult learning activities were twice those of low-qualified employees. For the European Union, based on the adult education survey, 2016.

18 For example, Dauth et al. (2017) find that the introduction of robots in Germany did not raise the risk of displacement for incumbent workers. Firms were often willing to retrain existing workers, but robots had a negative effect for new hiring and young labour market entrants. One reason for low displacement is employment regulation and high costs for dismissal, resulting in adjustment via other channels. Cedefop (2020) analyses the role of employers' responses and provides further evidence for the Irish case.

Leading the big waves drives long-term prosperity. Leading waves of industrial change requires innovation, and an economic and a societal model that supports change. Digital technologies have ushered in a major wave of industrial transformation, which is still ongoing. It has already transformed industries, production processes and the way we live and work. While digital technologies are prevalent in Europeans' lives, the European Union risks becoming a follower on digitalisation with its firms, particularly small ones, lagging behind on the adoption of technologies (EIB, 2019). The green transition, while starting out as a narrower process with the initial effects concentrated on specific industries, has the potential to broaden over time, similarly transforming production processes, work modes and consumption patterns.

Being able to drive change depends on local action and the right policy framework. The European Union will only be able to lead if countries work together. Moreover, timing for joint action is crucial. The costs of not shaping digitalisation and climate action are high for Europe, and include a loss in competitiveness and the future consequences of climate change. Mitigating these effects requires local action to incentivise innovation, broaden the diffusion of technology and encourage a more efficient use of resources – and it requires strategies to help people negatively affected by these changes to adapt.

Planning and advancing transition while managing associated risks poses considerable challenges at the local level. All regions and countries will be affected by digitalisation, climate change and the policies enacted to deal with these transitions.[19] Regions' capacities to plan for and adapt to change –by implementing digital public services, for example – differ, depending among other factors on financial resources, infrastructure and local expertise. However, the challenges are more daunting where twin transition risks for jobs are high.

Supportive labour market and welfare policies are needed to ensure no one is left behind. This process requires dedicated action at the local, country and European level. It includes targeted support and measures that preserve employment, rather than particular jobs. To support meaningful transitions, jobs with the prospect of future (local) growth, offering perspectives for employees, need to be identified. Moreover, the skill needs of these jobs and workers' current skills must be assessed to then provide the right support for bridging gaps.[20]

Seizing the job opportunities of the twin transition

The greening of the EU economy provides job opportunities in the short and the long term. Climate action can be an opportunity for EU businesses, fostering innovation and enhancing opportunities for climate-smart growth. In the long term, the green transition is expected to be employment-neutral or add jobs on balance (ILO, 2018; Fragkos/Paroussos, 2018; Griffin et al., 2019; Eurofund, 2019; Kapetaki, 2020). Moreover, climate action has an impact on health and safety at the workplace (Eurofund, 2013; ILO, 2018).

Jobs are expected to be created in renewable energy, recycling, construction and agriculture (Table 1). Europe is the only world region that can expect employment gains in agriculture by moving towards more organic farming. Job growth is also expected in the production and distribution of specialised products (ILO, 2018). The extent to which these new jobs materialise depends on whether European firms are able to spot and seize business opportunities, innovate, and harness new demand in the European Union and globally.

19 These reflect broader structural trends. However, the intensity of regional transition challenges, including those related to labour markets, may differ.

20 Although in a different context, Singapore provides one example of aligning economic development strategies with a strong emphasis on skill assessment and profiling and support for bridging skill gaps with a view to supporting economic development.

Table 1
Long-term employment effects, in selected sectors of the European Union

	Sectoral employment impact, difference from baseline in 2050 (in %)	
Sector	Share of total jobs 2015	Range of change in jobs by 2050 compared with 2015
Construction	6.7 %	+0.3% to +2.8%
Services	71.7%	-2.0% to + 0.9%
Agriculture	4.5%	-0.7% to +7.9%
Mining and extraction	0.5%	-62.6% to -2.9%
Power generation	0.7%	+3.6% to + 22.3%
Manufacturing (energy-intensive)	2.0%	-2.6% to + 1.8%
Other manufacturing	13.3%	-1.4% to + 1.1%

Source: *European Commission, 2019, 2018.*
Note: *Employment effects from JRC-GEM-E3 model. Ranges of estimates for jobs changed in 2050 reflect differences in modelling assumptions.*

Climate action has the potential to boost employment in the short to medium term, helping to support a job-rich recovery. Employment opportunities linked to greening can be a source of local job growth, offering "meaningful" transition opportunities, for example from mining to renewables. Moreover, these new jobs can help to sustain employment, support demand and strengthen the recovery from the coronavirus pandemic. In contrast, if the shock deepens, activity in cyclical sectors such as construction is likely to fall, adding further to rising unemployment.

For green jobs to materialise, Europe needs to invest, particularly in skills, and create the right mix of incentives. Stepping up action to generate local job opportunities linked to greening, for example through investment in long-lived energy infrastructure, refurbishment of buildings or measures related to urban renewal, can boost local jobs in the near-term (Box B). These efforts can have multiple long-term benefits, such as dealing with climate change, improving infrastructure and sustaining livelihoods.

Box B
Ramping up clean energy jobs in Europe: Insights from the IEA's Sustainable Recovery Plan[21]

The European Green Deal Investment Plan (EGDIP)[22] aims at mobilising at least €1 trillion in sustainable investments over the next decade, as part of the long-term efforts to reach net-zero greenhouse gas emissions by 2050 for the European Union, as well as contributing to short-term efforts to stimulate economic recovery in the face of the COVID-19 pandemic and the lingering effects of the financial crisis. These investments will profoundly reshape the energy sector across Europe, including investment and employment. Based on the International Energy Agency's (IEA) analysis, this mix of private and public expenditure could accelerate clean energy investment by 70% over historic levels in the coming decade.

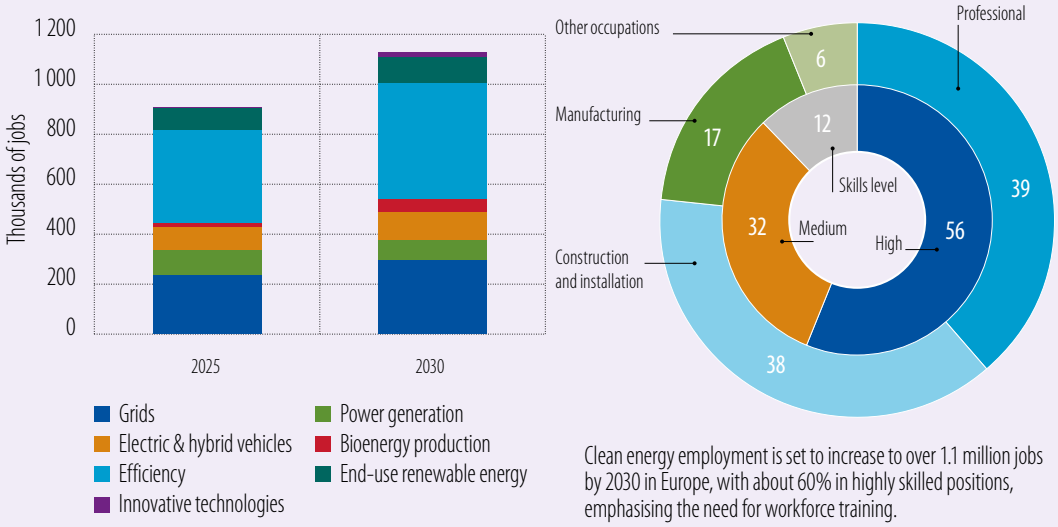
21 Box prepared by Daniel Wetzel (IEA).
22 See European Commission (14.1.2020): Sustainable Europe Investment Plan. European Green Deal Investment Plan.

Based on current policy commitments and investment needs, the IEA estimates 30% of increased investment could go to efficiency upgrades, retrofits and new efficient appliances. Around 45% could go to the electricity sector, with a large share going toward making grids more resilient, digital, capable of integrating more renewables — largely wind and solar — and enabling more flexible demand. Over 15% could be to support decarbonising transport, predominantly supporting the uptake of zero-emissions vehicles, including ramping up in biofuels, battery production, and charging infrastructure, but also some measures supporting advances toward a circular economy and making cities more liveable and low-carbon.

These levels of investment would require a scale up of energy and energy-related employment by over 1 100 000 people across Europe by 2030.

Figure B.1

New clean energy jobs above 2019 levels and share of roles created by occupation and skill level in 2030



Clean energy employment is set to increase to over 1.1 million jobs by 2030 in Europe, with about 60% in highly skilled positions, emphasising the need for workforce training.

Source: *Daniel Wetzel, IEA.*

Note: *Employment estimates are based on the IEA's projections for the European Union's energy sector investments. These estimates fully incorporate the European Union's overall climate-neutral targets in 2050 and the recent announcements to reduce greenhouse gas emissions by a minimum of 55% vs. 1990 levels by 2030. These projections also consider all existing national and EU-level policies and are aligned with near-term investments laid out in the EGDIP and other national commitments, including COVID-19 related economic recovery packages. Investments beyond these policy commitments are determined based on the IEA's World Energy Model.[23] Employment estimates include direct and indirect jobs and do not include induced jobs. The skill level classification is aligned with those employed by the International Labour Organization (ILO).*

In the early years, these jobs are concentrated in projects that can be ramped up quickly through existing programmes that can mobilise money quickly, such as energy efficiency retrofits and improvements to urban walking, cycling, and public transit infrastructure. As highlighted in the IEA's Special Report on Sustainable Recovery[24], efficiency retrofits can create 12 to 25 jobs for every million euros invested, depending on the region, and help stabilise employment in construction, one of the sectors more affected during the pandemic in some countries and typically strongly cyclical. Urban active mobility investment can create 10-19 jobs per million euros invested, and can also support commuting via means that minimise virus transmission during the pandemic.

23 IEA's World Energy Model Documentation is available online at: https://www.iea.org/reports/world-energy-model/documentation

24 IEA (International Energy Agency) (2020a), Sustainable Recovery: World Energy Outlook Special Report, IEA, Paris, https://www.iea.org/reports/sustainable-recovery.

In subsequent years, there will be higher levels of investment in power sector projects and the manufacturing of electric and efficient vehicles (Figure 1). The jobs that stand to be created are overwhelmingly in the engineering and construction of new projects and the manufacturing of new efficient and low-carbon technologies. Although they are a small employer today, investment in pilot projects as well as further spending on research and development play an important role in accelerating emerging industries. These new industries could serve as key employers in the future, for instance in hydrogen, storage, and carbon capture sequestration.

In Europe, almost 60% of new jobs created would be in highly skilled positions, requiring substantial training, and only around 10% would be low-skilled, requiring minimal retraining. The remainder would require moderate retraining, which can be focused on transitioning workers within the same industry from one segment to another or between industries but within the same occupation (for example a construction worker being retrained to conduct high quality energy investments in building envelopes). This underscores the importance of EGDIP's Just Transition Mechanism for supporting this retraining, but also for developing the skills of those entering the workforce for the first time, including programmes that support the increased participation of women and other underrepresented communities in the energy industry.

The location of these jobs is an important factor for policymakers, especially when directing programmes and funding. Jobs in the construction and delivery of retrofits have a relatively even geographic distribution: wherever there are buildings, retrofits can be performed. However, the scale of energy improvements and cost-effective measures may vary between different buildings and climate zones. Power generation and grid projects, while concentrated in specific regions with suitable resources, are typically delivered by engineering, construction and procurement firms with an employment base across different regions, aided by local contractors. One challenge is the geographic distribution of jobs in manufacturing, where regions with manufacturing benefit while others may be in decline. Regions where jobs are lost due to the energy transition can be a focus for investments in emerging sectors, like battery production. Environmental restoration in mining regions is another possibility, providing near-term employment for those close to retirement as others are retrained.

Many manufacturing processes need to be ramped up to meet the increased demand for clean energy technologies. For instance, global manufacturing capacity for solar and batteries needs to grow threefold if the world is to comply with the Paris Agreement. Therefore, while increased demand for electric vehicles or solar panels in the near-term may drive up manufacturing in other parts of the world, EGDIP's investments could help shift current production lines to efficient, low-carbon alternatives or seed new manufacturing in Europe. Countries around the world are already emphasising the importance of investing in these technologies now to be front-runners in the new clean energy economy, and are directing funding towards building up their own workforce to support this expansion.

This global race to ramp up clean energy industries coincides with a similar race to scale up digital industries. Many of the investments in grids, building efficiency, appliances, batteries, and electric vehicles all have strong digital components that make these industries mutually supportive. Many energy measures that include advanced control systems and communications functionality are more effective in reducing energy demand and improving energy system integration and security, such as demand response, electric and automated vehicles, and smart inverters for batteries and distributed solar photovoltaics. Policymakers could adopt standards that specify base levels of digital capability within the different energy funded programmes and could cost-effectively enhance energy measures, and mutually support policy objectives for both industries simultaneously.

Immediate job creation effects are stronger for less complex projects, where spending on materials makes up less of the costs. Green projects could also help adapt infrastructure to the changing demands of a post-pandemic world. The pandemic triggered short-term shifts in behaviour, such as the use of public transport and the greater emphasis on the quality of housing. Some of those behavioural changes may stick.

Central and Eastern Europe could benefit from new jobs created by greening. A large share of the housing stock in the region is poorly insulated, and in some countries a significant number of people cannot keep their homes adequately warm.[25] At the same time, a large share of the building stock was made using prefabricated technologies, which means that standardised solutions for refurbishment can be rolled out quickly. With buildings accounting for some 40% of energy consumed and 36% of carbon emissions, energy efficiency improvements in housing have the potential to significantly advance the European Union's climate goals.

The jobs and other benefits generated from renovation projects could advance social cohesion. Stepping up investment in greening combined with support for the development of complementary skills could bring forward job creation at different skill levels and help to mitigate further job polarisation. For example, many jobs in the construction sector require mid-level skills and pay middle wages. Moreover, refurbishments and other measures could reduce consumers' energy bills, improve resilience to climate events and price shocks and improve health and comfort.

So far, digital technologies have changed the content of jobs but have not led to job destruction on balance. Technological change has typically led to more and better employment in the long run. So far, the available evidence does not corroborate fears of "the end of work" ushered in by digital technologies. The net effects of technological change during the last few decades appear neutral or even positive once the processes of adjustment between firms and sectors are taken into account (Craglia et al., 2018). The computerisation of work from 1999 to 2010 seems to have led to employment increases in the European Union in net terms (Gregory et al., 2019) and the introduction of industrial robots does not appear to be associated with a significant decrease in manufacturing employment for Europe (Graetz and Michaels, 2018; Klenert et al. 2020). Before the COVID-19 crisis, the employment rate had reached a record high of around 73%.

EIB investment survey results further corroborate the job creation effects of digital firms. Digital firms have been more likely to add jobs than their non-digital peers over the past three years. Job creation by digital firms can be observed across all three country groups and particularly in Southern Europe. In contrast, a higher share of non-digital firms have cut jobs or kept employment stable. The rise in employment witnessed over the last few years also reflects digital firms' stronger growth and productivity. Notably, job creation is visible across the different digital technologies adopted by firms (Figure 10).

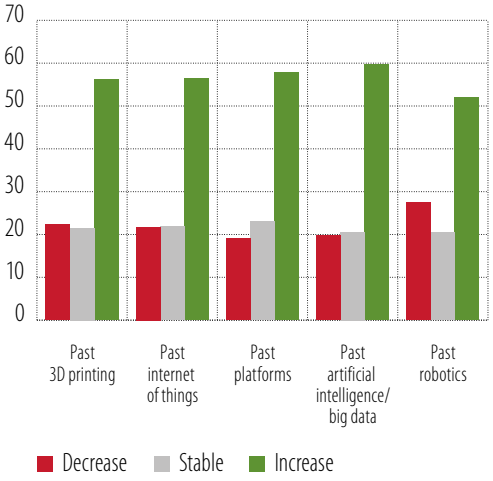
Digital firms have created "better" jobs, paying higher wages than their non-digital peers across all regions in Europe (Figure 11). They are also more likely to reward good performance by their employees (Cathles et al., 2020).

The employment outlook of digital firms has been more resilient during the pandemic. Asked about the structural impact of the pandemic on employment, non-digital firms appear somewhat more pessimistic, with 23% of firms expecting to reduce employment, compared with some 17% for the multiple adopters. The difference in the employment outlook may reflect a stronger direct impact on the operations and business continuity of non-digital firms in recent months. These firms may also fear that they have missed the boat on technological developments, since the pandemic is generally expected to boost digitalisation further.

Firms most advanced in implementing digital technologies are more optimistic on the job creation effects of those technologies in the future. Some 16% of digital firms in the European Union that have implemented multiple digital technologies expect those technologies to create more jobs, compared with 11% for single adopters. This dynamic holds across all three regions, with multiple adopters in Southern Europe the most confident that their digital technologies will increase employment (22%).

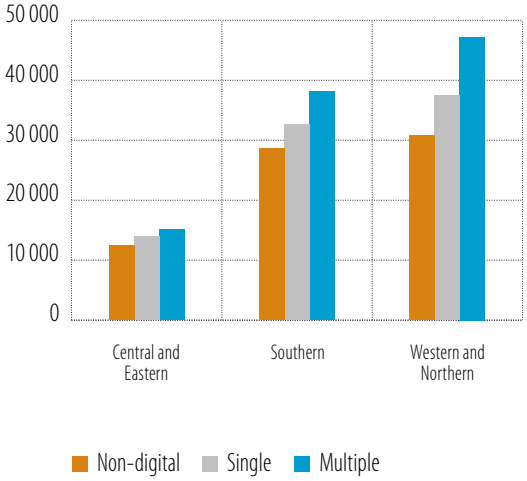
25 According to European Union Statistics on Income and Living Conditions, inadequate heating is a problem for more than 35% of Bulgarians and almost 30% of Lithuanians.

Figure 10
Share of EU firms reporting changes in employment over the last three years
(in %)



Source: *EIBIS 2020.*
Base: *Firms having adopted digital technologies.*
Question: *How many people did your company employ either full or part-time at all its locations, three years ago?*

Figure 11
Median wages by stage of digitalisation



Source: *EIBIS 2020.*
Base: *All firms.*
Question: *How much did the company spend on wages?*

However, some digital technologies are expected to lead to job losses. While the introduction of advanced robotics in recent years has increased employment on balance, firms expect robotics to reduce jobs in the future, particularly in Central and Eastern Europe (Figure 12). In contrast, other digital technologies such as platforms, big data or artificial intelligence are expected to be more employment-neutral.

Skill shortages have become entrenched as one of the key obstacles to corporate investment for EU firms in recent years. With the coronavirus pandemic, uncertainty naturally tops the list of corporate concerns but the availability of skills remains firms' second most important impediment to investment (around 73%, see Chapter 2). Concerns about skills have persisted over the last few years, pointing to a structural problem that is being exacerbated by rapid technological change.

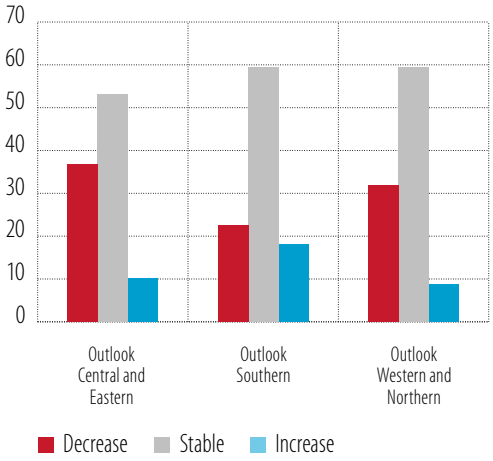
Firms seeking more advanced skills continue to experience more difficulties. Innovative companies, often seeking the new and advanced skills that are not so readily available, are more likely to experience bottlenecks (Figure 13). Innovative firms in Central and Eastern Europe are most likely to face skill constraints (82%). In addition, digital innovators and firms adopting innovation report more often that skills are an obstacle (76% and 80%).

The availability of skills is a bigger problem for many digital companies in the European Union, as compared to the United States. This is particularly the case for those having adopted multiple key digital technologies, arguably bringing on the digital transformation. Around 35% of US firms that adopted multiple technologies find the availability of skills to be a major obstacle to investment, compared with more than 44% in Southern Europe and some 40% in Central and Eastern and Northern and Western Europe. European firms that adopted a single digital technology also typically face skill constraints more often than their US peers.

Skill gaps can push firms to invest more in labour-saving technologies. Digital technologies can be labour-saving or labour-augmenting. What technology firms adopt and the quality and the quantity of jobs they (expect to) create depend on industry structures and the business environment, including the short-term outlook and longer-term obstacles (EIB, 2019). Adopting technologies that create jobs where digital technologies and human labour complement each other is more likely where the availability of

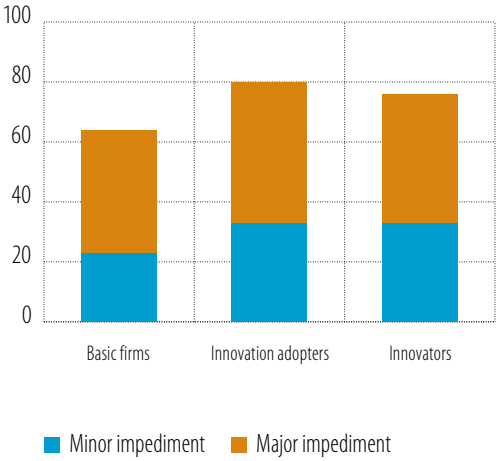
skills to support this is structurally better, for instance where a university or research centres are already in place, facilitating collaboration or the recruitment of personnel. At the same time, being able to exchange knowledge with these institutions can facilitate adoption.

Figure 12
Expected employment effects of robotics, by country group



Source: *EIBIS 2020.*
Base: *Firms that have implemented the technology.*
Question: *Looking ahead to the next three years, do you expect digital technologies implemented by your business to increase, decrease, or not change the number of employees in your business?*

Figure 13
Share of firms (in %) **reporting missing skills as an obstacle, by level of innovation**



Source: *EIBIS 2020.*
Note: *Innovators include incremental and leading innovators and developers.*
Base: *All firms.*
Question: *Thinking about your investment activities in your country, to what extent is the limited availability of skills an obstacle? Is it a major obstacle, a minor obstacle or not an obstacle at all?*

Skill shortages and the breadth of the skill base matter for digitalisation. It is difficult for firms to adopt technology and harness its potential when they lack the talent necessary to do so. Skill gaps slowing technology adoption and diffusion can stem from a lack of highly specialised talent. For example, shortages of information and communication technology (ICT) specialists have been persistent across the European Union, and many Member States have been found to have structural skill deficits in this area (European Commission, 2020a). At the same time, a more limited skill base, including the basic user skills, can limit technology adoption or discourage digital innovation and the creation of new digital businesses.

The diffusion of digital skills is crucial to avoiding further polarisation on labour markets and a deepening of digital divides in society. Looking ahead, about 90% of jobs will require some digital skills. However, in 2019, 42% of the EU population was unable to perform basic tasks, such as connecting to a WiFi network or using websites, displaying a lack of basic digital skills (European Commission, 2020a).

Critical gaps and how to address them

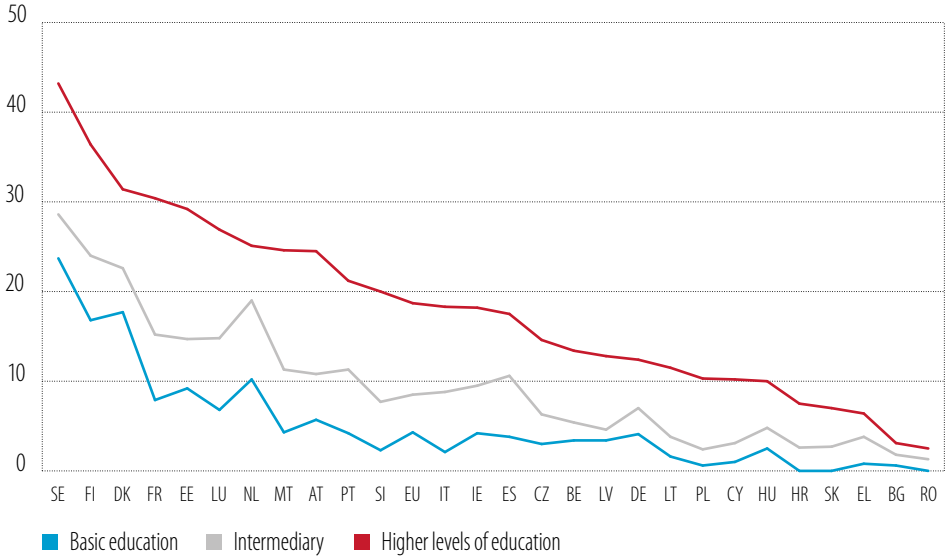
At present, participation is limited in the lifelong learning needed to adapt skills to changing work requirements. The European Union's current lifelong learning target is unlikely to be met. At European level, an average of at least 15% of adults should participate in lifelong learning by 2020.[26] While lifelong

26 The lifelong learning target is set out in the framework for European cooperation and training. Lifelong learning comprises all learning activities undertaken throughout an individual's life with the aim of improving knowledge, skills and competences, within personal, civic, social or employment-related perspectives. Adult learning refers to the participation of adults in lifelong learning. Adult learning usually refers to learning activities after the end of initial education.

learning activities have increased over the last decade, the latest results show that participation in lifelong learning for adults stood at 10.8% in 2019.[27] Moreover, people whose jobs are most at risk from structural changes and cyclical shocks are less likely to engage in dedicated learning activities or on-the-job learning.

Participation is highly dependent on previous levels of education. Adults with tertiary education are more than four times more likely to participate in adult learning than those with lower levels of education,[28] with pronounced differences across all Member States (Figure 14). The differences in participation are partly related to past experience with training and the setup of educational institutions, which make it easier for better-educated individuals to continue learning throughout their lives. Better-educated individuals are also more likely to have jobs that require and support continuous learning.

Figure 14
Participation in adult learning, by education level (in %)



Source: *Eurostat.*
Note: *Participation rate in education and training (last four weeks) by educational attainment level (2019).*

Employers play a key role in fostering adult learning. They finance the majority of job-related training in Europe and can provide working environments that incentivise and reward employee learning. However, firms' willingness and capacities to support training differ. Financial constraints and external factors can lead to firms investing less than what is socially optimal (Brunello and Wruuck, 2020).

Firms' operating environments influence who benefits from training. Firms invest in their workforce if it helps to improve productivity. Employers' willingness to train is influenced by company characteristics, innovation activity and the workforce composition, but also by institutional factors such as product and labour market regulation. Moreover, these matter for the breadth of training provision. There is some evidence that higher shares of flexible contracts are associated with lower training participation (Cabrales et al., 2014; ILO, 2016). Public and private investments in skills appear to complement each other in some areas. Some indications also suggest that manual workers (typically less likely to participate in training) engage in learning activities more often in countries that are more advanced in the transition towards the intangible economy (for example, Sweden, Finland, Ireland and the Netherlands).[29]

27 For adults aged 25-64.

28 Participation in adult learning stood at 18.7% among Europeans with tertiary education and at 4.3% of people with less than primary or primary and lower secondary education in 2019. Eurostat, based on the Labor Force Survey.

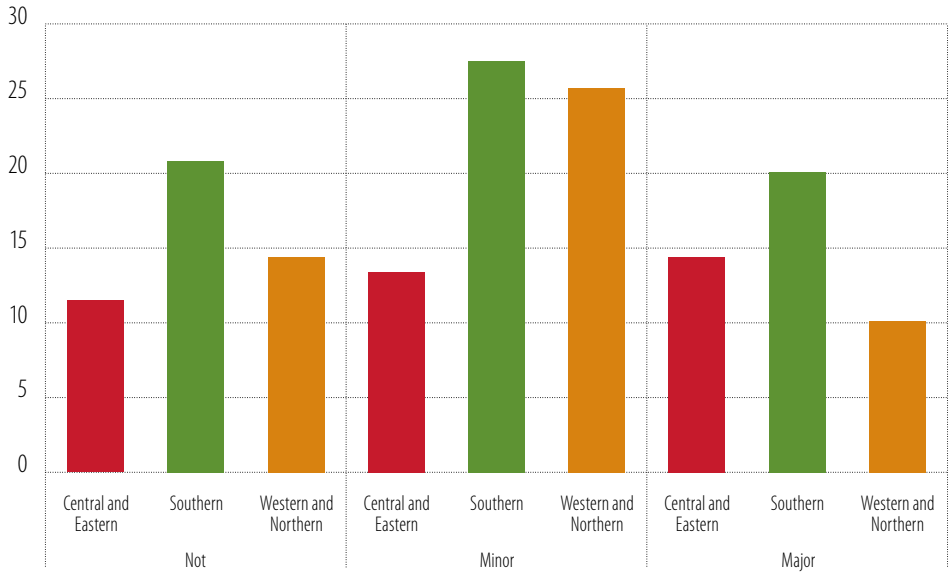
29 Based on assessment of Eurostat adult learning statistics by type of work.

Training is a riskier investment for smaller firms, as it typically accounts for a higher share of their total investment activities and employees may switch jobs. Also, they often face greater difficulties in covering losses in working time when employees are engaged in training activities.

Firms seeking skills – particularly digital ones – are more likely to provide training. Firms adding jobs and lacking skills are more likely to invest in training. Similarly, investment in digital skills is more likely to come from digital companies than those that are less cutting-edge. EIB Investment Survey data support the idea that digital firms seeking skills are more likely to provide training than their non-digital peers, with similar results across all three EU country groups (Figure 15). Fostering the diffusion of technology and sound management practices could also help increase and gradually broaden training.

The coronavirus crisis might negatively affect employer-sponsored training, at least temporarily. Evidence based on US data supports the idea that employer-sponsored training is pro-cyclical and suffered in the aftermath of the global financial crisis (Mendez and Sepulveda, 2012; Coy, 2018). While results for Europe are less clear due to limited availability of data (Brunello/Wruuck 2020), as firms face greater uncertainty, a more challenging financial situation, and hire less, their training investment might similarly contract.

Figure 15
Differences in training between digital and non-digital firms looking for specific skills (in percentage points)**, by country group**



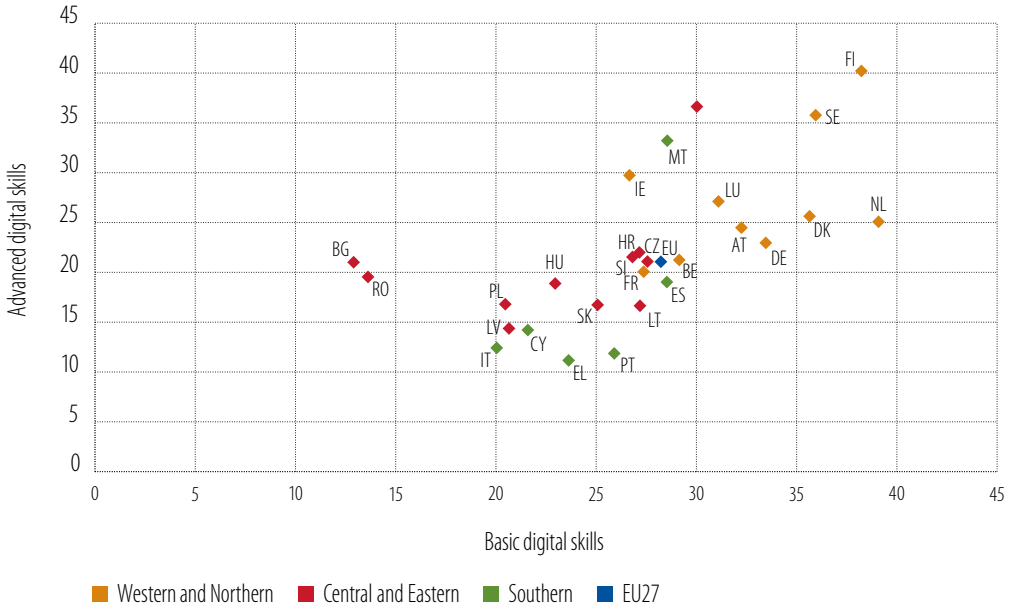
Source: *EIBIS 2020.*
Question: *Includes information on firms' investment in training, their adoption of key digital technologies to identify them as digital vs. non-digital firms and the extent to which they consider skills as an obstacle to investment activities (not an obstacle, minor or major obstacle).*

Many Europeans still lack the skills needed to thrive in a changing labour market. While the broadening of digital skills has advanced in recent years in the European Union, progress has been slow. In addition, the availability of advanced and basic skills typically goes together (Figure 16). Connectivity infrastructure can support the development of (basic) user skills, facilitating the more frequent use of technologies in private life and at work, but it is not sufficient. Further effort is needed to close the digital skills gap in Europe.

Education and employment matter for developing digital skills. Having developed digital skills strongly depends on socio-demographic factors. A majority, 88%, of Europeans with higher education and 69%

of the employed or self-employed have at least basic digital skills. In contrast, digital skill gaps are most pronounced among people with low levels of education. Some 44% of the unemployed and 30% of inactive individuals possess only basic or above digital skills.[30]

Figure 16
Development of basic and advanced digital skills (% of individuals)



Source: *European Commission, DESI (2020).*
Note: *Basic digital skills refers to basic internet user and software skills. Advanced digital skills considers ICT specialists and graduates.*

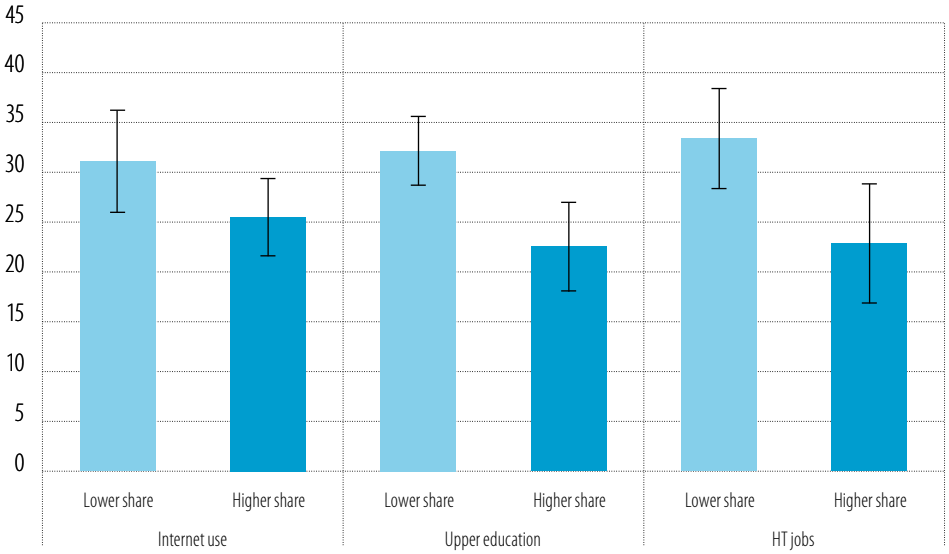
The COVID-19 crisis reemphasised the need to boost and broaden learning. The crisis also underscored how education and digitalisation can be a source of resilience. Individuals' concerns about unemployment increased less across European regions where the use of digital technologies is more prevalent and where a smaller share of the population had only low levels of education (Figure 17).

The coronavirus crisis disrupted traditional offline learning and increased job insecurities for many households. We find that the coronavirus shock sparked interest in e-learning, which is particularly suited for upgrading skills during lockdowns, when people are confined to their homes. Searches for e-learning spiked after the announcement of lockdown measures in EU countries, according to the Google search data (Figure 18). The spike in e-learning coincided with higher search interest in unemployment (Figure 19).

Interest in e-learning surged but the interest appears to have been short-lived. The highest search intensity for e-learning opportunities was measured in March-April 2020, during the initial phase of European lockdowns. Search intensity then declined to pre-pandemic levels over the summer period, while concerns about unemployment still appeared more elevated.

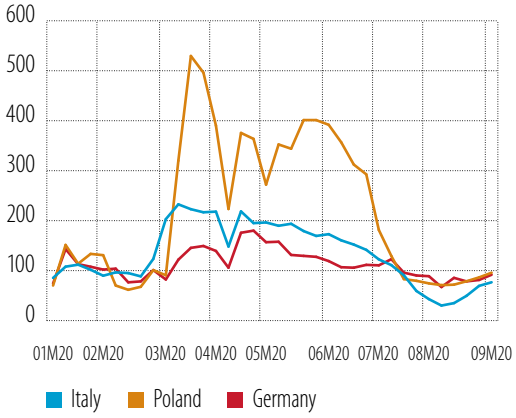
30 For 2019, Eurostat data on individuals' level of digital skills.

Figure 17
Regional impact of the coronavirus pandemic on unemployment concerns



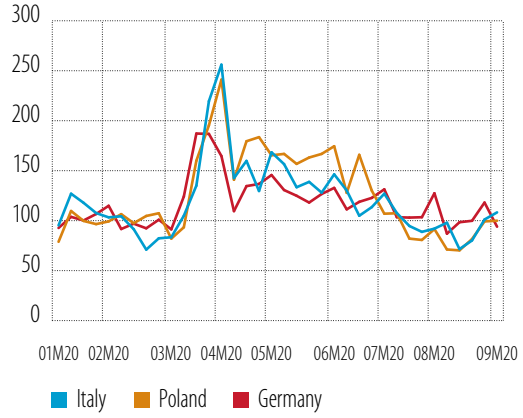
Source: *EIB Economics Department calculations.*
Notes: *Predicted Google search intensity for the term unemployment for an average region facing 1 000 newly identified COVID-19 cases. Lower share denotes 25th and upper share denotes 75th percentiles of variable regional distributions. Internet use reflects the share of the population that uses the internet on a daily basis. Upper education corresponds to the share of the population with an educational level of 3 or above, and HT jobs denotes the employment share in science and technology sectors. The results are based on 306 EU regions, excluding capital regions. Daily observations between January and May 2020, starting from cumulative 100 cases in a country. The model controls for regions' disposable income and population and includes fixed effects.*

Figure 18
Google search intensity for e-learning in selected EU countries



Source: *Google Trends*
Note: *Weekly data. Searches for e-learning as a topic. Data are rescaled for each country by making the average of January-February equal to 100.*

Figure 19
Google search intensity for unemployment in selected EU countries



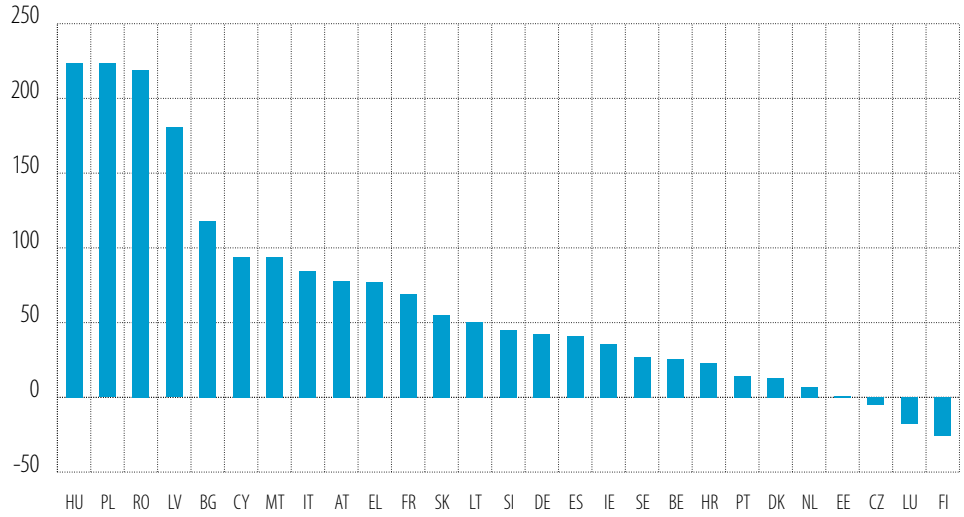
Source: *Google Trends*
Note: *Weekly data. Searches for unemployment as a topic. Data are rescaled for each country by making the average of January-February equal to 100.*

Interest in e-learning increased most in Central and Eastern Europe. In Hungary, Poland and Romania, the search intensity of e-learning increased by more than 200% (Figure 20). The increase was less

pronounced in some of the more developed EU members where participation in e-learning was more common prior to the pandemic.

Figure 20

Change in Google search intensity for e-learning in EU countries after lockdown, relative to the preceding period (in %)



Source: *Google Trends.*
Note: *Average daily search intensity from mid-March until end-May, relative to the search intensity from the beginning of January until mid-March, in percentages. Searches for e-learning as a topic.*

Changes in search interest reflect socioeconomic factors. The regional breakdown of search intensity helps to shed light on the structural determinants of e-learning searches (see Table 2). For each region we consider search data over two periods: from 1 January to the coronavirus outbreak, and from the outbreak to 31 May 2020. We combine this data with regional demographic and economic indicators from Eurostat to examine how regional variation in search intensity for e-learning links to regional economic and demographic characteristics.[31] After absorbing country fixed effects, the share of the population with tertiary education, together with disposable income, are the main regional determinants of search intensity for e-learning.

People in regions with high levels of education are more likely to seek online learning opportunities. Disposable income, on the other hand, has a negative coefficient. A possible explanation could be that in many countries, the strongest interest for e-learning comes not from the capital region, but from regions with major universities.

Structural learning inequalities persisted during the coronavirus outbreak. Online courses tend to be more popular among the more educated. Individuals with high levels of education are four times more likely than those with lower education to have used the internet for an online course.[32] The COVID-19 crisis did not change these pre-crisis patterns. When estimating the relationship between education and online learning for the pre-and post-pandemic sample separately, the estimated coefficients are not significantly different. For the moment, e-learning appears to be used more by people who already have relatively high levels of education and skills. Despite the technology being available, e-learning is unlikely to be a viable skill-acquiring option for the low(er)-skilled segment of the labour market, at least for the moment and on a stand-alone basis.

31 Eurostat data on socio-demographic characteristics for 2019.

32 16% of individuals with high levels of education used the Internet to participate in an online course compared to 4% for those with low levels of education. For EU27, 2019 (Eurostat).

Table 2
Regional determinants of Google search on e-learning – regression results

Linear regression, absorbing indicators		(Std. Err. adjusted for 24 clusters in geo)			Number of obs = 524 F(2, 23) = 8.69 Prob > F = 0.0015 R-squared = 0.5374 Adj R-squared = 0.5141 Root MSE = 20.1292	
E-learning search intensity	Coeff	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
Tertiary education	1.021509	0.290916	3.51	0.002	0.4197028	1.623314
Disposable income	-0.0043633	0.0011953	-3.65	0.001	-0.006836	-0.0018907
Constant	66.25534	13.30188	4.98	0	38.73831	93.77237
Country	absorbed (24 categories)					

Source: *EIB Economics Department estimates.*
Note: *The dependent variable is the average Google Search Intensity for e-learning as a topic in 286 EU regions, measured over two periods. The first period covers from 1 January 2020 to the coronavirus outbreak and the second covers from the coronavirus outbreak until 31 May 2020. The date of the outbreak is defined separately for each country based on Google mobility data. Regional measures of tertiary education levels and disposable income are from Eurostat. Standard errors are clustered by country.*

E-learning can be an important tool for improving skills after the pandemic, but it is not a panacea. In the short term, e-learning could offer ways to build up the skills of younger people in the labour market. Youth unemployment surged dramatically after the financial crisis, with potentially long-lasting effects on individual careers and long-term socioeconomic costs. Young people remain a more vulnerable group in the labour market, and youth unemployment rates have started to rise since the lockdown in March. At the same time, e-learning is more popular among the young, making it a potentially suitable tool for teaching new skills and preventing a surge in youth unemployment after the pandemic.

E-learning can also help to bridge gaps where access to more traditional types of training is limited. Our analysis shows that e-learning sparked significant interest during lockdowns. This was particularly true in Central and Eastern Europe, where the low cost and geographical flexibility of e-learning options may be attractive compared to more traditional types of training. However, adequate communications infrastructure must be in place for e-learning to take off.

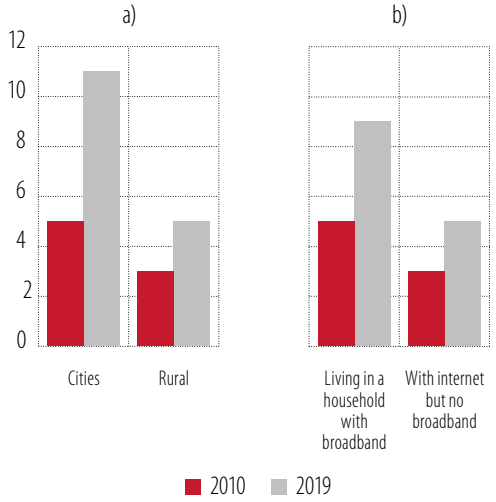
A more profound approach is needed to address unequal participation in traditional and online learning. On the one hand, results from search data analysis during lockdowns indicate a growing appetite for e-learning. However, the results also demonstrate that offline learning inequalities persist online and that the availability of technology alone does not ensure that that learning spreads as it needs to. Notwithstanding relatively broad household access to the internet, in 2019 only 8% of Europeans used it to do an online course. In some respects, for instance rural-urban disparities, inequalities appear to have widened (Figure 21, 22).

New policies to address adult learning requirements and learning inequalities are urgently needed. The green and digital transition could affect a high number of jobs in the coming years. The pandemic reemphasised the need to act on adult learning, as it has increased unemployment risks for many individuals and looks set to accelerate digitalisation further.

A case exists for stronger public support for adult learning and (re)training efforts, driven by the rise in demand for general skills, both through digitalisation and greening. These factors are compounded by higher unemployment risks due to the COVID-19 shock and the shifts the pandemic looks set to cause in the next few years, raising risks of structural unemployment.

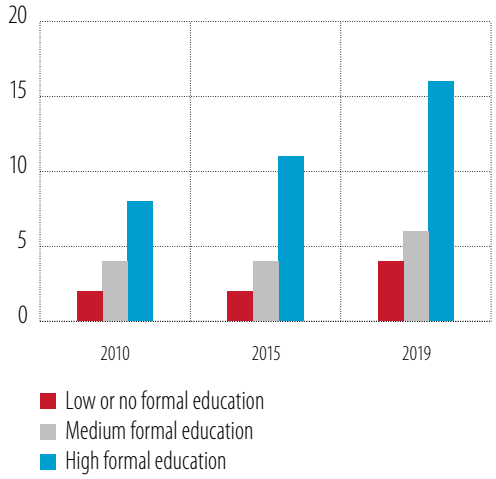
Stepping up efforts to boost adult learning needs to come with measures to tackle deep-seated learning inequalities online and offline, addressing inequalities of opportunity. The accumulation of high quality human capital relies heavily on access to quality healthcare and education infrastructure. This social infrastructure plays a role in addressing inequalities of opportunity and enabling people to develop their potential.

Figure 21
Share of individuals doing an online course, by a) degree of urbanisation and b) connectivity infrastructure (in %)



Source: *Eurostat.*
Note: *Participation for the last three months.*

Figure 22
Share of individuals doing an online course, by education level, EU27



Source: *Eurostat.*
Note: *Participation for the last three months.*

Europe must be mindful of the lessons learned from the last crisis, when investment, including in social infrastructure, was hit hard. Northern and Western European economies have continued to invest more in social infrastructure, including health and education. Those investments have increased resilience to long-term structural changes in the economy. Notably, the contraction in infrastructure investment following the financial and sovereign debt crisis aggravated differences with respect to labour markets but also with a view to social infrastructure investment (see Chapters 2 and 9 for further discussion of infrastructure investment and trends). This is a concern as it limits people's development potential, results in unequal access to basic services and often leads to poorer outcomes in healthcare or education. In the long term, regions that are able to develop human potential will be best positioned to adapt and thrive.

A mix of immediate and longer-term support is needed to avoid deepening inequalities and to facilitate adaptation to structural change in the current situation. Reskilling and upskilling activities, such as education and training with a focus on digital skills, is one of the seven flagship areas for investment and reforms under the recovery and resilience facility.[33] The facility together with the European Union's new budget, the Multiannual Financial Framework, should support the economic transformation while also making the process more inclusive by strengthening individuals' skills.

33 See European Commission for further information on the recovery and resilience facility.

Conclusion and policy implications

Digitalisation and the green transition will impact EU labour markets. Both transitions will change the kind of skills demanded and potentially destroy jobs. Both also have the potential to create new employment. Beyond lost jobs, there is a risk that people will not possess the skills needed for the jobs created by the transition, which could have profound social and economic consequences.

The digital and green transitions are not going to be "inclusive by default." Policies that actively foster social cohesion are needed to make the transitions inclusive. Measures to promote employment, facilitate the reallocation of workers, advance decent work and offer local opportunities for displaced workers are needed. Structural transformation can be inclusive if accompanied by the right mix of policies – policies that help create jobs and enable people to benefit from changes to the EU economy rather than being threatened by them. Investment in education and skills is crucial.

Europe has as an opportunity to avoid the experience of the financial and sovereign debt crisis, provide a strong recovery from the pandemic, and move forward on the long-term transition towards a digital and green economy. Certain measures could speed up the transition, such as supporting jobs linked to the renovation of buildings or urban renewal, and bring greening to life in a human-centred way.[34] Other measures could include support for start-ups and digital businesses with the potential to create further jobs in the future. Retraining can help people transition to more promising areas of economic activity and increase the productivity of firms that stand to benefit from structural shifts. Short-term measures should focus on vulnerable groups in the labour market, mitigating risks of scarring effects and long-term unemployment.

Investments need to focus on people if the green and digital transition is to be successful. Not having the right skills in place serves to slow down digitalisation, potentially negatively affecting firms and increasing polarisation among them. At the same time, a lack of sufficient skills limits individuals' job prospects in a changing labour market. Both digitalisation and greening will continue to change the demand for skills in the years to come. Reforming adult learning systems and broadening participation are therefore needed to deal with the risks of a growing gap in workers' skills and further labour market polarisation. A renewed focus on adult learning must be coupled with investment in quality education, which forms the basis for the lifelong learning needed to boost innovation and support the digital and green transition. Investment in each of the three areas will complement the others and raise the economic and societal returns.

Some places in the European Union are more at risk of experiencing larger-scale job losses linked to the transition towards a greener and more digital economy. Many of the regions at high risk of losing jobs are already grappling with other challenges. Dealing with the risks posed by the green and digital transition will require strong local administrations that can identify future job opportunities, provide adequate support for individuals and devise strategies to transform and revitalise local economies.

In the long term, regional disparities will be driven by regions' ability to respond to economic changes and to reinvent themselves. Successful transition management needs to be grounded in the local context, but the European Union can play a role in supporting this process by providing targeted adjustment assistance, support for capacity building and investment aimed at strengthening regions' growth prospects. Some ways the European Union can help Member States is through support for the development of territorial adjustment plans and providing project-level expertise. In addition, support for structural reform and effective monitoring of economic policy can help to foster local transitions.

Regions at high risk from both the digital and green transition are primarily located in Central and Eastern Europe. The growth model there needs to be re-examined if these countries' economies are to continue converging with the rest of the European Union. Digitalisation and the transition towards

34 See for instance Commission President Ursula von der Leyen on a New European Bauhaus.

a greener economy could be part of a new growth model, together with a focus on more home-grown innovation and strengthening the skill base. Measures that support the greening of the economy – such as housing renovation to improve energy efficiency – could create jobs improving the quality of life.

Digitalisation can be a source of job creation. For this to happen, the right conditions need to be in place to create quality jobs. Those conditions include a workforce with the right skills. A strong skill base supports the development of increasingly digital innovation and the diffusion of technology. Some of the skills sought by digital firms will likely remain in high demand for some time, and those skills can also help companies to reposition themselves after the coronavirus pandemic. Public-private cooperation is one way to support the development of these critical skills and improve job prospects. Policies that incentivise investments in technology, machinery upgrades, processes and employee skills will contribute to the digital and green transition as well as help create quality jobs – thus creating an EU economy that works better for all.

Digital technologies can facilitate broader learning – but they cannot do it alone. Digital technologies can help people learn new skills, but making sure those new skills are recognised and certified is crucial, as is ensuring the quality of educational content offered. Online learning can help develop skills and improve human capital. But inherent learning inequalities must be addressed to fully leverage the potential of digital learning. Dealing with those inequalities requires a strong focus on investment in education, including broadening the use of digital tools so that they can effectively support learning in schools and universities.

Investment in education and social infrastructure is paramount for equality and broad-based economic growth in the long-term. The public-spending adjustments following the financial crisis took a toll on social infrastructure in many parts of Europe. For its part, the pandemic laid bare gaps in health and education systems. Investment in social infrastructure is fundamental to improving societies' resilience, ensuring access to critical services and addressing inequalities of opportunity. Cuts come at a potentially high cost to people and the EU economy.

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Data annex

The availability and quality of the data on investment are critical to supporting effective policymaking. In addition to national accounts, economists need to rely on other sources of macroeconomic data to analyse important aspects of investment, including infrastructure investment and intangible investment, and they increasingly make use of firm-level data.

The EIB has taken important steps towards bridging some of the data gaps by developing an internally consistent methodology to estimate infrastructure investment and public-private partnership (PPP) finance; by running a survey on corporate investment and investment finance; and by participating in the financing of the production of a database on investment in intangible assets and stocks of intangible capital. This annex outlines these datasets and provides references to detailed methodological notes.

Estimating infrastructure investment in the European Union

Data on infrastructure investment, let alone its financing sources, are not available in any ready-to-use form. Over the years, the EIB has developed a new methodology to estimate infrastructure investment.

The basic idea is to use Eurostat's national accounts data on gross fixed capital formation (GFCF) in the sectors commonly considered to be "infrastructure sectors" (such as education, health, transport and utilities) to construct estimates of total and government infrastructure investment.[1] Non-government infrastructure investment is then derived as the difference between the two.

In a next step, the aggregate of non-government infrastructure investment is broken down into project-based and corporate infrastructure investment. Project-based infrastructure investment consists of PPP and non-PPP projects. These subcomponents of project-based infrastructure investment are obtained from IJ Global, where EPEC[2] data assist in delineating the PPP component of project-based infrastructure investment. Hence, the residual after subtracting project-based infrastructure investment from non-government infrastructure investment serves as a proxy for corporate infrastructure investment.

Finally, newly available Eurostat data on GFCF allow for a more precise proxy for infrastructure investment, which is GFCF in other buildings and structures. The new data have the advantage of excluding many non-infrastructure investments – such as investments in trucks or in other machinery and equipment (that are included in total fixed assets) – and therefore reduce the risk of overestimating infrastructure investments. The new Eurostat data also enable us to differentiate between GFCF in the transport sector and in the information and communication technology (ICT) sector (which were previously lumped together). This gives us a more granular view of individual investment trends across different sectors.

Although the new data capture infrastructure investment better, a few caveats remain. The most important one being the fact that the new data do not enable us to distinguish between GFCF in total fixed assets and in other buildings and structures for the government sector. This means that we have to approximate government investment in other buildings and structures. To do so, we use the following formula:

$$GGFCF(obs) = GGFCF(tfa) * \left(\frac{government\ net\ capital\ stock(obs)}{government\ net\ capital\ stock(tfa)} - implied\ depreciation \right),$$

1 For details see Wagenvoort, R., de Nicola, C. and Kappeler, A. (2010).

2 EPEC Data portal: https://data.eib.org/epec

where *GGFCF(obs)* and *GGFCF(tfa)* are, respectively, government GFCF in other buildings and structures and in total fixed assets, where implied depreciation is derived for the total economy as:

$$implied\ depreciation = \left(\frac{total\ economy\ net\ capital\ stock(obs)}{total\ economy\ net\ capital\ stock(tfa)} - \frac{GFCF(obs)}{GFCF(tfa)} \right).$$

That is, we use the share of other buildings and structures in the government net capital stock as a proxy for the share of government GFCF in other buildings and structures (adjusted for differences in depreciation rates). In other words, we assume that the share of government GFCF in other buildings and structures is equal to its historical share.

It should be noted that applying this formula requires us to make two minor data adjustments. First, when data on the net capital stock of a country are missing, we replace the missing value with the average net capital stock of the region in which the country is located (Western and Northern Europe, Southern Europe or Central and Eastern Europe). Second, to deal with outliers, we set negative implied depreciation differentials equal to zero.

EIB Investment Survey

General module

The EIB carries out an annual survey of firms in the European Union (EIBIS General Module) with the aim of monitoring investment and investment finance activities and capturing potential barriers to investment. The survey covers approximately 12 500 companies across the EU27 and the United Kingdom every year and slightly more than 800 firms in the United States for the last two waves. It is administered by telephone (in the local language) and takes an average of 20 minutes to complete. The first wave of the survey took place in 2016 and the survey completed its fifth wave in 2020.

Using a stratified sampling methodology, the EIBIS General Module is representative across all 27 Member States of the European Union, the United Kingdom and the United States. It is representative across four firm size classes (micro, small, medium and large) and four sector groupings (manufacturing, services, construction and infrastructure) within the individual countries.

Firms have to have a minimum of five employees be interviewed, with full-time and part-time employees counted as one and employees working less than 12 hours per week being excluded. Eligible respondents are senior employees with responsibilities for investment decisions.

The survey is designed to build a panel of observations over time, and is set up in such a way that survey data can be linked to firms' reported balance sheet and profit-and-loss data (see EIBIS-Orbis matched dataset below). Approximately 40% of the companies interviewed in each wave are companies that have already taken part in the survey in the previous wave. The fifth wave of the survey took place between May and August 2020.

The EIBIS General Module complements pre-existing information on investment activities in the European Union. It adds a firm-level dimension to the macroeconomic data available and thus allows for more fine-grained analysis of firm investment patterns. It also adds to existing firm-level surveys at a national level by providing full comparability of results across countries. The survey complements the European Commission investment survey by asking a much wider set of both qualitative and quantitative questions on firm investment activities and the European Central Bank/European Commission SAFE survey by focusing on the link between firm investment and investment finance decisions.

The EIBIS is a very powerful instrument built according to the highest scientific standards. To guarantee this, every step of the survey process is executed and closely monitored by experts in the field. All steps – sampling and weighting, questionnaire development and translation, the fieldwork, and quality control

and data processing – are also subject to strict controls and validation. More information on these technical aspects can be found in the technical report produced by the market research company conducting the survey (Ipsos MORI, 2019). Table 1 presents key numbers about EIBIS.

Table 1
EIBIS at a glance

27	EU Member States are all consistently represented by the survey – more specifically, non-financial enterprises with at least five employees and belonging to NACE categories C to J.
4	industry groupings and size classes determine the representativeness of the data within almost each Member State.
11 971	firms belonging to the EU27 participated in the last wave of the survey, compared to 11 882, 11 738, 11 753 and 12 071 in the previous waves of the survey.
800	US firms participated in the last wave of the survey.
9 752	of all firms participating to the last wave responded for at least two consecutive waves.
88%	of firms surveyed in 2020 agreed to be contacted again for next year's survey.

All aggregated data using the EIBIS General Module in this report are weighted by value added to better reflect the contribution of different firms to economic output. The aggregate survey data, questionnaire and a detailed account of the survey methodology are available on www.eib.org/eibis.

Representativeness of the general module

The EIB Investment Survey is designed to be representative for the European Union (EU27), the United Kingdom and the United States at a country level and for most countries at a country-industry-group and country-size-class level.

In a recent EIB working paper (Brutscher, Coali, Delanote and Harasztosi, 2020), we assessed the data quality of EIBIS. We did this in three steps. Firstly, we benchmarked the sampling frame from which all survey respondents are drawn, the Bureau van Dijk Orbis database, against official statistics to see how well our sampling frame captures the relevant business population.

Secondly, we compared the final EIBIS sample against random draws of firms from the same sampling frame and compared statistics constructed from the financial information included in the sampling frame. The purpose of this exercise was to assess whether and to what extent firms' willingness or unwillingness to participate in the survey may have led to a selection bias.

Lastly, we compared aggregate statistics calculated from the final EIBIS sample to corresponding statistics from Eurostat and the Organisation for Economic Co-operation and Development (OECD). In addition, we compared statistics based on financial information calculated from EIBIS to the counterpart obtained from the CompNet database. This purpose of this exercise is to evaluate both the level and dynamics of financial information calculated from firm-level data.

Overall, the results from all three steps are very positive. Firstly, the assessment of the sampling frame, a comparison of the Bureau van Dijk Orbis dataset with the Eurostat Structural Business Statistics (SBS) for the EU27 and the United Kingdom[3] for the relevant sector/size classes showed coverage ratios (such as the number of firms in Orbis /number of firms in the SBS database) between 75% and 100% for the majority of countries. It is between 50% and 75% in a few countries, and in only four – Cyprus, Greece, Luxembourg and Poland – does the coverage ratio fall below 50%.[4]

3 For the United States, the statistics were compiled from the US Census Bureau and the Bureau of Economic Analysis.

4 An important driver of the positive coverage ratio is that EIBIS samples firms with five or more employees. Coverage ratios tend to be higher for larger firms, so excluding the smallest firms from sampling significantly boosts coverage.

Having a sampling frame that covers a high percentage of the population of interest is necessary for the EIBIS survey results to reflect what is happening in the non-financial corporate sector in the European Union. It is not a sufficient, however, insofar as, like any other survey, EIBIS runs the risk of selection bias if there are systematic differences between firms that are willing to participate in the survey and firms that are not.

Secondly, to test whether (and if so, to what extent) the EIBIS sample is subject to such selection issues, we compared the distribution of a set of financial ratios in the final EIBIS sample against those of five randomly drawn samples from the same sampling frame. The financial ratios were calculated using information in Orbis. The idea was that if the distributions between the EIBIS sample and the random samples are statistically identical; this provides evidence that selection bias does not pose a major issue for representativeness and vice versa.

Using a Kolmogorov-Smirnov approach to compare the two samples, we find that for almost all countries, the percentage of variables for which the null hypothesis of equal distribution in the EIBIS and random samples is rejected is very low, suggesting a high degree of resemblance between EIBIS and the random sample.[5] In other words, comparing the final EIBIS sample with a series of random samples from the same sampling frame, we find little evidence of sampling bias in our data.

Finally, a comparison of the financial information from Orbis for firms in the final EIBIS sample to CompNet data also suggests a good coverage of both EIBIS and Orbis information. The CompNet data are based on a "distributed micro-data approach"; relevant data are extracted from often-confidential firm-level datasets available within national central banks or national statistical institutes and aggregated so that the confidentiality of firm data is preserved. The outcome of CompNet is a wide range of indicators at the country-sector-size-class level.

To assess the final EIBIS sample; we reproduced the same country-sector-size-class level indicators using the Orbis information for firms in EIBIS (where possible) and compared them to those in the CompNet dataset. What we found is a very close match between the two datasets, with the evolution of financial variables in EIBIS and the CompNet database being very similar.

More information on both the EIBIS General Module and the Add-on Module can be provided upon request to eibis@eib.org.

EIB Municipality Survey 2020

In 2020, the EIB Municipality Survey surveyed 685 municipalities in the European Union on their infrastructure investment activities and associated barriers.

The survey was administered by telephone (in the local language) and targeted at mayors, treasurers and/or municipalities' chief civil engineers. It took on average (median) 20 minutes to complete. Fieldwork took place between June and August 2020. As part of the survey, 685 municipalities were interviewed in all 27 Member States, split across the following countries and country groupings (regions).

Table 2
Number of interviews per country grouping

Western and Northern Europe	268
Southern Europe	268
Central and Eastern Europe	168

5 The Kolmogorov-Smirnov (KS) test is a nonparametric statistical test for the equality of probability distribution between two samples. Unlike a t-test, KS does not just compare the means of a variable, but also tests the null hypothesis that two samples are drawn from the same distribution by quantifying the distance between the empirical distribution functions of two samples. It therefore compares the shapes of the two distributions and evaluates whether the vertical differences between them are statistically significant.

The sample frame from which municipalities were randomly selected was a comprehensive list of European municipalities. All larger municipalities were eligible to be included in the exercise. The exact size of the cut-off was decided country by country to ensure a minimum number of interviews per country, which was between five and 57 (depending on the population size of the country). The survey results can thus be interpreted as reflecting the views of larger municipalities in each country.

Regional and European Union-wide figures are weighted using country weights based on the urban population in each country, thus taking into account size differences across countries. Within countries, answers are unweighted, giving each municipality the same weight.

More information about the design of the Municipality Survey can be found in the 2020 EIBIS technical report. The publication is available at www.eib.org/eibis.

EIB Online Survey on Environmental Innovations

Complementing the above-mentioned surveys, the EIB, together with Ipsos, administered an online survey. This Online Survey on Environmental Innovations collected 1 609 firm-level responses on the introduction of environmental innovations, the motivations to do so and the obstacles encountered. In addition, the survey asked companies about the current policy designs and regulations in place, as well as about the financing and impacts of the environmental innovations.

Eligible companies were sampled from Crunchbase (43% of respondents) and Orbis (57% of respondents) in the EU27, the United Kingdom and the United States. It took respondents approximately 15 minutes to complete the survey and the setup was automatically adjusted depending on whether firms introduced environmental innovations or not. The fieldwork started at the beginning of September 2020 and was closed mid-October.

EIBIS-Orbis matched dataset

This report includes analysis based on a dataset that combines firm-level information from Bureau van Dijk's Orbis with the first survey round of EIBIS – the EIBIS-Orbis matched dataset. The matching was carried out by the current survey provider Ipsos to preserve firms' anonymity. Orbis is a proprietary dataset that contains firm-level accounting information and ownership data, gathered and standardised to the so-called "global format" that makes accounting data comparable across jurisdictions. Items from the balance sheet and profit-and-loss accounts have been used to construct standard financial ratios for firms that reflect financing activity and financial health. All data were reviewed following standard cleaning procedures to eliminate outliers and inconsistencies. Negative values for fixed assets, total assets and other stock variables were removed and all ratios have been winsorised at 1% level.

The matched dataset complements the cross-sectional perspective of EIBIS with time series information starting in 2000. It makes it possible to construct custom panel datasets used in several analyses in this report.

Patent data

The patent data used in this chapter comes from PATSTAT (Worldwide PATent STATistical Database). This is a single patent statistics raw database, held by the European Patent Office (EPO) and developed in cooperation with the World Intellectual Property Organization (WIPO), the OECD and Eurostat. With the objective of being sustainable over time, PATSTAT came into operation in 2006 and concentrates on raw data, leaving indicator production mainly to its licensed users. PATSTAT's raw patent data come from more than 100 regional and national patent offices worldwide, including of course the largest and most important organisations such as the European Patent Office (EPO), the United States Patent and Trademark Office (USPTO), the World Intellectual Property Organization (WIPO), the Japanese Patent Office (JPO) and the Chinese Patent Office (SIPO). PATSTAT is a relational database: more than 20 related

tables contain information on relevant dates (filing, publication, grant, etc.), applicants and inventors, technological domains, references to prior art, etc. Updates are produced twice a year, in a spring and autumn edition. The data sourced for this chapter were produced in collaboration with ECOOM (The Centre for Research and Development Monitoring).

How do we measure innovation and knowledge diffusion?

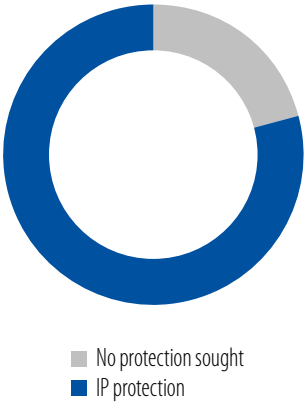
Throughout Chapter 8, different data sources are used to gain a clearer understanding of the climate and digital innovation landscape. In an ideal world, we would have detailed statistics available on each firm's own R&D investment in green and digital technologies, as well as on its external knowledge sourcing, implementation and further dissemination of the different innovations. In the real world however, such ready-made data are unfortunately not available (for a detailed discussion on the difficulties in measuring intangible assets, see Haskel and Westlake, 2018).

To gain insight into what is going on in climate and digital innovation, we have relied on EPO patent data, survey data and data taken from Crunchbase. The table below gives an overview of the different data sources and their uses. In Chapter 8, we do not refer to R&D data because they are already extensively discussed in other chapters and they are not sufficiently fine-grained for an examination of the different underlying domains in green and digital innovation. In addition, while R&D expenditure is a good measure of a firm's investment in innovation, it is by no means an output measure.

To grasp the (intermediate) outputs of innovation, patent data have long been broadly accepted proxies. They allow for levels of completeness (both geographically and over time) and granularity that are not attainable with other data sources (for a more detailed discussion of patent data and their merits – and disadvantages – see Box B in Chapter 8).

The instrumental nature of patent data in measuring climate change innovations is reflected in the number of companies seeking protection for these innovations. One of the arguments against using patent data to measure innovation is that not all firms patent all their innovations. However, the propensity to patent appears relatively high among firms introducing new green technology (Figure 1).

Figure 1
Share of environmental innovators seeking IP protection



Source: *EIB Online Survey on Environmental Innovations.*
Base: *All environmental innovators.*
Question: *In relation to any of the changes generating environmental impacts in your own company, which of the following applies?*

Given that patent data only focus on technological innovation, we have used survey data to assess the level of adoption of green and digital technologies by different firms, as well as the overall taste for green investment. We have worked with data from the EIB Investment Survey, as well as data gathered

from a targeted online module. This online module is different in its setup and scope, but is a unique exercise in which firms are specifically asked about their environmental innovations, knowledge diffusion, motivations and obstacles and investment and finance.

Besides firm-level survey data allowing for a complementary look at climate innovations from a different angle, the online module in particular helped us focus on startups and scale-ups, which are by nature less active in patenting. The online module respondents are sourced from Orbis and Crunchbase, and therefore provide more detailed insight into specific subgroups of firms. In some instances, Crunchbase is also used as a stand-alone database for providing overall insight into the green and digital activities of startups and scale-ups.

Using these complementary data sources enriches the climate debate. Not only can we look at the issue from different angles, we can also evaluate the robustness of the main messages across different data sources and different stages of innovation.

Table 3
Measuring the different stages of innovation

Technology development	R&D expenditure and personnel	(-) input measure of innovation (-) difficult to identify environmental activities (-) limited detailed data availability (+) ease of communication (+) good coverage of government expenditure
	Patented inventions	(+) measures innovation by definition (+) measures (intermediate) outputs of innovation (+) granularity, possibility to identify specific "environmental" aspects (+) global coverage, long-time series (-) captures only technological innovation (-) timeliness
Technology diffusion	Patenting activity	
Non-tech innovation and adoption of technologies	Survey data	(+) can measure broader and all aspects of innovation (-) availability, cost, comparability

The EU Industrial R&D Investment Scoreboard[6]

The EU Industrial R&D Investment Scoreboard provides economic and financial data and analysis of the top global corporate research and development investors. It is based on company data extracted directly from each company's annual report.

The Scoreboard has been published annually since 2004 to provide a reliable, up-to-date benchmarking tool for comparisons between companies, sectors, and geographical areas, as well as to monitor and analyse emerging investment trends and patterns. It aims to raise public awareness and support for R&D investment among individual companies and policymakers, and encourages companies to disclose information about their R&D investments and other intangible assets.

The 2019 edition of the Scoreboard comprises the 2 500 companies investing the largest sums in R&D in the world in 2018/19. These companies, based in 44 countries, each invested over EUR 30 million in R&D for a total of EUR 823.4 billion, which is approximately 90% of the world's business-funded R&D.

The data for the Scoreboard are taken from companies' publicly available audited accounts. As in more than 99% of cases these accounts do not include information on the place where R&D is actually performed, the company's R&D investment in the Scoreboard is attributed to the country in which it has its registered office. The Scoreboard's approach is, therefore, fundamentally different to that of statistical offices when preparing business enterprise expenditure on R&D data, which are specific to a given territory. The R&D financed by business sector in a given territorial unit (BES-R&D) includes R&D

6 Prepared by Sara Amoroso (European Commission, Joint Research Centre) and Nicola Grassano (European Commission, Joint Research Centre).

performed by all sectors in that territorial unit. The Scoreboard R&D figures are hence comparable to BES-R&D data only at a global level; this should be borne in mind when interpreting the Scoreboard's country classifications and analyses.

The data for the 2019 Scoreboard were collected from companies' annual reports and accounts by Bureau van Dijk – A Moody's Analytics Company. In order to maximise completeness and avoid double counting, the consolidated group accounts of the ultimate parent company are used. Companies that are subsidiaries of any other company are not listed separately. Where consolidated group accounts of the ultimate parent company are not available, subsidiaries are included. In the case of a demerger, the full history of the continuing entity is included. The history of the demerged company can only go back as far as the date of the demerger to avoid double counting of figures. In case of an acquisition or merger, pro-forma figures for the year of acquisition are used along with pro-forma comparative figures, if available.

The R&D investment included in the Scoreboard is the cash investment funded by the companies themselves. It excludes R&D undertaken under contract for customers such as governments or other companies. It also excludes the companies' share of any associated company or joint venture R&D investment when disclosed. However, it includes research contracted out to other companies or public research organisations, such as universities. Where part or all of R&D costs have been capitalised, the additions to the appropriate intangible assets are included to calculate the cash investment and any amortisation eliminated.

More information on the Scoreboard and methodological limitations is available at: https://iri.jrc.ec.europa.eu/rd_monitoring.

Investment in climate change mitigation

Climate change mitigation investments are spread across many economic sectors, they have diverse impacts on greenhouse gas emissions and the data sources have varying degrees of accuracy and consistency. The estimates drawn together in this report are organised under the headings renewable energy and energy networks, energy efficiency, transport infrastructure, agriculture forestry and land use, and R&D.

These categories correspond to the EU taxonomy: low-carbon activities (compatible with a 2050 net zero carbon economy – such as renewables, electric vehicles, afforestation, etc.); transition activities (activities that contribute to a transition to a zero net emissions economy in 2050 but that are not currently operating at an expected optimal level – such as building renovation, etc.); and activities that facilitate low-carbon performance, substantial emissions reduction or environmentally sustainable investments (enabling activities – such as smart technologies, R&D, etc.).

Renewable energy

The International Energy Agency (IEA) provided estimates for the regional blocs (European Union, United States and China) of total investment in renewable energy. These are based on public information and IEA estimates of capacity additions, combined with estimates of investment costs. These cost estimates are not published and were not released to the EIB for this study. As a result, there are limits on the depth of the analysis that can be performed.

End-use renewables (rooftop solar thermal, etc) are included with renewable generation. This is a larger amount for China than for the United States and European Union.

A proportion of investment in networks is assigned to renewable energy. Firstly, network investment is divided between maintenance (replacement of existing lines) and expansion. All expansion is assigned to renewables. Very little non-renewable capacity is being installed so all expansion is due to renewables.

The remaining investment in maintenance is divided between renewable and non-renewables according to the share of renewable energy in total generation capacity.

Bloomberg New Energy Finance (BNEF) data were made available via EIB access to the BNEF database.

BNEF data are available for China, European Union and the United States, but not all EU Member States are included. BNEF data cover 15 EU Member States: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Poland, Portugal, Spain and Sweden.

The clean energy data on new projects reflect new project commitments. The basis of these data are different from the IEA data. Whereas the IEA data record investment in the year the money was spent, BNEF data record the expenditure in the year of financial close of the project. BNEF data do not provide comprehensive coverage (such as rooftop solar thermal), and do not estimate total investment cost. Their data are typically the announced project cost at financial close, and this may be different to the IEA's estimate of investment cost within a specific year.

When there is reference to BNEF data, the following definitions apply:

Wind – Electricity generation using wind turbines. Included in this sector are players across the entire value chain of both offshore and onshore developments. From manufacturers of turbines, components and subassemblies to developers, generators, utilities and engineering firms.

Solar – All technologies which capture energy directly from the sun. These include production of electricity using semiconductor-based technology (PV) materials, use of concentrated sunlight to heat fluids that drive power generation equipment (solar thermal), and passive methods which use sunlight to heat water. Whilst company level investment of passive methods is recorded, investment in passive projects is not.

Biofuels – Liquid transportation fuels including biodiesel and bioethanol. These can be derived from a range of biomass sources including sugar cane, rape seed, soybean oil of non-food cellulosic feedstock. Our database excludes producers of base biomass, but includes suppliers of everything from the processing technologies and equipment, through the logistics of distribution, to manufacturers of energy systems which are specially adapted for the use of biofuels and products, and the services on which they depend.

Biomass and Waste – Electricity and or heat produced with bio-based feedstocks, typically through incineration but also through more advanced processes like gasification or anaerobic digestion. This sector also includes waste-to-energy which includes energy produced through landfill gas projects and incineration of municipal and industrial waste.

Energy smart technologies – This sector covers technologies like digital energy, smart grids, power storage, hydrogen and fuel cells, advanced transportation and energy efficiency on both the demand and supply side.

Other renewables – Includes small hydro – hydro projects with capacities small or equal to 50 MW; geothermal – extraction of useful power from heat stored in the earth; marine – the extraction of tidal, wave and thermal energy from the ocean.

Energy efficiency

The IEA made available estimates of investment in energy efficiency for the United States, China and the EU27 from 2014 to 2019. In broad terms, the methodology of calculating these estimates looks at the additional cost of an energy-efficient alternative over and above the less efficient alternative that serves a similar purpose. In the auto sector, for example, many manufacturers make eco models that are more expensive than the regular model. The cost difference, under the IEA methodology, is assigned to energy efficiency investment. The IEA describe the methodology in detail in the Energy Efficiency Investment Report.

The underlying calculations have not been made available to the EIB. No breakdown has been provided for the EU Member States.

The IEA methodology has changed over time. Originally, a top down methodology was used, which applied average energy prices to the annual energy savings (due to improvement in energy intensity). This addressed the question: how much would consumers have been willing to pay for the improvement in energy intensity visible from one year to the next?

The new bottom up methodology has also been refined over a number of years.

Without the opportunity to review the underlying model and data, it is difficult to judge the accuracy of the data. The IEA have made their own judgement, and in their report discuss the implications at the global level. They do not make conclusions about developments at a fine degree of granularity. Therefore, caution needs to be exercised in reading too much into the energy efficiency data.

Transport infrastructure

The OECD International Transport Forum (ITF) collects data on an annual basis from its member countries, covering investment, maintenance spending and capital value of transport infrastructure. Data are collected from transport ministries, statistical offices and other institutions designated as official data sources.

The lack of common definitions and practices to measure transport infrastructure spending hinders comparisons between countries. While the survey covers all sources of financing, a number of countries exclude private spending. Coverage of urban spending also varies between countries. Indicators such as the share of GDP needed for investment in transport infrastructure depend on a number of factors, such as the quality and age of existing infrastructure, maturity of the transport system, geography of the country and transport intensity of its productive sector. Caution is therefore required when comparing investment data between countries. However, data for individual countries and country groups are consistent over time and useful for identifying underlying trends in levels of spending. Definitions and methods are addressed in a companion report (ITF, 2013).

For the United States, the data sources have changed. The 1992-2003 data are from the US Department of Transportation (Bureau of Transportation Statistics, 2005). The 2004-2015 data are from Railroad Facts, published by the Association of American Railroads.[7] Since 2004, data cover only Class 1 Railroads. Class 1 Railroad capital expenditures accounts for roughly 94% of total railroad capital expenditures.

Forestry

Eurostat data are available for the European Union for gross fixed capital formation in forestry up to 2017. Data are extrapolated to 2019 assuming a constant ratio to total GFCF.

For the United States, data are available from the Bureau of Economic Analysis up to 2018. These are also extrapolated assuming a constant ratio to total GFCF.

No data are available for China.

Research and development

BNEF data are used for R&D. BNEF source the data as follows. Government R&D figures are sourced from IEA, International Monetary Fund (IMF), OECD and various government agencies. Corporate R&D is sourced from Bloomberg for key quoted companies in all clean energy sectors.

The data were made available in current USD billion rounded to the nearest hundred thousand. This gives rise to rounding errors and the sum of government and corporate R&D does not equal the sum of R&D across sectors.

7 See Capital Expenditures table on https://www.aar.org/.

For comparison of climate change mitigation investment between the United States, China and the European Union, government and corporate R&D have been used. For analysis of the EU Member States, the sector breakdown is also used.

Inflation and exchange rates

Data are presented in real 2019 EUR million. Source data are on different bases and the following procedures were used to convert them to real 2019 EUR million.

IEA investment data
IEA investment data are in real 2019 USD billion. These were converted to real 2019 EUR by applying the average 2019 exchange rate (from the Bank of England). Where necessary, the data are further converted to current EUR million using the GDP deflator for the EU27. The GDP deflator is derived from the Eurostat data by rebasing to 2019=100. This rebasing is done so as to preserve the implied inflation rates year by year.

For the real EUR data, these procedures have the effect of preserving the growth rates in the IEA data.

BNEF clean energy and R&D
BNEF data are in current USD billion. They were converted to real 2019 EUR with the following steps. Firstly, the USD series are put in real terms using the US GDP deflator. The deflator is rebased to 2019=100 preserving the implied year-to-year inflation rates. Secondly, the Real USD series are converted to real 2019 EUR using the average 2019 exchange rate from the Bank of England.

This procedure avoids introducing changes due to changes in the exchange rate. Only the 2019 exchange rate is used in the conversion. However, exchange rate effects may already be present in the original BNEF data.

If required, the real EUR data are converted to current EUR using the EU GDP deflator.

OECD data and Eurostat data on Forestry and Transport
These data are in current EUR and are converted to real 2019 EUR using the applicable GDP deflators. The country-by-country deflators are derived from the Eurostat data and rebased to 2019=100 as described above. Use of the country-specific deflators takes account of differences in inflation in different countries. This is the best procedure for making country comparisons. However, it should be noted that the method does not necessarily maintain additivity – the sum of the deflated countries does not equal the deflated total.

Avoided energy consumption and avoided CO_2

Avoided energy consumption and avoided CO_2 are calculated for the purpose of comparison with investment levels.

Avoided energy is calculated by breaking down the change in final energy consumption into the change due to improvements in energy intensity and the change due to GDP growth. The method used follows the standard LMDI methodology summarised by Ang (2015). The change due to the improvement in energy efficiency is then used as avoided energy consumption in the denominator. Similar methodology is applied for CO_2, using CO_2 intensity instead of energy intensity.

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Glossary of terms and acronyms

3D printing	Also known as additive manufacturing. Variety of processes in which material is joined or solidified under computer control to create a three-dimensional object, with material being added together (such as liquid molecules or powder grains being fused together), typically layer by layer.
ABS	Asset-backed security.
Active innovators	Firms that invest in R&D (R&D-to-sales ratio higher than 0.1%).
Adaptation	Addresses the risks posed by climate change rather than the underlying causes.
Adopting firms	Firms that have no substantial R&D (R&D-to-sales ratio lower than 0.1%) but have introduced or developed new products, processes or services, according to the EIB Investment Survey (EIBIS).
Adult learning	The participation of adults in lifelong learning. Usually refers to learning activities after the end of initial education and is a central component of the European Union's lifelong learning policy. The main indicator to measure adult learning is the rate of participation in education and training, which covers formal and non-formal education and training.
AFME	Association for Financial Markets in Europe.
AI	Artificial intelligence. A system's ability to correctly interpret external data, to learn from such data, and to use such learning to achieve specific goals and tasks through flexible adaptation.
AMECO	The annual macro-economic database of the European Commission's Directorate General for Economic and Financial Affairs.
APP	Asset Purchase Programme. ECB purchase programmes under which private and public sector securities are purchased to address the risks of an excessively prolonged period of low inflation.
Augmented or virtual reality	Presentation of information integrated with real-world objects, using a head-mounted display.
Automation	Substitution of work activities undertaken by human labour with work performed by machines with the aim of increased quality and quantity of output at lower costs.
Average treatment effect on the treated	The average effect of a given treatment on the group of individuals that received the treatment (as opposed to, for example, the effect of the treatment averaged across all individuals in a study, regardless of whether or not they received the treatment).
Backward citation	Citations referring to previous patents upon which the current invention (described in the patent application) is based.
Baltics	Estonia, Latvia and Lithuania.
Baseline	A scenario also known as a "reference" or "benchmark" or "non-intervention" scenario, which depicts a future state of society and/or environment in which no new environmental policies are implemented apart from those already in the pipeline today, or in which these policies do not have a discernible influence regarding the questions being examined.

BCBS	The Basel Committee on Banking Supervision is the primary global standard-setter for the prudential regulation of banks and provides a forum for regular cooperation on banking supervisory matters. Its 45 members comprise central banks and bank supervisors from 28 jurisdictions.
Benelux	Belgium, the Netherlands and Luxembourg.
Big data	Extremely large data sets that may be analysed computationally to reveal patterns, trends and associations, especially relating to human behaviour and interactions.
Biotech	Biotechnology, often abbreviated to biotech, is the manipulation of living organisms or their components to produce useful, usually commercial products.
BIS	Bank for International Settlements (Basel, Switzerland).
Blending	Tools to help investors blend financing with additional sources. Blending can include a grant element or guarantees.
Blockchain	A growing list of records (blocks) that are linked using cryptography.
BLS	Bank Lending Survey. ECB survey carried out four times a year, which provides information on bank lending conditions in the euro area.
bn	Billion (1 000 million).
BNEF	Bloomberg New Energy Finance.
Border carbon adjustment (BCA)	A trade measure intended to level the playing field between domestic producers facing costly climate-change measures and foreign producers facing very few.
Bureau van Dijk's Orbis database	Database of private and listed company information from around the world that includes companies' financial accounts, ownership structures and details of mergers and acquisitions activity.
Business angel	An individual who provides capital for startups, usually in exchange for convertible debt or ownership equity.
BVAR	A vector autoregressive process (VAR) model estimated with Bayesian techniques. Model parameters are treated as random variables, and prior probability distributions are assigned to them, enabling the use of prior research results. Bayesian methods have become an increasingly popular way of dealing with the problem of over-parameterisation.
Capital cost	A cost deriving from, or forming part of, capital expenditure on a project.
Capital Markets Union	European Commission action plan to establish the building blocks of an integrated capital market in the European Union by 2019.
Carbon intensity	The ratio of greenhouse gas emissions divided by activity, such as greenhouse gas emissions/GDP.
CCM	Climate change mitigation. Mitigation addresses the underlying causes of climate change.
CCS	Carbon capture and storage is a group of technologies that can remove almost 100% of the carbon dioxide from large-scale point sources of carbon such as energy-intensive industries (such as steel, cement and refining) and fossil fuel power.

CDS	A credit default swap is a financial derivative or contract that allows an investor to "swap" or offset his or her credit risk with that of another investor. Quanto CDS are cross-currency credit default swaps for which the protection payment in the case of default is capped with the currency being different from that of the notional debt.
Cedefop	European Centre for the Development of Vocational Training.
CEE	Central and Eastern Europe.
Central and Eastern Europe	Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia.
CEO	Chief Executive Officer.
CESEE	Central, Eastern and South-Eastern Europe.
CFC	Consumption of fixed capital.
Circular economy	A systemic approach to economic development designed to benefit businesses, society and the environment. In contrast to the "take-make-waste" linear model, a circular economy is regenerative by design and aims to gradually uncouple growth from the consumption of finite resources.
Climate change adaptation	Measures to deal with the impact of changing weather patterns or extreme weather events.
Cognitive technologies	Include natural language processing, data mining and pattern recognition. Relevant for automation, machine learning and information technology, such as big data analytics or artificial intelligence.
Committee of the Regions (CoR)	The European Committee of the Regions is a political assembly composed of 329 members and 329 alternates from all EU countries (grouped by political party and headed by the President) who have been elected at local or regional level (for example as Mayors or Presidents of a region).
Common Equity Tier 1 Ratio	Regulatory ratio computed for banks in order to assess their capacity to withstand major shocks. It is calculated by dividing Core Tier 1 capital by risk-weighted assets. The ratio must be above a level determined in the so-called Basel III package.
Countercyclical capital buffers	Buffers that require banks to hold capital at times when credit is growing rapidly so that the buffer can be reduced if the financial cycle takes a downturn or the economic and financial environment becomes substantially worse.
Cross-country citations (CCC)	An index representing the relative intensity of citations between the citing country and the cited country.
CRR and CRD	Capital Requirements Regulation (CRR) and Capital Requirement Directive (CRD). Legal texts issued by the European Parliament and Council to align EU bank capital standards with Basel III recommendations and strengthen banks' capacity to withstand adverse economic developments.
De-meaning	Subtracting the sample mean from each observation so that it is mean zero.
Depreciation	A reduction in the value of an asset over time, due in particular to wear and tear; a decrease in the value of a currency relative to other currencies.
DESI	The Digital Economy and Society Index. A composite index that summarises relevant indicators on Europe's digital performance and tracks the evolution of EU Member States in digital competitiveness.

Developers	Firms that have substantial R&D (R&D-to-sales ratio equal to or higher than 0.1%) but have not introduced or developed new products, processes or services, according to the EIB Investment Survey (EIBIS).
Digital	Firms that have partially or fully implemented at least one of the four digital technologies in recent years (see "Digitalisation").
Digitalisation	The adoption of one of four digital technologies in the manufacturing and services sectors respectively. The technologies include "3D printing", "advanced robotics", "internet of things", and "big data" in the manufacturing sector, and "digitalisation of internal routines", "web-based applications for marketing and sales", "provision of digital products or services over the internet", and "big data" in the services sector.
Dividend discount model	A method of valuing a company's stock price based on the theory that its stock is worth the sum of all of its future dividend payments, discounted back to their present value.
Drones	Powered, unmanned aerial vehicles that can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or non-lethal payload.
EBA	European Banking Authority.
EBIT	Earnings before interest and taxes.
EBITA	Earnings before interest and taxes and amortisation.
ECB	European Central Bank.
EE	Energy efficiency.
EIB	European Investment Bank.
EIBIS	European Investment Bank Investment Survey.
EIF	European Investment Fund.
EIOPA	European Insurance and Occupational Pensions Authority.
Energy audit	An assessment of the energy needs and efficiency of a building or buildings.
Energy efficiency gap	The difference between the cost-minimising level of energy efficiency and the level of energy efficiency actually achieved.
Energy intensity	Energy consumption divided by activity, such as energy/GDP.
Entrepreneurship	The process of designing, launching and running a new business.
EPEC	European PPP Expertise Centre.
EPO	European Patent Office
Equity risk premium	The excess return that investing in the stock market provides over a risk-free rate.
ESG bonds	Bonds issued for the financing of companies/activities fulfilling Environmental, Social and/or Governance standards.
ESM	European Stability Mechanism.

ESMA	European Securities and Markets Authority.
ESRB	European Systemic Risk Board.
ETS	EU Emissions Trading System.
EU	The 27 Member States of the European Union (taken as a whole when used for data comparison with other groups).
EU Industrial R&D Investment Scoreboard	Economic and financial data and analysis of the top corporate R&D investors (top 2 500 global R&D companies and top 1 000 EU R&D companies) based on company data extracted directly from each company's annual report.
Evergreening	Also called forbearance lending, or zombie lending. Characterises the behaviour of banks that delay the recognition of losses on their credit portfolio by rolling over loans to high-risk borrowers, in order not to further impair their reported capital and profitability.
External finance	In the EIB Investment Survey, this consists of: bank loans excluding subsidised bank loans, overdrafts and other credit lines; other terms of bank finance including overdrafts and other credit lines; newly issued bonds; newly issued equity (including quoted or unquoted shares); leasing or hire purchase; factoring/invoice discounting; loans from family/friends/business partner; grants (financial support or subsidies from regional or national government); and funding provided by the public sector.
FAVAR	The factor-augmented vector autoregressive (FAVAR) model is now widely used in macroeconomics and finance. In this model, observable and unobservable factors jointly follow a vector autoregressive process (VAR), which further drives the co-movement of a large number of observable variables. FAVAR models can be estimated in one or two steps, using classical or Bayesian estimation techniques.
FDI	Foreign direct investment.
Finance constrained	In the EIB Investment Survey (EIBIS), a firm is considered finance constrained if it was: (i) rejected when seeking any external financing for an investment; (ii) quantity constrained (dissatisfied with the terms and the amount received in the last request for external financing); (iii) price constrained (the firm did not apply because it thought the conditions of external financing would be too expensive); or (iv) discouraged from seeking any external financing (the firm did not apply because it thought the application would be turned down).
Financing Condition Index	An index indicative of tensions in financial markets. The index is extracted from a FAVAR model. It synthesises a large set of information contained in time series related to financial developments, uncertainty and asset pricing.
Fintech	Financial technology. Computer programs and other technology used to support or enable banking and financial services.
Forward citation	Citations or references to the patent in question.
GDP	Gross domestic product. The total value of goods produced and services provided in a country during one year.
GDPR	(European) General Data Protection Regulation.
GFC	Global financial crisis. Refers to the worldwide financial crisis of 2007-08.

GFCF	Gross fixed capital formation. The net increase in physical assets (investment minus disposals) within the measurement period. It does not account for the consumption (depreciation) of fixed capital, and also does not include land purchases. It is a component of the expenditure approach to calculating GDP.
High growth enterprises	Enterprises that have an average annual growth rate of turnover greater than 10% per year over a minimum of three years and at least ten employees at the beginning of the growth period.
High-tech knowledge-intensive services	Motion picture, video and television programme production, sound recording and music publishing; programming and broadcasting; telecommunications; computer programming, consultancy and related activities; information services; scientific research and development (NACE codes 59 to 63 and 72).
High-technology manufacturing sectors	Pharmaceutical products and preparations; computer, electronic and optical products (NACE codes 21 and 26).
Human capital	The knowledge, skills, competencies and other attributes embodied in individuals or groups of individuals acquired during their life and used to produce goods, services or ideas in market circumstances.
ICT	Information and communications technology.
IEA	International Energy Agency.
IFRS 9 Expected Credit Loss (ECL) approach	International Financial Reporting Standard 9 introduces a new impairment model based on expected credit losses, resulting in the recognition of a loss allowance before the credit loss is incurred.
ILO	International Labour Organization.
IMF	International Monetary Fund.
Incremental innovators	Firms that have substantial R&D (R&D-to-sales ratio equal to or higher than 0.1%) and have introduced or developed products, processes or services that are new to the company, according to the EIB Investment Survey (EIBIS).
Information asymmetry	A situation in which one party to an economic transaction (usually the seller) possesses greater material knowledge than the other party (usually the buyer); also called asymmetric information.
Infrastructure	Infrastructure as defined for the EIB Infrastructure Database includes the following sectors for its macro-analysis: transport, utilities, health, education and communication. Infrastructure in the EIB Municipality Survey captures social, urban transport, digital, water and waste utilities, climate change mitigation and climate change adaptation.
Infrastructure governance	Governments' readiness to respond to the diverse and complex issues involved in infrastructure decision-making, according to the Hertie School of Governance infrastructure governance indicators.
Infrastructure sector	Based on the NACE classification of economic activities, firms in groups D and E (utilities), group H (transportation and storage) and group J (information and communication).
Institutional sectors	The general government, corporations and households are the three institutional sectors in this report.

Intangible investment	In the EIB Investment Survey (EIBIS), intangible investment consists of investment in: research and development (including the acquisition of intellectual property); software, data, IT networks and website activities; training of employees and organisation and business process improvements (including restructuring and streamlining).
Intellectual property products.	In the European System of Accounts, intellectual property products are defined as fixed assets that consist of the results of research and development, mineral exploration and evaluation, computer software and databases, entertainment, literary or artistic originals and other intellectual property products intended to be used for more than one year.
Internal finance	In the EIB Investment Survey (EIBIS), internal finance consists of internal funds or retained earnings (such as cash, profits).
IPCC	Intergovernmental Panel on Climate Change.
IRENA	International Renewable Energy Agency.
IRR	Internal rate of return.
ISCED	International Standard Classification of Education. A statistical framework for organising information on education.
ISCO	International Standard Classification of Occupations.
KLEMS	An EU industry-level growth and productivity research project. KLEMS stands for EU-level analysis of capital (K), labour (L), energy (E), materials (M) and service (S) inputs.
Knowledge-intensive market services	Water transport; air transport; legal and accounting activities; activities of head offices, management consultancy; architectural and engineering, technical testing and analysis; advertising and market research; other professional, scientific and technical activities; employment activities; security and investigation activities (NACE codes 50, 51, 69, 70, 71, 73, 74, 78, 80).
Large companies	Firms with at least 250 employees.
Leading innovators	Firms that have substantial R&D (R&D-to-sales ratio equal to or higher than 0.1%) and have introduced or developed products, processes or services that are new to the country or to the global market, according to the EIB Investment Survey (EIBIS).
Less developed regions	EU NUTS 2 regions with GDP per capita below 75% of the EU average.
Levelised cost of electricity	The unit cost of a generating asset over its lifetime.
Lifelong learning	Encompasses all learning activities undertaken throughout life with the aim of improving knowledge, skills and competences, within personal, civic, social or employment-related perspectives. The intention or aim to learn is the critical point that distinguishes these activities from non-learning activities, such as cultural or sporting activities.
Low-carbon economy	An economy based on low-carbon power sources (not based on fossil fuels).
Low-technology manufacturing sectors	Sectors with NACE codes 1–18 and 31–32.

M&A	Mergers and acquisitions are transactions in which the ownership of companies is transferred to or consolidated with other entities.
Manufacturing	Based on NACE classification of economic activities, firms in group C (manufacturing).
Mark-up	The ratio of the cost of a good or service to its selling price, expressed as a percentage of the cost.
Medium-high-technology manufacturing sectors	Chemicals; electrical equipment; machinery and equipment; motor vehicles; other transport equipment (NACE code 20 and NACE codes 27–30).
Medium-low-technology manufacturing sectors	Coke and refined petroleum products; rubber and plastic products; other non-metallic mineral products; basic metals; fabricated metal products, except machinery and equipment (NACE codes 19, 22–25 and 33).
More developed regions	EU NUTS 2 regions with GDP per capita above 90% of the EU average.
Multiple technologies	Firms that have implemented at least two of the four digital technologies in recent years, according to the EIB Investment Survey (see "Digitalisation").
Municipal digital sophistication	The municipality has at least two of the following capacities in place: provision of wireless internet in public spaces; provision of digital or online government services; digital payment systems; or real time traffic monitoring for public transport.
Municipal green administrative capacity	The municipality has at least two of the following capacities in place: green budgeting or procurement; inventory of the carbon footprint of municipal operations; or land use planning, to deal with extreme weather events, including retention areas.
MW	Megawatt.
MWh	Megawatt hour.
NACE	"Nomenclature statistique des activités économiques dans la Communauté européenne" (Statistical Classification of Economic Activities in the European Community). The industry standard classification system used in the European Union.
NBER	National Bureau of Economic Research.
NEET	Young person who is "Not in Education, Employment or Training".
NGFS	Network on Greening the Financial System.
No innovation	Firms that have no substantial R&D (R&D-to-sales ratio lower than 0.1%) and have not introduced or developed new products, processes or services, according to the EIB Investment Survey (EIBIS).
Non-digital	Firms that have not yet implemented any of four digital technologies considered in recent years or have not heard of them (see "Digitalisation"). The technologies include "3D printing", "advanced robotics", "internet of things", and "big data" in the manufacturing sector, and "digitalisation of internal routines", "web-based applications for marketing and sales", "provision of digital products or services over the internet", and "big data" in the services sector.
Non-formal education and training	Education and training activities outside of schools, colleges and universities.

Non-PPP projects	Projects carried out by project companies (SPVs) that are not public-private partnerships.
NPLs	Non-performing loans.
NUTS	"Nomenclature des unités territoriales statistiques" (Nomenclature of territorial units for statistics). A hierarchical system for dividing up the economic territory of the European Union.
OECD	Organisation for Economic Co-operation and Development.
Other knowledge-intensive services	Publishing; veterinary activities; public administration and defence, compulsory social security; education; human health; residential care; social work; creative, arts and entertainment; libraries, archives, museums and other cultural activities; gambling and betting; sports activities and amusement and recreation (NACE codes 58, 75, 84–88, 90–93).
Output gap	The amount by which the actual output of an economy falls short of its potential output.
Patent	Patents are documents issued by an authorised agency, granting exclusive right to the applicant to produce or to use a specific new device, apparatus or process for a limited period. The protection conferred by a patent gives its owner the right to exclude others from making, using, selling, offering for sale or importing the patent invention for the term of the patent, which is usually 20 years from the filing date, and in the country or countries concerned by the protection.
PATSTAT	Contains bibliographical data relating to more than 100 million patent documents from leading industrialised and developing countries.
PCT	Patent Cooperation Treaty. Provides a unified procedure for filing patent applications to protect inventions in each of its contracting states.
PEPP	The ECB's pandemic emergency purchase programme (PEPP) is a non-standard monetary policy measure initiated in March 2020 in reaction to the COVID-19 outbreak. It is a temporary asset purchase programme of private and public sector securities. In June 2020, the initial envelope of EUR 750 billion was increased to EUR 1 350 billion.
PELTRO	Pandemic emergency longer-term refinancing operations. Longer-term refinancing operations that have provided an effective backstop after the expiry of the bridge longer-term refinancing operations (LTROs) conducted since March 2020. The operations provide longer-term funding to counterparties with decreasing tenors, starting with a tenor of 16 months in the first operation and ending with a tenor of 8 months in the last operation.
Perceived gap	Firms' perceived investment gap computed on their responses to the question: Looking back at your investment in the past three years, would you say that investments have been in line with your needs, above your needs or below your needs to ensure the competitiveness of your company going forward?
Percentile	Each of the 100 equal groups into which a population or other data can be divided according to the distribution of values of a particular variable.

PIAAC	Programme for the International Assessment of Adult Competencies is a programme of assessment and analysis of adult skills. The survey measures adults' proficiency in key information-processing skills – literacy, numeracy and problem-solving – and gathers information and data on how adults use their skills at home, at work and in the wider community. The survey is conducted in over 40 countries and measures cognitive and workplace skills.
Platform technologies	Technologies that connect customers with businesses or customers with other customers.
Potential GDP	See "Potential output".
Potential output	Potential output refers to the highest level of real gross domestic product that can be sustained over the long term with the available resources and labour efficiency. Potential output depends on the capital stock, the potential labour force (which depends on demographic factors and on participation rates) and the level of labour efficiency.
PPP	Refers either to: i) public-private partnership; or ii) purchasing power parity.
PPS	Purchasing power standards. An artificial currency unit. Theoretically, one PPS can buy the same amount of goods and services in each country. However, price differences across borders mean that different amounts of national currency units are needed for the same goods and services depending on the country. PPS are derived by dividing any economic aggregate of a country in national currency by its respective purchasing power parities.
Procyclical	A positive correlation between the value of a good, a service or an economic indicator and the overall state of the economy, growing when the economy grows and declining when the economy declines.
Production processes	Processes related to actual production, such as machinery and equipment.
PV	Photovoltaics.
R&D	Research and experimental development.
RCI	Regional Competitiveness Index.
RES	Renewable energy source.
Robot	Defined in the IFR database as "automatically controlled, re-programmable, and multipurpose machine".
Routine-biased technological change (RBTC)	Predicts that ICT and digitalisation developments are changing the pattern of capital labour substitution. While it will lead to an increase in jobs that are rich in cognitive, non-routine tasks (typically high-skilled) it is associated with a decline in jobs rich in routine tasks (cognitive and manual). Many of these require middle skill levels and are found in the middle income distribution. Some of the routine jobs are of the manual type and are at the lower end of the income scale. At the same time, RBTC is also associated with an increase in demand for manual non-routine jobs, such as in the area of personal services. The result of RBTC would be greater job polarisation.
RTA	The relative technological advantage or specialisation index captures the share of patents in a technology field as a share of a country's total patents, weighted by the same share in the European Union overall.

S&P 500	Standard and Poor's Index of 500 of the largest stocks that trade on the New York Stock Exchange and Nasdaq.
SAFE	Survey on Access to Finance for Enterprises. A survey on the access to finance of small and medium-sized enterprises conducted by the ECB and the European Commission.
Scale-up	Startups in a later stage of development (growth phase) are typically referred to as scale-ups.
Securitisation	The conversion of an asset, especially a loan, into marketable securities, typically for the purpose of raising cash by selling it to other investors.
Services	Based on the NACE classification of economic activities, firms in group G (wholesale and retail trade) and group I (accommodation and food services activities).
Single technology	Firms that have implemented only one of the four digital technologies in recent years (see "Digitalisation").
Skill-biased technological change	A shift in production technology that favours skilled over unskilled labour by increasing its relative productivity and, therefore, its relative demand. Traditionally, technical change is viewed as factor-neutral.
Smart grids	Electricity supply networks that use digital communications technology to detect and react to local changes in usage.
Smart infrastructure	Results from the augmentation of physical infrastructure with digital capacity.
SMEs	Small and medium-sized enterprises. Firms with fewer than 250 employees.
SMEsec	SME securitisation. Transactions backed by SME loans, leases and other products.
Social infrastructure	In the EIB Municipality Survey comprises healthcare, care for the elderly, childcare, education and training, as well as social and affordable housing.
Southern Europe	Cyprus, Greece, Italy, Malta, Portugal and Spain.
SPV	Special purpose vehicle. A subsidiary company with an asset/liability structure and legal status that makes its obligations secure, even if the parent company goes bankrupt.
SSM	Single Supervisory Mechanism.
Start-up	A young firm with high growth ambitions.
STEP	Short Term European Paper Programme.
Sunk cost	A cost that has already been incurred and cannot be recovered.
Support processes	Processes supporting production, such as lighting, ventilation and compressed air production.
SURE	The European instrument for temporary Support to mitigate Unemployment Risks in an Emergency.
Tangible investment	Investment in, for example, land, business buildings and infrastructure or machinery and equipment, as defined in the EIB Investment Survey (EIBIS).
Targeted longer-term refinancing operations	Eurosystem operations that provide financing to credit institutions. By offering banks long-term funding at attractive conditions they preserve favourable borrowing conditions for banks and stimulate bank lending to the real economy.

TCFD	Task Force on Climate-related Financial Disclosures.
TFP	Total factor productivity. The efficiency in combining production factors to create added value.
Tobin's *q*	The ratio of the market value of a company's assets (as measured by the market value of its outstanding stock and debt) to the replacement cost of the company's assets (book value).
Transition regions	EU NUTS 2 regions with GDP per capita 75%-90% of the EU average.
Transport infrastructure	In the EIB Municipality Survey comprises footpaths and cycling lanes, intra-urban public, inter-urban and urban-rural transport connectivity, and charging stations for electric vehicles.
UK	United Kingdom.
UNCTAD	United Nations Conference on Trade and Development.
UNESCO	United Nations Educational, Scientific and Cultural Organization.
UNFCCC	United Nations Framework Convention on Climate Change.
Unicorn	Scale-up with a firm valuation of USD 1 billion or more.
US	USA – the United States of America.
VC	Venture capital. A type of private equity focused on startup companies with high growth potential.
WEF	World Economic Forum.
WEF Infrastructure Quality Score	Question from the World Economic Forum's Global Competitiveness Report: How would you assess general infrastructure (such as transport, telephony, and energy) in your country? 1 = extremely underdeveloped; 7 = extensive and efficient by international standards.
Western and Northern Europe	Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Luxembourg, the Netherlands and Sweden.

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European Investment Bank
98-100, boulevard Konrad Adenauer
L-2950 Luxembourg
+352 4379-1
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