INVESTMENT REPORT
2019/2020

European Investment Bank
The EU bank

accelerating europe's transformation

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Investment and Investment Finance in Europe

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 innovation, climate change mitigation, equity markets, skills and corporate digitalisation activities. The report draws extensively on the results of the annual EIB Investment Survey (EIBIS). 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.

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Executive summary

Europe may be on the cusp of a cyclical downturn…

Investment activity in the European Union has now recovered from the last recession. Since 2013, investment growth has outpaced growth in gross domestic product (GDP). This has brought investment up to nearly 21.5% of the European Union's GDP, 0.5 percentage points above its long-term average.

Yet the economic climate is worsening. Real GDP growth has slowed down over the last year in line with falling export demand and weakening manufacturing output. Trade disputes and Brexit are contributing to rising uncertainty and deteriorating expectations regarding the economic environment and investment outlook.

Investment is likely to join the slowdown in the coming year. So far, the impact of slowing GDP growth on investment has been limited, but this is likely to change as the slowdown spreads to the service sector. Data from the European Investment Bank Investment Survey (EIBIS) 2019 show that EU firms have become more pessimistic about the political and regulatory environment and now expect the macroeconomic climate to worsen. The number of EU manufacturing firms planning to reduce investment in the current year has risen for the first time in four years.

… just as it needs to speed up investment in response to historic challenges

Europe cannot afford to wait out another cyclical downturn. After a lost decade of weak investment and policy focused on short-term crisis management, urgent action must be taken on a number of structural fronts. These include:

- **Keeping pace with the digital revolution –** enhanced innovation and adoption of digital technologies are needed to maintain Europe's ability to compete in the global economy.
- **Climate change and the zero-carbon transition –** delays mean that a tremendous acceleration of efforts is required, both globally and across Europe.
- **Rebuilding Europe's social cohesion –** comprehensive measures are needed to strengthen the social and economic inclusion of all Europeans, not least across geographical and generational divides.

Europe must seize a once-in-a-generation opportunity to transform its economy. European policymakers need to tackle the slowdown and embark on a long-term strategy to make Europe more sustainable, more competitive and more inclusive. European countries must take the opportunity of historically low interest rates to support these efforts, but not merely from the perspective of short-term stimulus. Action needs to be threefold:

- **Undertaking public investment to enhance the conditions for sustainable and inclusive growth.**
- **Creating the right environment for private investment to accelerate the transformation.**
- **Promoting efficient financial intermediation across the European Union.**

Gaps in innovation, digitalisation and the dynamic process of firm renewal are a drag on Europe's ability to compete

The European Union is risking a gradual loss of global competitiveness, with slow innovation, adoption of digital technologies and productivity growth, standing in contrast to rapid technological change worldwide and the emergence of new global players. Structural barriers and rigidities lie behind many of these trends, often preventing the necessary reallocation of resources within the economy.

- **Research and development (R&D) expenditure in the European Union lags behind that in peer economies, and is over-dependent on the automotive sector.** The United States spends almost 1 percentage point of GDP more on R&D than the European Union (a gap principally explained by lower business R&D spending in Europe), and China's R&D investment has also now surged ahead, both as a share of total world R&D and as a percentage of GDP. A small number of companies, sectors and countries account for a large share of business R&D expenditures. Many European companies are major global R&D players, but a large number of these are in the automotive sector (which is facing structural change) and relatively few are in the fast-growing technological and digital sectors. European companies make up only 13% of those that have entered the group of top R&D spenders since 2014, compared to 34% for the United States and 26% for China.

- **The adoption of digital technologies in Europe is slow, with a growing digital divide among firms.** Firms that adopt digital technologies tend to invest more, innovate more and grow faster, enjoying first-mover advantage. However, the share of digital firms in the European Union's manufacturing sector, 66%, is lower than in the United States, 78%, with an even larger gap of 40% to 61% in services. Investment in information technology by service sector companies is 1 percentage point of GDP lower in the European Union than in the United States. Slow digitalisation in the European Union partly reflects a lack of European presence in tech sectors that were "born digital." There is also a growing digital divide between larger and younger European firms that have already adopted digital technologies and smaller and older firms that have not. Smaller and older firms are more likely to find access to investment finance difficult, potentially exacerbating this divide. The need for better management practices and skills is also a likely constraint on digitalisation.

- **A large and persistent productivity gap has opened between the most productive European firms and the rest.** Less productive firms find it very difficult to move up the productivity ladder (70% of those at the bottom remain there for at least three years). Meanwhile, the most productive firms – which tend to be large – face little competition from below. Such lack of mobility could hamper the diffusion of knowledge and innovation and exacerbate the misallocation of resources. Structural rigidities and weak business dynamics (creation, growth and replacement of firms) reinforce the productivity gap. We estimate that productivity growth would be 40% higher without these frictions. The impact of structural rigidities is most evident in Southern Europe, where productivity growth has stagnated across the productivity distribution.

- **Europe has too few start-ups and scale-ups**, with the United States having four times as many per inhabitant as the European Union. European scale-ups tend to grow more slowly and are more likely just to target their local market, rather than a continental or global market. A number of structural factors help to explain this: smaller markets in Europe due to the lack of European economic integration in services; greater difficulty in attracting top talent and a general lack of staff with the right skills; and a relatively underdeveloped venture capital market that suffers from home bias and limited scale. Local start-up success stories have an enormous impact by attracting willing investors and fuelling exit markets for the next generation of start-ups (including through stock markets or corporate acquisitions), putting the European Union at a disadvantage. US corporations have spent 100 times as much as their European counterparts on acquiring young firms since 2012, driving venture capital investment.

- **The slow adoption of smart infrastructure by the public sector is a lost opportunity to improve services and stimulate private investment.** Infrastructure investment in Europe stands at a 15-year low of 1.6% of GDP, with the greatest declines seen in regions that are already lagging behind in infrastructure. Modernising infrastructure by combining physical assets with digital technologies has the potential to increase efficiency and reduce unwanted impacts, and synergy effects could also provide a boost to private sector investment in new technologies. Yet only 17% of EU regions report plans for smart infrastructure investments in the near future. Current regulatory frameworks for regulated sectors like utilities tend to incentivise efficiency gains over the innovative use of digital technologies to diversify product offerings.

Time is running out for the transition to a net zero-carbon economy

Keeping world temperature increases to 2°C – or even 1.5°C – is still economically feasible, but the European Union is not doing enough. We must reach net zero emissions by 2050 if we are to have a reasonable chance of keeping the global temperature increases well below 2°C, beyond which the world will face unacceptable ecological, economic and societal consequences. To play its part in reaching this goal, the European Union needs to agree and enact a comprehensive climate change strategy, with accelerated investment at its core. Although substantial progress has been made, investment is not yet on track:

- **The European Union invested EUR 158 billion in climate change mitigation in 2018.** At 1.2% of GDP, this figure is marginally less than the United States (1.3%) and little over a third of China's performance (3.3% of GDP). While investments in renewable energy have fallen partly because of cost reductions, the transport sector remains largely fossil fuel-based. Europe leads in energy efficiency investments, but investment in lower-carbon transport – particularly rail – is much higher in China and the United States. Transport is expected to become the largest source of greenhouse gas emissions beyond 2030.

- **Europe's weak performance in climate-related R&D is a threat to its competitiveness**, given the importance that still-immature technologies will have in the transition. While the United States leads climate-related R&D spending, China has recently quadrupled its spending, slightly overtaking the European Union.

- **Some Member States risk missing their 2020 targets for the share of renewables in energy consumption.** Approximately half of the Member States are considered on track, with six already thought to be unlikely to meet their 2020 targets.

- **To achieve a net zero-carbon economy by 2050, the European Union must raise investment in its energy system and related infrastructure from around 2% to 3% of GDP, requiring mobilisation of private investment.** Even more will be needed when all investments to decarbonise the transport sector are considered. Some two-thirds of investment will have to come from energy users, including for building insulation, improved industrial processes and new transport technologies.

- **The energy transition has implications for cohesion and social inclusion.** Especially high levels of investment will be required for the Eastern and South-Eastern EU countries, while some regions will be particularly affected by the decline in carbon-intensive industries, creating a need for re-skilling. Higher energy costs and home renovation needs may be a challenge for lower income households.

Widening social divides are a threat to Europe's economic future and its capacity to manage change

One of Europe's strengths has been its social model, but this model needs to be renewed and adapted in the face of rising inequality and new strains from technological change. Social cohesion is key to Europe's ability to adapt to a changing world economy and meet the demands of the zero-carbon transition. Social mobility is essential for getting the most out of European's talents and ambitions, maximising economic performance and prosperity. Yet several trends are cause for concern:

- **Income inequality within EU countries has increased in recent decades, despite the mitigating impact of redistribution policies.** Real EU GDP per capita has grown by 45% since 1995. However, the pre-tax income of the bottom 50% has grown by only 16%, while that of the top 1% has grown by 50%. The global financial crisis triggered a short-lived reduction in pre-tax income inequality, but levels have since risen, with income stagnating or falling (particularly in Southern Europe) for those on the lowest incomes. There is wide variation in the success of different Member States in addressing this inequality. Meanwhile, wealth inequality, which is much higher than income inequality, remains a driver of future income inequality through the distribution of returns on assets such as real estate and equity.

- **Income inequality between regions and between urban and rural areas has also risen.** Changes in technology and the structure of the economy are concentrating ever more economic activity and high-skilled jobs in metropolitan areas. The economic dynamism of cities may increase overall national prosperity, but growing spatial inequality puts pressure on social cohesion. It is further exacerbated by lower infrastructure investment in less well-off, less dynamic regions, as indicated by their reported infrastructure needs.

- **Progress on social mobility has slowed, or even reversed, with implications for cohesion, growth and competitiveness.** Intergenerational social mobility (in terms of types of occupation, and not accounting for changes in economic structure) improved for the Baby Boomer generation but appears to have weakened for Generation X. This may reflect rising income inequality and has negative implications for the efficient allocation of talents and skills, as well as for the social impact of market outcomes.

- **A lack of staff with appropriate skills remains the most severe obstacle to investment by firms, with automation set to massively increase skills needs.** A majority, 77% of firms, report that a lack of staff with the right skills is an impediment to investment. Removal of this constraint could theoretically raise EU productivity substantially. Meanwhile, 42% to 52% of jobs (depending on the region) can be considered at risk of automation, creating an urgent need for re-skilling to maintain competitiveness and seize new economic opportunities. The fact that skill constraints tend to distort firms' investment towards labour-saving improvements, rather than towards the development of new products and services, is a concern in this context.

Undertaking public investment is essential to enhance the conditions for sustainable and inclusive growth

Against the backdrop of a global slowdown and where fiscal space allows, public investment should be front-loaded with priority given to growth-enhancing expenditure. The large-scale public investment needed to support infrastructure digitalisation and the zero-carbon transition will require comprehensive and detailed medium-term planning. Given weak growth and very low long-term interest rates, governments with available fiscal space should consider frontloading this investment as much as possible through increased borrowing. More fiscally constrained governments should prioritise expenditure that enhances growth and leverages private sector financing:

- **Smart infrastructure can offer a "quick win",** involving the development and implementation of national medium-term strategies to integrate digital technology into infrastructure. Cross-border cooperation can lead to economies of scale and pan-European synergies.

- **Improving public authorities' technical capacity** for project planning and implementation, together with greater inter-regional cooperation, is an essential complement to finance for unlocking investment opportunities.

- **Investment in digital technology can enhance public services and regional cohesion,** potentially offering both quality and efficiency improvements, as well as new modes of service delivery for more remote and underserved regions.

- **Public finance can help catalyse the rollout of green technology** – as in the European Battery Alliance – to complement market-based instruments. For infrastructure, public finance and strategic roadmaps can enable the rollout and integration of renewables and low carbon technologies, such as electric vehicles and smart appliances.

- **Improving the accessibility and quality of education is a "win-win" for inclusion and competitiveness.** It should include retraining and life-long learning tailored to changing market demands for specific skills.

Create the right environment for private investment to support transformation

Direct public investment must be complemented by action on the barriers and misaligned incentives that hold back private sector investment. In this way, swift reforms can help counteract an economic slowdown. More importantly, they can enable the innovation, business investment and business dynamism needed to raise productivity and achieve long-term competitiveness and sustainability. Public and private investment should be seen as complementary, with well-targeted public investment creating catalytic opportunities for private investment.

- **Build on public investment in R&D with greater support for innovation and investment in intangibles**, such as software and databases, employee training, business process improvements and better management practices. Enhanced cooperation between businesses, universities and research centres is also important for the spread of new technologies. Front-loaded investment in digital infrastructure, with financing and technical capacity-building for digitalising firms, could accelerate digitalisation and the diffusion of innovation. An enhanced focus on climate-related R&D is essential for both competitiveness and the zero-carbon transition.

- **Tackle barriers to the entry and growth of young innovative firms, to enhance competition, business dynamics and productivity**. While the role of many leading companies in pushing the technological frontiers should be supported, there is also a need to address barriers to firm entry and barriers to growth, such as size-dependent business regulation, network effects and winner-takes-all dynamics. Removing impediments to the exit of under-performing firms is also vital. Such structural rigidities stifle the diffusion of innovation, the efficient allocation of resources across the economy and, ultimately, the productivity and competitiveness of the European economy. Competition policies, product and labour market regulations and the implementation of the digital single market are all important in this regard.

- **Remove regulatory obstacles to investment in smart infrastructure.** In the utilities sector, pricing regulations tend to favour a focus on efficiency improvements over product innovation and diversification. A more flexible regulatory approach is needed to enable more disruptive innovation that explores how digital technologies can enhance the quality and diversity of infrastructure services.

- **Clear climate and energy policy signals are needed, with a supportive regulatory framework, better access to climate finance and better aligned incentives.** This will enable firms and investors to roll out strategies and investment plans that are in line with zero-carbon transition goals, speeding up the transition and reducing the risk of stranded assets. Extending and tightening the European Emissions Trading System is one option to better align incentives, as is carbon taxation that could help fund measures to support inclusion, with border tax adjustments to protect the competitiveness of European firms. Incentivising energy audits has also proven to be a useful tool to raise investment in energy efficiency.

Promote efficient financial intermediation across the European Union

The financial sector in the European Union still needs to do more to support long-term investment and higher-risk investment by young and innovative firms. After years of accommodative monetary policy, liquidity is not in short supply. Yet these financial resources are still not reallocated efficiently. The financial system does not currently facilitate sufficient maturity transformation at a time when long-term investment needs are very high. It exhibits a bias towards financing established but often non-innovative and less efficient firms – even when they have difficulty servicing their debt – rather than taking risks on new entrants and innovative challengers. This reticence undermines business dynamism, allocative efficiency and productivity growth.

A lack of financial integration across the European Union is a threat to convergence and cohesion. Within the financial sector, there is still significant evidence of home bias, which means that savings are not being reallocated to their most productive use across the Union. Ultimately, this could impede economic convergence and feed a process of polarisation within the European economy.

The focus of reforms needs to turn from strengthening resilience to enabling the financial sector to play its role in building a competitive, sustainable and inclusive Europe. The regulatory overhaul in the wake of the global financial crisis succeeded in strengthening the banking system. It has so far failed, however, to reignite financial integration. The Capital Markets Union and other regulatory initiatives need to prioritise overcoming fragmentation, generating the long-term finance needed for the zero-carbon transition, and fostering risk-taking finance – particularly equity – to support start-ups, scale-ups and other innovative firms that have the potential to transform the European economy.

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Director, Economics Department
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Introduction

This year's Investment Report analyses three major policy issues – the competitiveness of European firms, social cohesion and climate change mitigation. We live in times of rapid technological change, where the digital revolution is taking centre stage. The internet and digital technologies are quickly and radically altering the way we work, socialise and organise our lives. At the same time, climate change is at the forefront of policy discussions around the world, as it becomes increasingly clear that the consequences of delaying action would be catastrophic. The speed of climate and technological changes means that it is definitely too early to anticipate their full impact in the economic and social spheres. The policy responses to these challenges also need to consider income inequality and social inclusion to ensure the sustainability of technological progress.

Technology companies are among the most valuable in the world. 20 years ago, there were just three technology companies in the top ten most valuable firms, and these were all telecoms, retailers and oil-and-gas corporations. Now there are six – with four of them sitting right at the top. These companies are also among the biggest research and development (R&D) and innovation spenders in the world. However, none of them are from the European Union, highlighting how much more difficult Europe is finding it to produce new successful companies in high technology sectors compared to the United States and China.

Despite the pace of technological change, productivity growth has slowed down across advanced countries. Average productivity growth in the European Union over the last five years is only half what it was in the late 1990s. The difference is similar across OECD members. Slower productivity growth means that economic growth is slower in the medium to long run and average incomes rise more slowly.

At the same time, a significant and persistent productivity gap exists between productivity leaders and all other firms in the European Union. This gap is persistent because low-productivity firms are finding it difficult to increase their relative productivity, while leader firms seem to hold an increasingly stable position at the top of the productivity distribution. The productivity gap may explain the coexistence of rapid technological change and a productivity slowdown. This productivity gap hinders economic growth, but also means that there is enormous potential for future growth if knowledge and innovation diffusion improves and resources are more efficiently allocated across companies by allowing unproductive firms to exit the market and productive firms to grow.

Technological progress and innovation are increasing income inequality. This is due to an increase in the wage-skill premium, i.e. the difference between the incomes of high-skilled and low-skilled workers. Pre-tax incomes in the bottom 10% of the EU income distribution increased by only 16% between 1995 and 2018, while the pre-tax incomes of the top 1% increased by 50%. Outcomes differ within different EU countries, but the general trend does not change – top earners have increased their incomes more than bottom earners.

Modern technological progress is also leading to the geographical concentration of economic activity. It has improved the fortunes of large cities and led to stagnation and relative decline in smaller towns and rural areas. While cities' dynamism may increase overall national prosperity, growing spatial inequality puts pressure on social cohesion within countries. Not everyone is willing or able to move to large cities and even if this were possible, congestion, pollution and intra-city inequality might result in lower rather than higher social welfare.

A widening digitalisation gap among firms is further accentuating the productivity gap and wage inequality. Firms that organise their business around digital technologies are more productive, more profitable and pay higher salaries. Furthermore, digitalisation and automation reduce demand for workers in routine-based tasks typically requiring low and medium skills, and increase demand for higher-level professional and managerial skills. When displaced workers are slow to retrain and upgrade their skills, income inequality increases.

Where the supply of higher skills is slow to catch up, it hinders the adoption of new technologies and influences the choices of technologies taken up. Results from the EIBIS 2019 show that the main bottleneck to digital adoption is a lack of staff with the right skills. However, the share of mentions is much higher among firms that have already adopted than firms that have not, suggesting that finding the right people often only becomes an issue after adoption. When skill shortages constrain firms, they become more inclined to invest in digital technologies for automation purposes rather than to develop new products or services. When the availability of staff is not a constraining factor, the opposite is true.

Climate change has significant potential to negatively affect both economic activity and inequality. Initially, climate change is expected to increase the occurrence of extreme weather events that cause substantial and increasing economic losses. The less well-off are more exposed to such events as their ability to adapt is constrained by their financial and social conditions – events like hurricane Katrina in 2005 are a harsh reminder. Climate change will also affect the way we organise our lives and economic activity and will likely affect the productivity of those who are slow to adapt.

Addressing climate change will have distributional consequences that have to be taken into account by policymakers. The transition to low carbon emissions technologies will engender a large industrial transformation, whereby whole industries might disappear. Countries that are heavily reliant on industries like coal mining and coal-based electricity generation will be disproportionately affected by the transition. Policies – particularly at a European and global level – should therefore ensure fairness to and buy-in from those most affected.

This report brings together internal EIB analysis and collaborations with leading experts in the field to study the major policy issues. It is structured into three parts. Parts I and II are designed to track recent developments in gross fixed investment, including infrastructure, intangible capital and climate investment (Part I), and investment finance (Part II). Part III is a collection of three chapters focusing on start-ups, productivity and skills.

The report incorporates the latest results from the annual EIB Investment Survey (EIBIS). The survey covers some 12 500 firms across the European Union and a wide spectrum of questions on corporate investment and investment finance. It therefore provides a wealth of unique firm-level information about investment decisions and investment finance choices, complementing standard macroeconomic data.

The analysis draws extensively on several specialised modules of the EIBIS designed to focus on a different topic every year. Data from the Start-up and Scale-up survey, the Skills and Digitalisation survey and the Municipality survey were all used throughout the report.[1]

Throughout the report, EU countries are often placed into three groups with several common features (Figure 1). The countries that have joined the European Union since 2004 and rely substantially on EU cohesion and structural funds are in the Central and Eastern Europe group. Cyprus, Greece, Italy, Malta, Portugal and Spain form the Southern Europe group. The remaining members of the European Union are in Western and Northern Europe. While groupings are based on geographical position, countries within each group share many common structural economic characteristics, thereby justifying economic analysis based on such a grouping. Throughout the report, the United Kingdom is considered separately from these groups.

1 More information about these surveys is available in the Data Annex of this report and at www.eib.org/eibis

Figure 1
Country groups used in this report

Source: *Map drawn using Draw Geographical Maps, R package version 3.3.0.*

Investment in the European Union is up **18%** but, on balance, firms now see the **economic climate** as negative for investment, **by a margin of 22%**

1% of **GDP** is the size of the investment gap between the European Union and the United States in **information and communication technologies**

The European Union is investing **1.25%** of GDP **in climate change mitigation**, one-third that of China

Investment rates in middle-income regions have declined by **14%** since 2002, while investment rates in high-income regions have increased by **1%**

Investment in infrastructure is stuck at **1.6%** of GDP

Slowness in leveraging the digital opportunity: Only **17%** of **regions** want to prioritise investments in **smart infrastructure** over the next few years

58% of **firms** in the European Union are **digital**, vs **69%** in the United States

PART I

Investment in tangible and intangible capital

Chapter 1

Gross fixed capital formation, economic growth and social cohesion in the European Union

Real gross domestic product (GDP) growth in the European Union slowed in 2018 and the first half of 2019. This moderation followed rising uncertainty and slowing external demand due to escalating tensions in international trade, the deceleration of the Chinese economy and Brexit. While domestic demand still offsets these developments, continuing problems in the manufacturing sector may threaten economic expansion across the European Union.

Real investment continued growing despite the moderation. Investment growth remained robust across all institutional sectors, as households, corporations and governments increased real investment expenditure. Slowing investment growth in machinery and equipment was offset by investment in other buildings and structures. Uncertainty together with the deteriorating economic, political and regulatory environment in the European Union may negatively affect investment later in 2019 and 2020.

Low interest rates and a slowing economy provide the right backdrop for a more determined shift by governments from current to capital expenditures. Such a shift is necessary to address increasing investment needs related to climate change mitigation and adaptation, infrastructure and innovation. As a side effect, putting an emphasis on government investment may also help tackle the likely economic slowdown.

Slowing investment in machinery and equipment, especially information and communications equipment, along with a deteriorating economic outlook may undermine the competitiveness of European firms. The information and communications technology (ICT) equipment investment gap between the European Union and United States exceeds 1% of European Union GDP and is fully accounted for by a lack of investment in the services sector. Slower ICT adoption may further reduce productivity growth.

Increased inequality in the European Union poses a threat to social cohesion, investment and economic growth. Income inequality in the bloc has increased over the past 40 years, despite the mitigating impact of redistribution policies. Income inequality between large cities and less densely populated areas also rose, as technological progress and the new economy concentrate ever more economic activity and highly skilled jobs in large cities and metropolitan areas. A relative slowdown since 2000 in the increase of interpersonal inequality is good news for societies with high social mobility. Those with low social mobility will not feel the effects any time soon, however.

Introduction

The current expansion of the EU economy is in its seventh year. At the end of 2018, real GDP per capita was 10% higher in the European Union compared to 2013, while investment was 18% higher.[1] The current economic outlook has deteriorated and uncertainty has increased, however. This chapter looks at investment developments in 2018 and 2019 and discusses the likely drivers of its near-term direction, with a particular focus on corporate investment.

In addition to the focus on investment this year, the first chapter of this report takes a look at income inequality and social cohesion in the European Union. Social cohesion may not play a direct role in explaining investment behaviour, particularly in the near term. Indirectly, however, and especially in the longer term, inequality and social cohesion determine the economic environment, the efficient allocation of talent and skills, and the extent of trade and economic openness, all of which underpin investment and economic growth.

Economic environment in the European Union

The European economy has entered its seventh year of economic expansion. On an aggregate level, the EU economy began growing again in the second half of 2013 after five years of recession and stagnation (Figure 1a). Real GDP growth picked up gradually and exceeded potential GDP growth in the fourth year of the expansion, opening a positive output gap. While this estimated output gap remains positive, real GDP growth slowed down noticeably in the second half of 2018. Weakening manufacturing production and lower external demand for EU exports are the main reasons behind this deceleration.

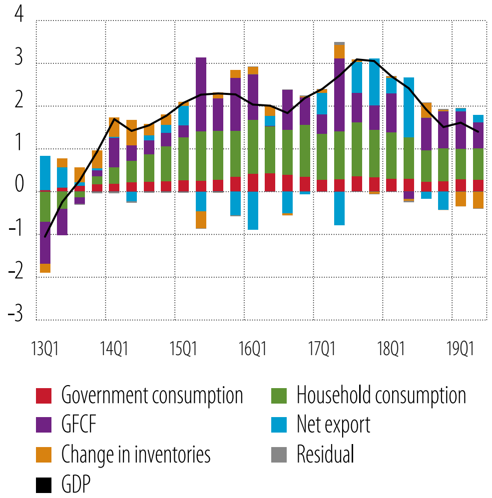
The strength of the economic expansion relies on domestic demand. Initially, the European economic recovery was largely due to strong net exports. As it gained momentum, employment and household disposable income rose and fuelled household consumption (Figure 1b). Business capital expenditures also picked up, while fiscal policy gradually moved from restrictive to neutral. Growing domestic demand has accounted for about 97% of real GDP growth over the past three years.[2] Since the second half of 2018, however, domestic demand growth has seen a noticeable slowdown, raising concerns about the strength of the economic expansion in the near term.

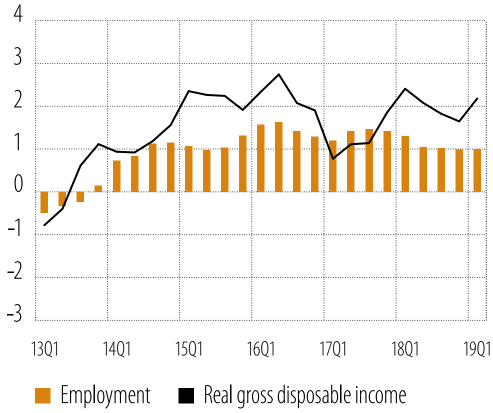
The economic expansion has seen solid employment gains and gradually tightening labour markets (Figure 1b, Figure 2). The financial crisis and the ensuing economic recession brought unemployment rates to highs not seen in many EU economies since the 1980s. The last six years of economic expansion have brought rates of unemployment down to their lowest levels since 1995 (Figure 2) for most EU members (with the exception of Italy, Spain and Greece), with employment rates well above pre-crisis levels in most EU economies. However, these welcome developments resulted in tight labour markets across the European Union. Data from the 2019 EIB Investment Survey (EIBIS) show that a lack of staff with the right skills was the most common barrier to investment among non-financial firms for a second consecutive year (Figure 17 and Figure 18). The recent slowdown of the European economy is still not visible in European labour markets.

1 Investment and gross fixed capital formation (GFCF) are used interchangeably in this report.

2 Domestic demand is defined here as the sum of final consumption, investment and stock building expenditures by private and general government sectors in real terms.

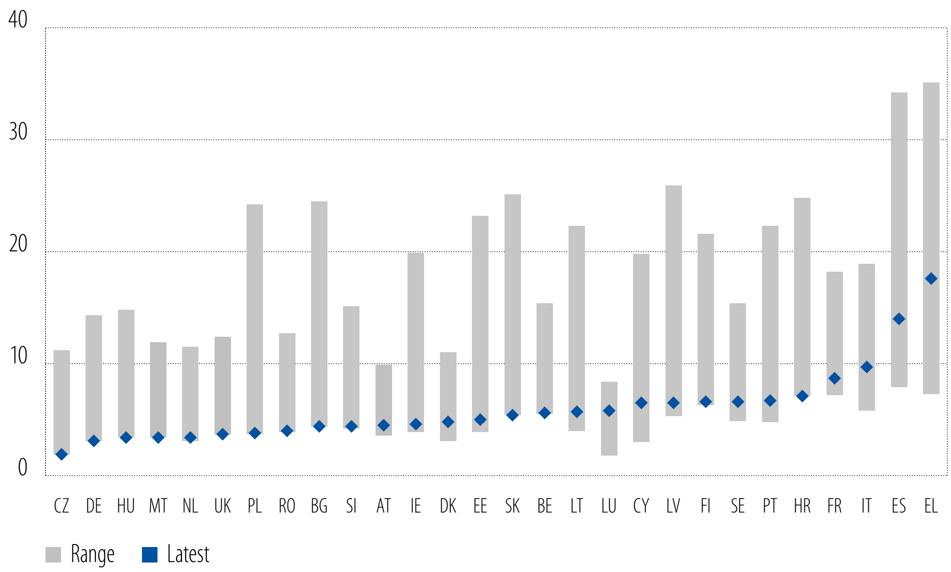
Figure 1
Evolution of real GDP and the labour market in the EU





Source: *Eurostat and EIB staff calculations.*
GFCF stands for gross fixed capital formation.

Figure 2
Unemployment rates in the EU since 1995

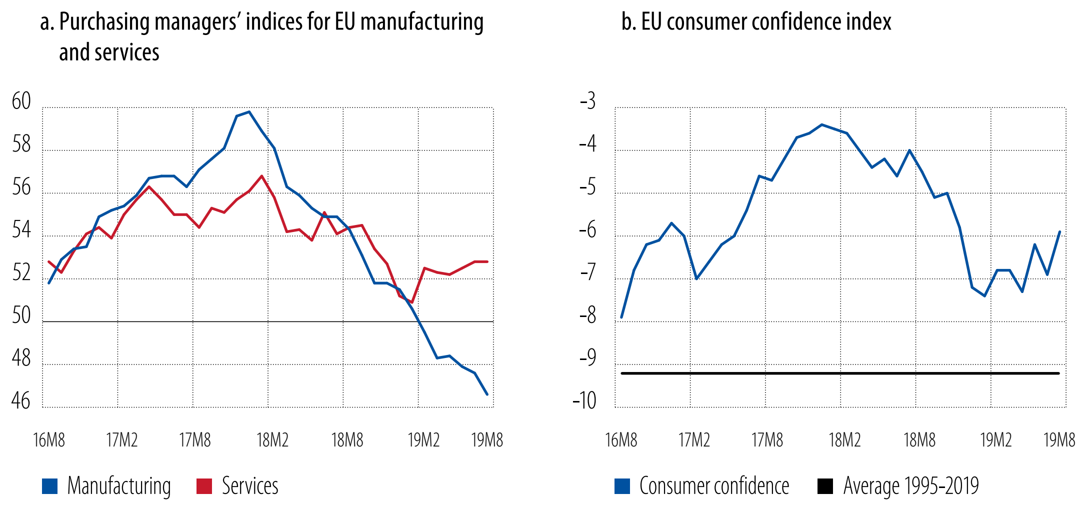


Source: *Eurostat and EIB staff calculations.*

The strong exports of EU firms made a major contribution to the economic recovery and to the strength of the ensuing expansion up until 2018. Pick-up in external demand in 2010, combined with subdued domestic demand across the European Union, gave an initial boost to most EU economies in 2013 and subsequent years. Strong export performance pushed real GDP growth rates above 3% per year in 2017 (Figure 1a) and on average, EU real exports have grown 2.5 percentage points faster than real GDP since 2013. However, export growth slowed down in 2018, and net exports started to drag on GDP growth.

Growth in European manufacturing slowed down sharply in 2018 and in early 2019. Solid domestic demand and tight labour markets notwithstanding, manufacturing production slowed down sharply in the second half of 2018 and this weakness continued into the first half of 2019. The production of capital and intermediate goods fell the most, with Germany hit particularly hard (manufacturing production in the year to June 2019 fell by 9%). The decline was even more pronounced in the production of intermediate (-13%) and capital goods (-16%). While this decline was offset by relatively good performance from the service sector (Figure 3) both in Germany and across the European Union, good overall economic performance cannot be taken for granted in the near term, especially if the downturn in manufacturing continues.

Figure 3
Business and consumer confidence indices



Source: *Markit Economics for purchasing managers' index (PMI); Eurostat for consumer confidence.*
Note: *All indices are seasonally adjusted. The consumer confidence index comes from DG ECFIN Consumer surveys.*

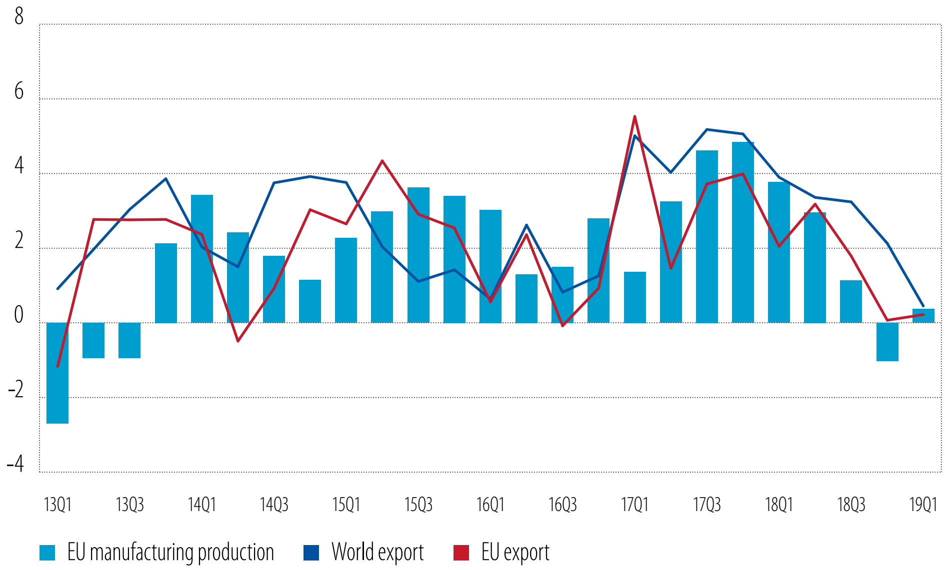
Weakness in European manufacturing parallels a sharp slowdown in EU export growth (Figure 4). Growth in EU exports declined in 2018 and in early 2019 in lockstep with a slowdown in global trade. The fall in exports appears to be closely related to the downturn in EU manufacturing production, especially in Germany, with the volume of German goods exports declining by 5% in the year to April 2019. Goods exports in the other large EU economies – France, Italy and Spain – also slowed significantly in 2018, but unlike German exports began to rebound in the first half of 2019. Germany's position as an international trade hub and its intense trade links with the decelerating Chinese economy may be behind the marked slowdown in exports.

Since early 2018, rising international trade tensions have weakened world trade and European exports (Figure 4). Following earlier investigations by the US Department of Commerce, the US administration imposed safeguard tariffs on solar panels and washing machines in January 2018, acting on the US president's intensifying rhetoric about unfair foreign competition. Although the tariffs are imposed on all US imports, they targeted China and only had a small impact on EU economies. The new tariffs nevertheless contributed to increasing policy uncertainty around the world and in Europe

(Figure 2, Chapter 5). The US action was followed by retaliatory measures by trading partners, further increasing tensions. The US administration then implemented a series of additional tariff increases aimed at all imported steel and aluminium along with consumer and investment goods from China, and made announcements regarding tariffs on cars and car parts.

Figure 4

Real manufacturing production and merchandise exports (percentage change over the same quarter in the previous year)



Source: *World Trade Organisation (WTO) database (merchandise exports), Eurostat (manufacturing production) and EIB staff calculations.*

Note: *Manufacturing production is volume index 2015=100; merchandise export is volume index 2005=100.*

US tariffs on steel and aluminium are unlikely to have a major impact on European exports. A recent study by the Joint Research Centre of the European Commission (Sallotti et al., 2019) makes a model-based assessment of the likely effects of the announced increase of US tariffs on steel and aluminium on the affected countries. The authors find that the impact would be minimal for the European Union, with a decrease of around 1% in basic metal EU exports and industry employment. The reduction in value added is expected to be even smaller, although certain countries (like Sweden and Germany) will be hit harder than others. New tariffs on car and car part imports to the United States, if imposed, may have a greater impact on EU economies, amounting to around 0.1% of the European Union's GDP (Huidrom et al., 2019).

Available estimates on how a general increase of US tariffs would affect EU exports show a contained negative impact. A recent study by economists at the European Department of the International Monetary Fund (IMF) estimates the impact of the United States imposing a 5% tariff on all imports from the European Union and a reciprocal European measure (Huidrom et al., 2019). The study presents the differential impact of tariffs on gross exports and on value-added exports.[3] The estimated fall in US demand for value-added European exports is about 0.2%, which is about 50% higher than the impact on gross exports for advanced Europe and about three times higher than for emerging Europe. Another study, carried out by economists at Banque de France (Berthou et al., 2018), points out that there are indirect effects on GDP from worsening financial conditions, reduced productivity and increased uncertainty. These indirect effects may more than double the impact.

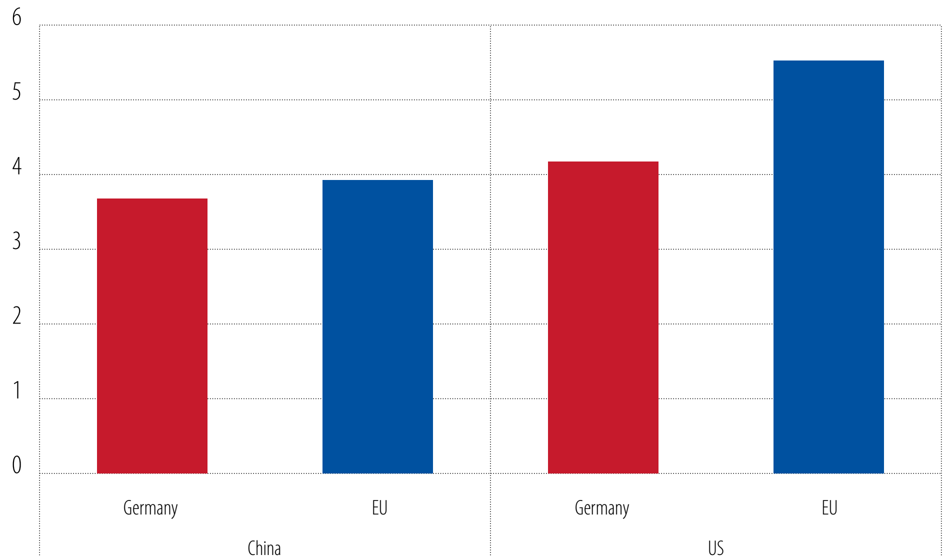
3 Value-added exports only include the domestic value added of intermediate and final goods absorbed in the destination country. Gross exports is a broader category and includes value-added exports as well as the domestic value added of intermediate goods exported on to third countries, the domestic value added of exported intermediate goods that return to the home country and, finally, the foreign value added of exports.

US tariffs may affect European exports even if direct EU exports to the United States are exempt. Trade friction between United States and China reduces the relative final price of EU imports in the two countries for the products affected by increased tariffs. The IMF estimates the effects to be very small and positive, at least in the short term (IMF, 2019). Gunnella and Quigletti (2019) find a very small negative impact for euro area GDP both in the short and long term. In their study, the negative effects from reduced business confidence outweigh the positive effects of increased exports. A reduction of US-China bilateral trade may mean less investment by the affected export sectors in China and the United States, reducing demand for capital goods imported from the European Union. The volume of these exports is not small. German value added in capital goods exported to China and the United States amounts to about 8% of total German exports. For the European Union this figure is closer to 10% (Figure 5). Given the minimal estimated effect of the tariffs implemented so far, most of the impact on EU exports will come from these dynamics and the increased uncertainty stemming from growing international tensions and Brexit.

Figure 5

German and EU value added to capital goods exports to China and the US

(% of total gross exports)



Source: TIVA database, OECD.

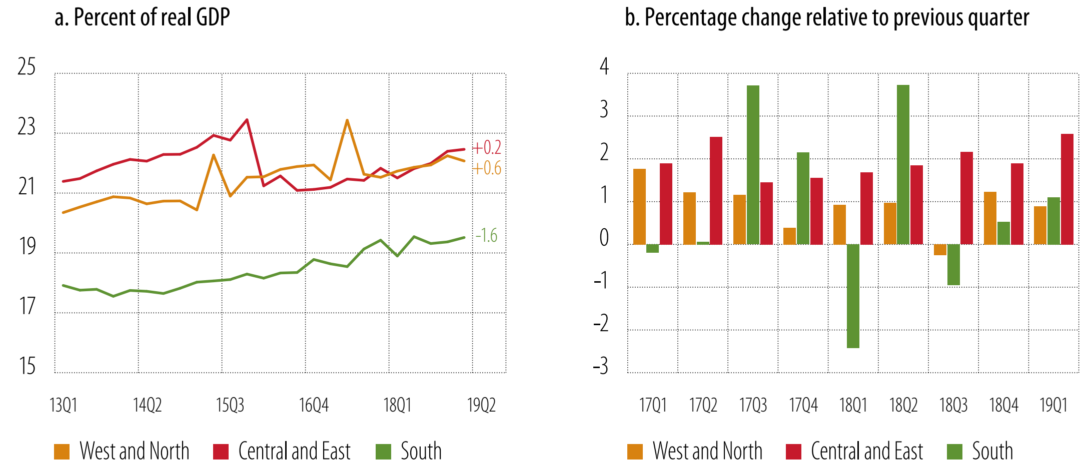
The effects of a no-deal Brexit may be significant, at least in the near term. The IMF (2019) estimates that in the event of a no-deal Brexit, EU GDP will fall 0.4% to 0.6% below a baseline scenario that assumes a Brexit deal (no increases in tariffs and a 10% gradual increase in non-tariff barriers). The Organisation for Economic Cooperation and Development (OECD) estimates a loss for the EU economy of about 1 percentage point of GDP (OECD, 2016). The uncertainty emanating from the uneven Brexit process has been quite high, and has been stoked recently by the British government's decision to leave the European Union at the end of October 2019 even if a deal isn't in place. That uncertainty may already be taking a toll on EU economic activity.

Aggregate investment dynamics

In 2018, real gross fixed capital formation in the European Union increased faster than real GDP for a fifth consecutive year. Real gross fixed capital formation grew about 0.5 percentage points faster than real GDP in the European Union, pushing the EU investment rate up further (to nearly 21.5%), practically equal to the long-term average.[4] As it stands, the investment rate in Western and Northern Europe is 0.6 percentage points higher than its long-term average and is essentially equal to the average investment rate of Central and Eastern Europe (Figure 6a).[5] Investment in Central and Eastern Europe suffered a substantial setback in 2016 as projects supported by EU structural and investment funds for the previous programming period were completed in 2015 (EIB, 2017). The investment rate has recovered some of its lost ground since then, slightly exceeding its long-term average in 2019. The average investment rate of Southern Europe also grew in 2018 and at the beginning of 2019, but remains 1.6 percentage points below both its long-term average and the average for other EU economies.

Figure 6

Real gross fixed capital formation in the EU



Source: *Eurostat and EIB staff calculations.*
Note: *Real variables are in euro 2010 chain-linked volumes. The figures in panel a show difference between latest value and average over 1995-2018.*

Investment growth was more uneven in 2018 than in the previous five years. In 2018, investment growth in the European Union fell to 2.3% from 3.7% a year. The slowdown came after several years of strong growth. The slowdown came with more volatility, however, which mostly came from Germany, Italy and Ireland – as seen in the quarterly growth series for Western and Northern and Southern Europe (Figure 6b). This volatility partly reflects the marked slowdown of Italy and Germany in 2018 and major volatility in investment in intellectual and property products in Ireland.

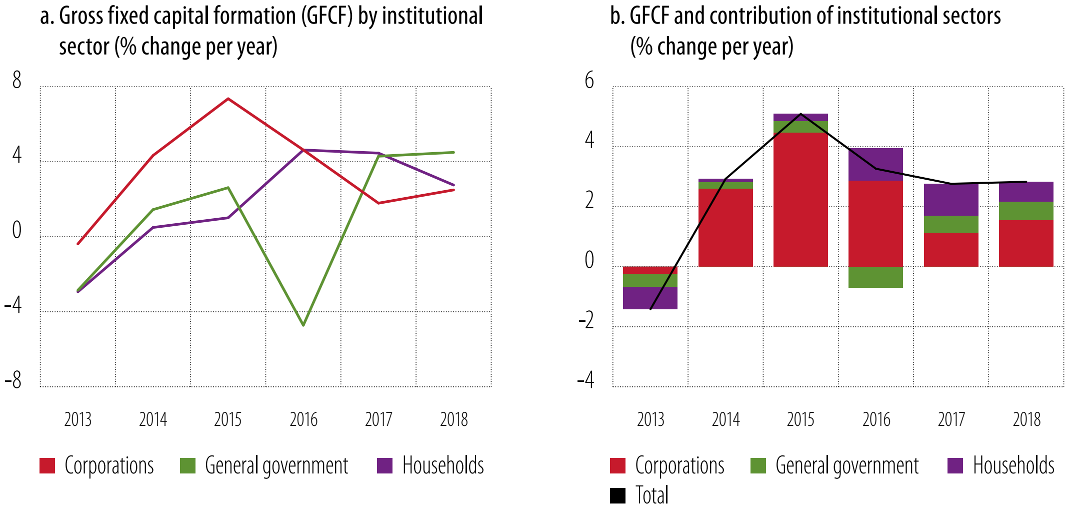
Investment increased across all sectors of the EU economy. In 2018, the real investment of the general government increased more than 4% for a second consecutive year, after a significant decline in 2016. Real household investment slowed somewhat relative to the two preceding years, growing 2.75%. Real corporate investment increased by 2.5% (Figure 7a), contributing about one half of total investment growth (Figure 7b). Investment by households and the general government each contributed about one-quarter of total investment growth in 2018. The corporate sector's contribution to growth in 2018 was below its share of total investment (62%), while the general government's contribution was above its share (13%). Households' contribution was in line with their share of total investment (24%).

The composition of investment in the European Union changed in 2018. The contributions of investment in dwellings and machinery and equipment to total investment declined in 2018 and early 2019 (Figure 8a). The decline was offset by higher investments in other buildings and structures and in intellectual property

4 Investment rate = gross fixed capital formation to GDP. In this section, the long-term average is calculated over 1995-2018.
5 The right-hand axis shows the difference between latest reading and long-term average value of the investment rate.

products. These developments are predominantly limited to countries in Western and Northern Europe (Figure 8d) and Central and Eastern Europe (Figure 8c). In Southern Europe, the decline of machinery and equipment investment in late 2018 was due to a drop-off in Italy, but also to temporary weakness in Spain (Figure 8b). Growth in machinery and equipment investments was much weaker in 2018 and early 2019 than in the previous four years. The largest contribution to investment growth in Central and Eastern Europe in 2018 and early 2019 was from investment in other buildings and structures (Figure 8c). Investment in this asset, in particular, in this region is influenced by the EU budget cycle (EIB, 2017)

Figure 7
Annual growth of real GFCF by institutional sector (% change)



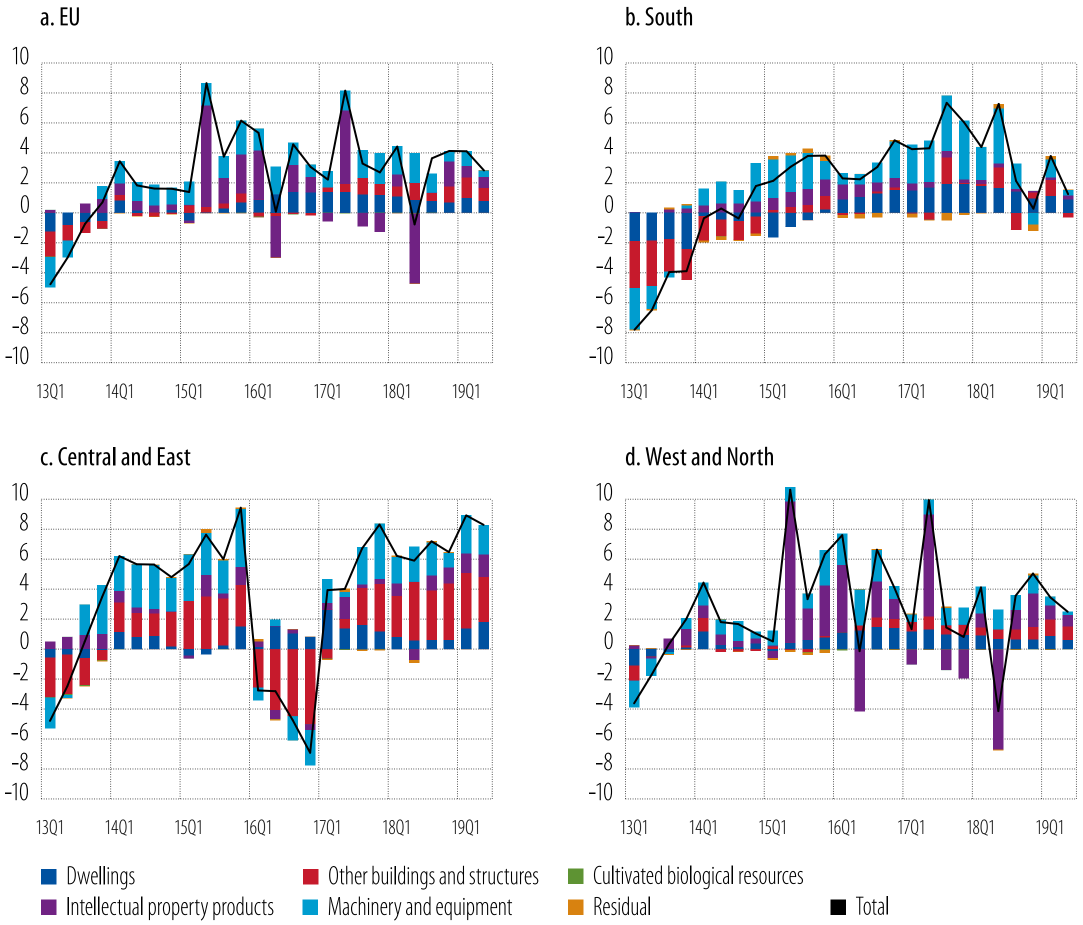
Source: *National sector accounts, Eurostat and EIB staff calculations.*
Note: *Nominal values for GFCF from the national sector accounts are transformed into real using investment specific deflators from national accounts statistics.*

Weakening investment in machinery and equipment in the European Union would increase the investment gap with the United States. The gap that opened between EU and US investment rates in machinery and equipment after the financial crisis (EIB, 2018) remained in 2018 (0.6 percentage points of GDP) and might increase further as the outlook for the two economies diverges. The gap is fully explained by the difference in investment in information and communication technology (ICT) equipment, which in 2018 stood at 1% of Europe's GDP (Figure 9a). Industry-level data suggests that the gap in ICT investment in the services sector accounts for nearly 90% of the total ICT gap between the United States and the European Union (Figure 9b).[6] Only in the manufacturing sector do EU economies invest slightly more in ICT equipment as a share of their GDP.

6 The services sector on this chart includes wholesale and retail trade (NACE Rev. 2 code G), Accommodation and food service activities (I), and information and communication (J).

Figure 8

Real GFCF and contribution by asset type (% change over the same quarter in the previous year)

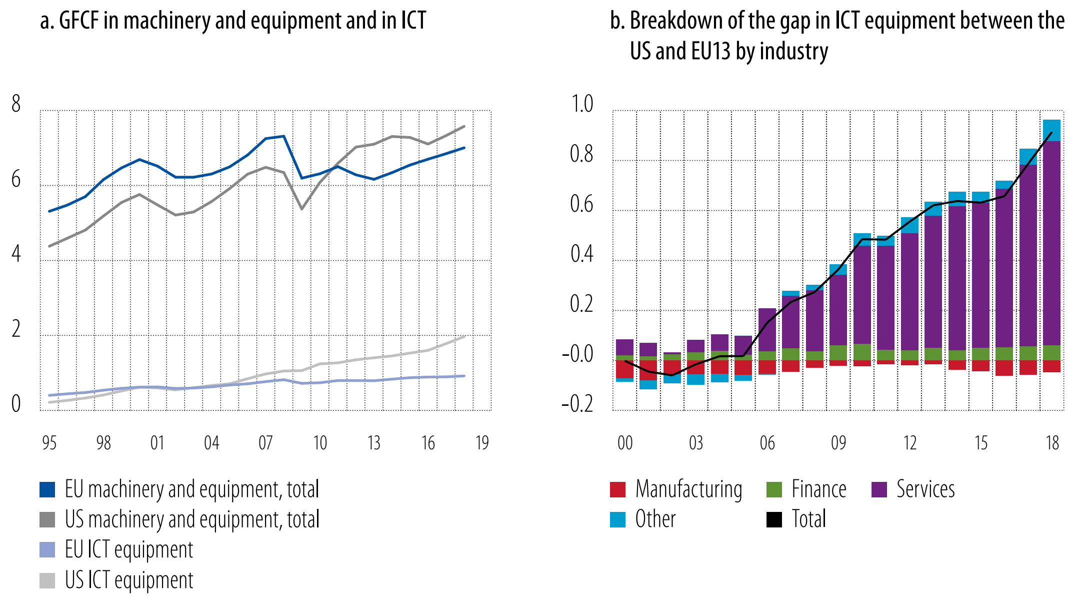


Source: Eurostat and EIB staff calculations.

The investment gap in ICT equipment may further increase the productivity gap between the United States and the European Union (Box A). Recent research by EIB economists provides evidence that investment in ICT equipment increases labour productivity. More precisely, higher levels of ICT equipment provided per hour worked increase output per hour in the non-farm, non-financial business sector. This result, however, does not apply to all machinery and equipment. The use of more non-ICT equipment per hour is associated with lower labour productivity, controlling for country and industry-specific effects.

Figure 9

Real GFCF in total machinery, equipment and weapons systems and ICT equipment in the EU and US (% of GDP)



Source: *Eurostat for the European Union, OECD National Accounts for the United States and EIB staff calculations.*
Note: *Data for the United States are in US dollars and constant prices, 2012 base year and in euro 2010 chain-linked volumes for the European Union. 'EU13' on panel b refers to the aggregates for 13 EU Member States for which there are data for ICT investment by industry. These are Austria, Belgium, Czech Republic, Estonia, Ireland, Italy, Finland, France, Lithuania, Luxembourg, the Netherlands, Slovenia and Sweden. Taken together these countries account for 53% of EU GDP.*

Box A

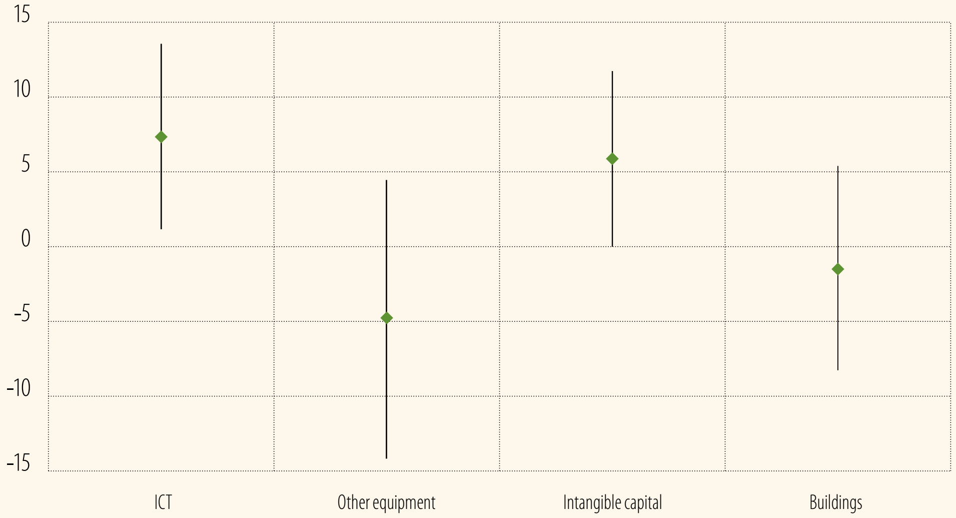
Productivity and information and communication equipment investment

Recent work by EIB economists examined how the use of different fixed capital assets affects labour productivity.[7] The study was motivated by the recent weakness of equipment investment in the European Union relative to the United States, especially in ICT. The information comes from the EU KLEMS database and includes 25 industries that make up the non-financial, non-farm business sector in 13 EU members and the United States. The resulting dataset is an unbalanced panel covering 1980 to 2015.

The study found that higher levels of ICT capital per hour worked are associated with higher labour productivity, controlling for country, sector and time-specific factors. The study estimated a Cobb-Douglas production function with labour input and four different types of capital: ICT equipment, other equipment, intangible capital and buildings.[8] Figure A.1 plots the estimated structural parameters along with a 95% confidence interval. The elasticities of labour productivity with respect to ICT equipment and intangible capital are positive and significant, highlighting the importance of the two asset types for productivity.

7 Gökce-Gökten, M. and Kolev A. (forthcoming).
8 Intangible capital here is the sum of capitalised R&D, software and databases.

Figure A.1
Estimated structural parameters



Note: *Estimated parameters α_i, i = 1,2,3,4 (circles) and 95% confidence interval (lines). The coefficient on ICT has a p-value of 0.03 and the coefficient on intangible capital has a p-value of 0.09. The remaining coefficients are not significantly different from zero at significance levels of 10 or lower.*

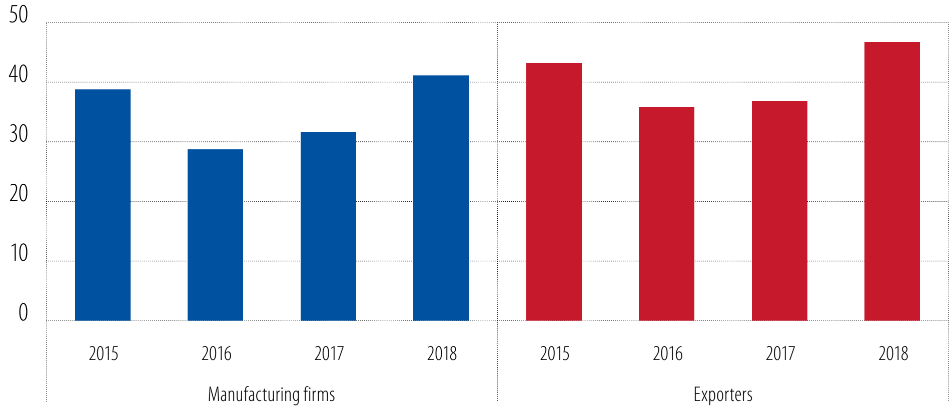
The slowdown in manufacturing production and exports did not have a material impact on investment in 2018 and early 2019. Business investment remained robust in this period despite the conspicuous slowdown of manufacturing and increased uncertainty. One possible explanation is that the share of manufacturing in total business investment is only around 20% (EU-wide) and that for exporters it is even smaller. Given that domestic demand remains strong across EU Member States, other sectors may have offset a hypothetical decline in manufacturing investment. Data from EIBIS show that the average investment rate in the EU manufacturing sector in 2018 was actually higher than in any of the three preceding years (Figure 10a), and the same is true for the investment rate of exporters.

The slowdown in investment may nevertheless materialise later in 2019 and 2020 as uncertainty mounts, international trade conflicts escalate and the economic outlook deteriorates. EIBIS data show that the share of firms that plan to reduce investment in 2019 rose for the first time in four years both for manufacturing and exporting firms (Figure 10b). Rising uncertainty due to Brexit and further escalation of international trade tensions are beginning to take their toll on investment across the European Union.[9] This may be further aggravated by a deteriorating economic, political and regulatory climate, as discussed in the next section (Figure 13).

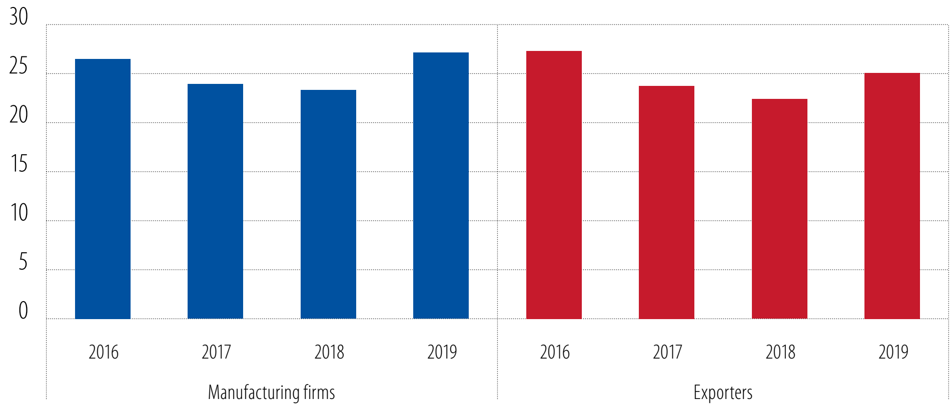
9 The next section on corporate investment further discusses the effects of uncertainty on investment and the link between perceptions about increasing uncertainty and declining external demand.

Figure 10
Investment rates and investment expectations by export status

a. Manufacturing firms (left) and exporting firms (right) (investment to total fixed assets, %)



b. Share of manufacturing firms (left) and share of exporting firms (right) planning to decrease investment in the current year (%)

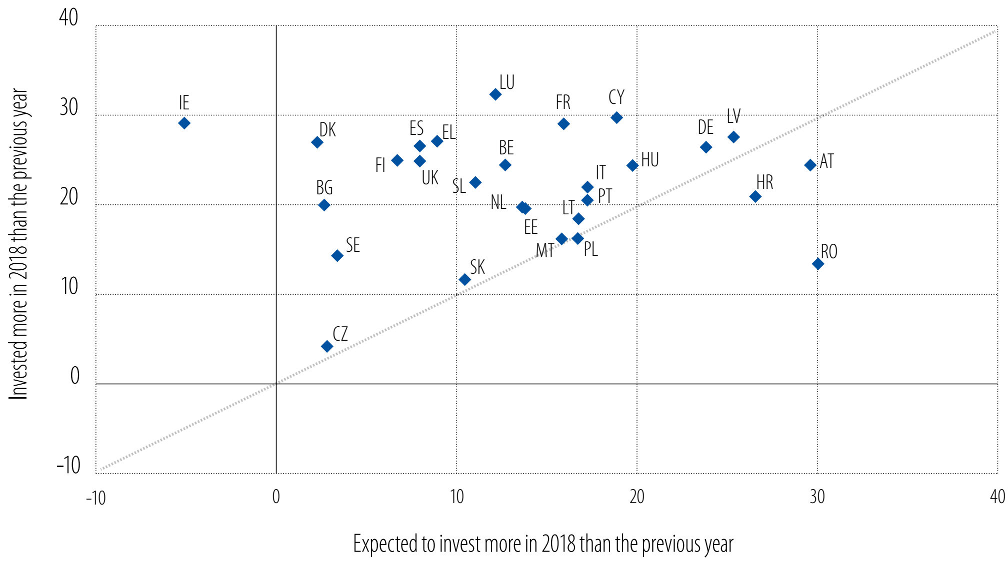


Source: *EIBIS 2016, 2017, 2018, 2019 and EIB staff calculations.*
Base: *All manufacturing firms (left) and exporting firms (right) excluding don't know/refused responses.*
Question: *Investment rates are computed as the ratio of investment to total fixed assets. These are derived from two questions, one asking about total investment spend in the last financial year and the other about the value of total fixed assets in the last financial year. Investment plans are derived from two questions: firms who had invested in the last financial year were asked if they expect to invest more, around the same amount or less than last year; and firms who had not invested in the last financial were asked if they expect to invest in the current financial year.*

Corporate investment

Firms' investment activities exceeded expectations in 2018. For a third consecutive year, firms' realised investment was above what they had expected a year earlier (Figure 11). The countries that outperformed expectations to the greatest degree were Ireland, Luxembourg, Denmark and Spain. Firms in Romania, Croatia and Austria, on the other hand, invested less than expected.

Figure 11
Correlation of expected and realised investment (net balances)



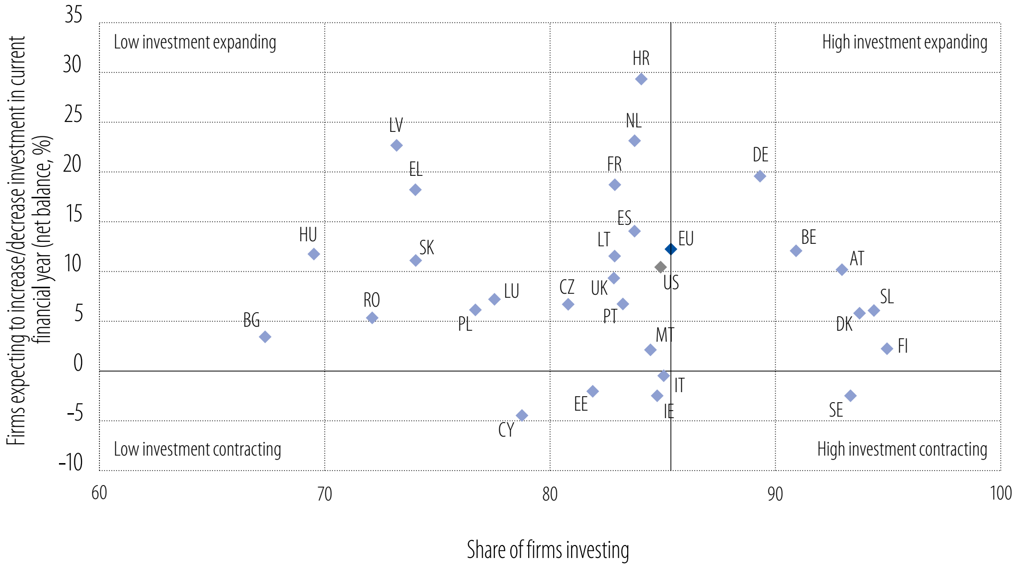
Source: *EIBIS 2018 and EIBIS 2019.*
Base: *All firms (excluding don't know/refused responses).*
Question: *Expectations are derived from two questions: firms who had invested in the last financial year were asked if they expect to invest more, around the same amount or less than last year; and firms who had not invested in the last financial were asked if they expect to invest in the current financial year. Realised investment is derived from the following question: Overall was this more, less or about the same amount of investment as in the previous year?*

For 2019, firms still have a positive investment outlook, yet less so than a year ago. The most recent EIBIS continues to place the majority of EU countries in the upper half of the investment cycle map (Figure 12a). This means that, going forward, more firms expect an expansion of their investment activities than a reduction. Compared to one year ago, firms' investment outlook has deteriorated in almost all countries (Figure 12b), with the most marked drops being seen in Cyprus, Italy and Hungary. Firms in Ireland are also rather pessimistic about their future investment activities. That said, the investment expectations of Irish firms have regularly undershot actual investment in previous waves of the EIBIS. This year, pessimism most likely reflects a cautious outlook in the context of slowing international trade and continuing Brexit negotiations.

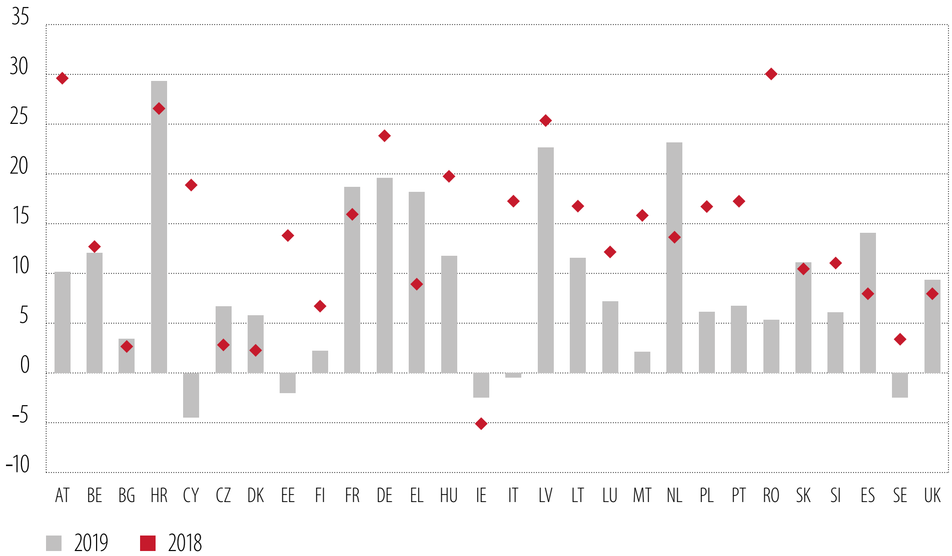
The relative deterioration of firms' investment outlook comes with expectations of a deteriorating political and regulatory environment as well as a marked deterioration of the macroeconomic climate. Firms continue to be positive about their internal cash generating capacities and access to external finance over the next 12 months, but expect the political and regulatory environment to worsen. After a downward revision of their economic outlook last year, firms adjusted their sector and macroeconomic outlook down further. For the first time since the beginning of EIBIS in 2016, the number of firms expecting a deterioration in the economic climate exceeds the number of firms expecting an improvement (Figure 13). Firms are most downbeat about the economic outlook in the United Kingdom, Finland, Sweden and Poland. Overall, larger firms, manufacturing firms and leading or innovative firms are most bearish about the economic climate going forward.

Figure 12
Corporate investment dynamics

a. Investment cycle

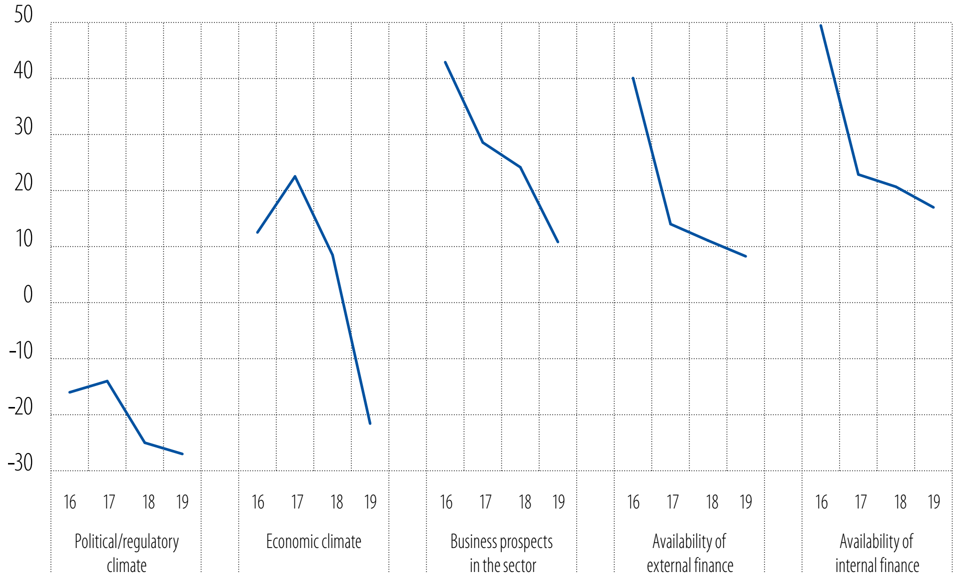


b. Share of firms expecting to increase/decrease activities in the current financial year (% net balance)



Source: *EIBIS 2018 and EIBIS 2019.*
Base: *All firms (excluding don't know/refused responses). Share of firms investing shows the percentage of firms with investment per employee greater than EUR 500. The y axis crosses the x axis at the EU average in 2016.*
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 13
Investment drivers, firms expecting an improvement/worsening (% net balance)

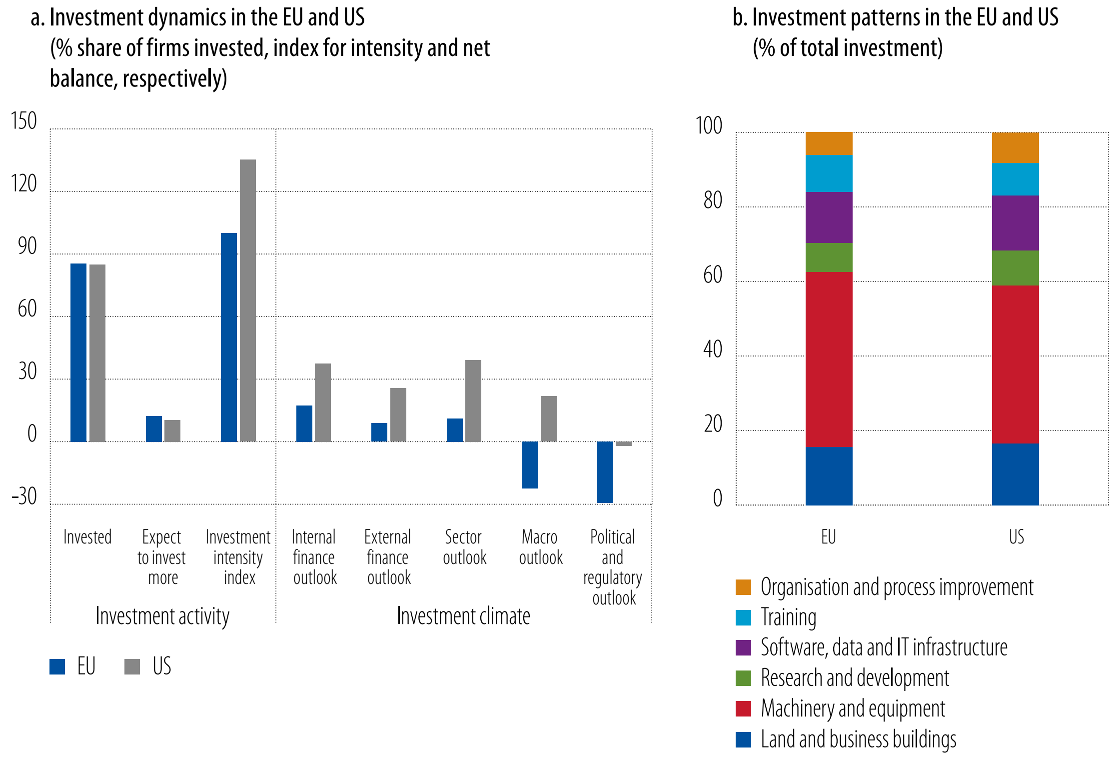


Source: EIBIS 2016, EIBIS 2017, EIBIS 2018 and EIBIS 2019.
Base: All firms (excluding don't know/refused responses).
Question: Do you think that each of the following will improve, stay the same, or get worse over the next 12 months?

As it stands, corporate investment dynamics seem more fragile in the European Union than in the United States. This year, for the first time, EIBIS also includes a sample of US firms as a benchmark for Europe. It shows a similar share of firms investing in the European Union and the United States, but a lower investment intensity (investment spending per employee) in the European Union. While about the same share of firms expect to increase their investment activities going forward, this is certainly not sufficient to close the gap in investment intensities. Furthermore, the views of US and European firms about the investment environment in the near term diverge; European firms are a lot more pessimistic about their broader economic outlook than US firms and are also more negative about the course of the political and regulatory environment in which they operate, even though US firms also expect a deterioration in this regard overall (Figure 14a).

Qualitative differences in investment activities exist between the European Union and the United States. The EIBIS data show that European firms tend to allocate a smaller share of their investment to intangible assets (Figure 14b). This is true across European regions. In the same vein, EU firms target less of their investment to the development of new products, processes and services (16% compared with 19% in the United States). Firms in the European Union also invest less in improving energy efficiency. While US firms allocate 12% of their investment spending to this purpose, in the European Union it is only 9%.

Figure 14
Corporate investment in the EU and US



Source: *EIBIS 2019.*
Base: *All firms (excluding don't know/refused responses).*
Question: *In the last 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?*
Question: *What proportion of total investment was for (a) replacing existing buildings, machinery, equipment, IT (b) expanding capacity for existing products/services (c) developing or introducing new products, processes, services?*

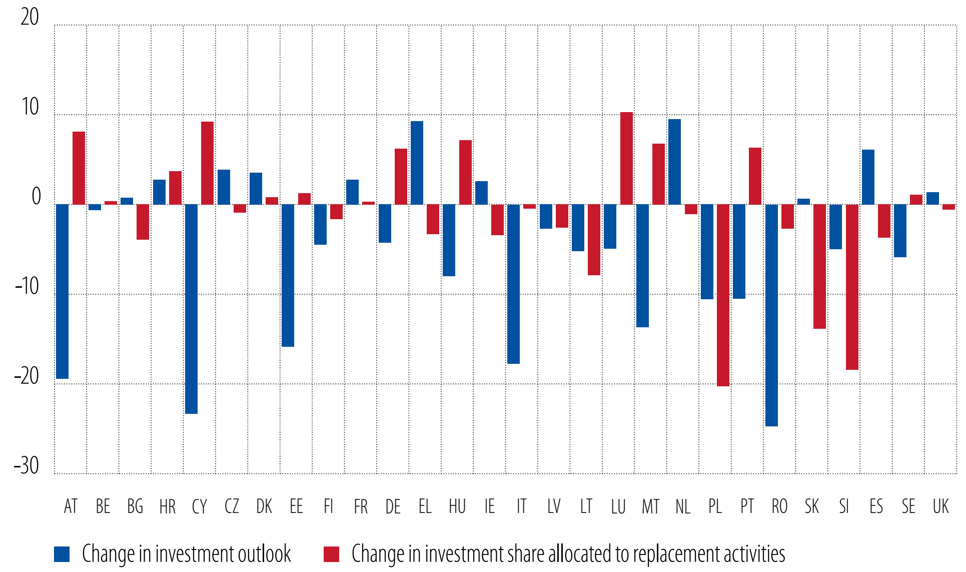
A deteriorating investment climate is a threat to Europe's competitiveness. As firms' outlook worsens, not only do they tend to invest less but they also allocate an ever larger share of their investment to replacing existing assets. The share of investment that goes to innovation and capacity expansion – both of which are key for competitiveness (EIB, 2017) – declines (Figure 15).

The evolution of robot adoption in recent years is a prime example of deteriorating European competitiveness following a diverging economic outlook. Data from the International Federation of Robotics show that Europe used to have a clear lead in robot adoption compared to the United States (Figure 16a), but this advantage has melted away over the past decade. The loss of leadership can be linked to relatively weak investment conditions in the past decade. The result is a particularly marked slowdown in robot adoption in Southern Europe – which also saw the strongest decline in investment activities. The result is confirmed by regression analysis (Figure 16b).[10]

10 Brutscher, P.B. and Ravillard, P. (forthcoming).

Figure 15

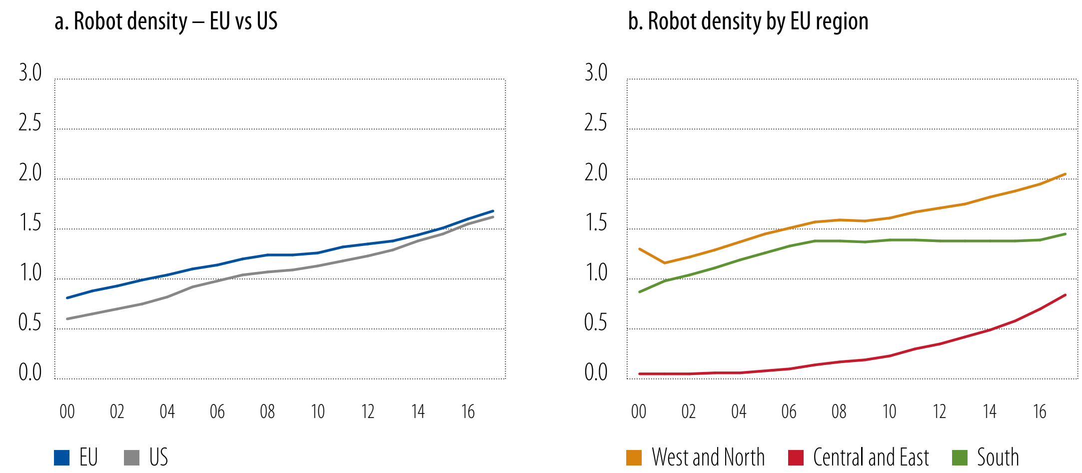
Investment outlook and investment purpose (change from previous year in percentage points)



Source: *EIBIS 2018 and EIBIS 2019.*
Base: *All firms and all firms that invested in the last financial year.*

Figure 16

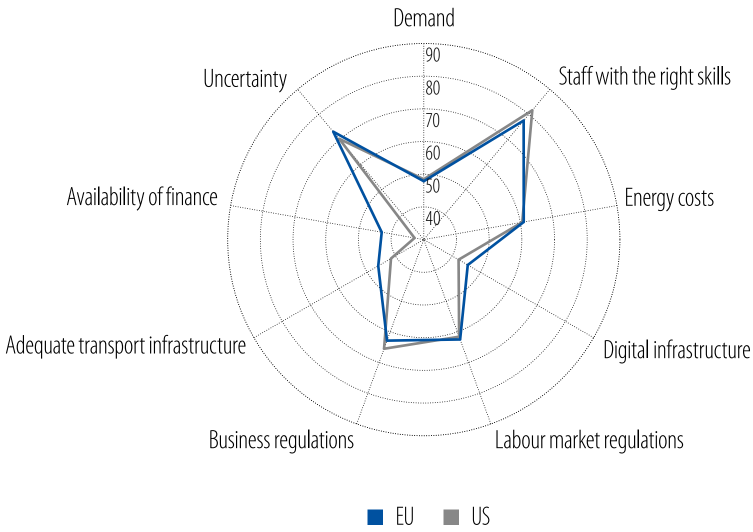
Evolution of robot adoption (robots per thousand workers)



Source: *International Federation of Robotics and Eurostat. EIB staff calculations.*

The main barriers to investment for EU businesses remain a lack of staff with the right skills and uncertainty, with 77% of firms reporting lack of staff and 73% quoting uncertainty. Business regulation and labour market regulation take third and fourth place, with 63% of firms mentioning those regulations. US firms report very much the same barriers as EU firms, while the difference between the European Union and the United States stems from access to finance and transport and digital infrastructure. These barriers are reported more frequently by EU firms, indicating their relative disadvantage in these areas. Firms active in Greece, Cyprus, Latvia and Malta are the most behind, and frequently mention all of these areas as obstacles (Figure 17).

Figure 17
Barriers to investment (% of firms)



Source: *EIBIS 2019.*
Base: *All firms (excluding don't know/refused responses).*
Question: *Thinking about your investment activities in #country#, to what extent is each of the following an obstacle? Is it a major obstacle, a minor obstacle or not an obstacle at all?*
Note: *Shares sum over minor and major obstacles.*

Frequent mentions of lack of staff with the right skills are linked to difficulties in finding new staff. A lack of staff with the right skills primarily reflects difficulties in hiring new staff, and less the concerns firms have with their existing staff (EIB, 2018). Chapter 9 of this report discusses the consequences of skill shortages in more detail.

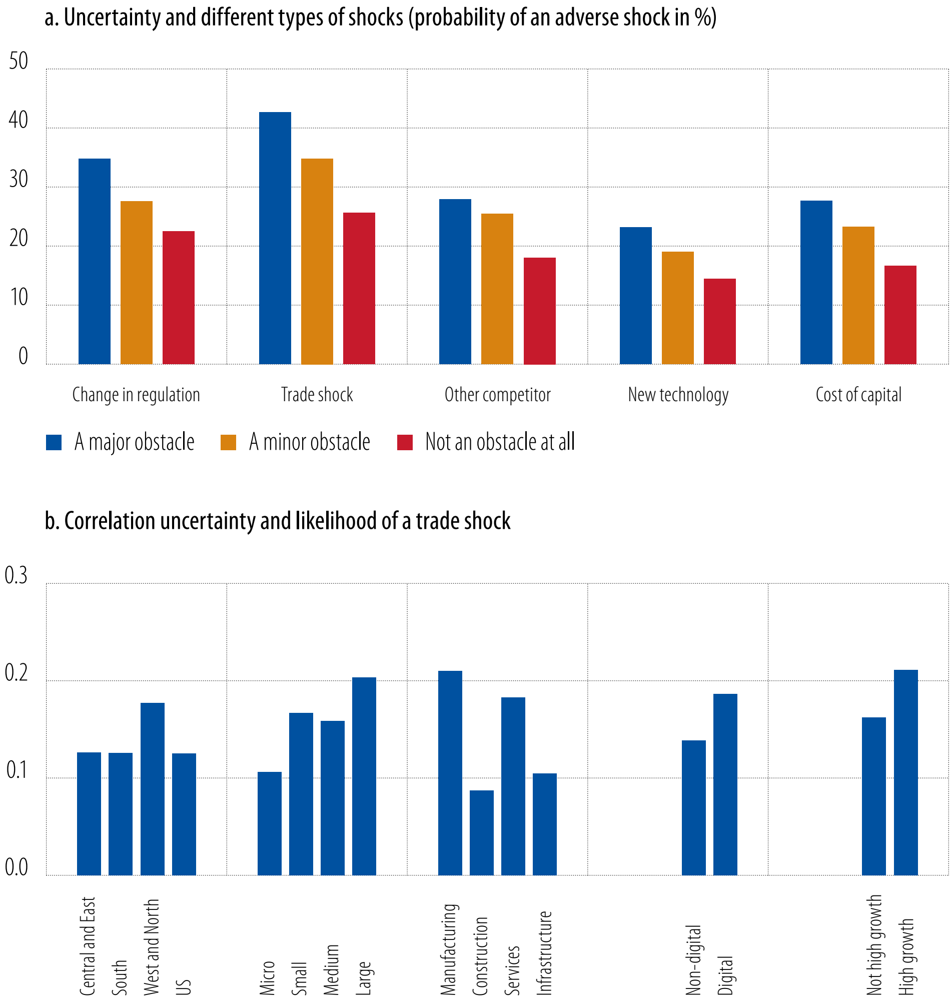
Uncertainty about the future is closely linked to fears of adverse developments that will affect external demand. In EIBIS 2019, firms were asked to estimate the probability of adverse changes in their environment. Firms gave a 30% chance to negative changes in external demand, while they said the likelihood of other adverse changes – in regulation, competition, technology or the cost of capital – was lower. Firms that considered uncertainty to be a barrier to investment attributed higher probabilities to the various negative scenarios than those that do not see uncertainty as an impediment to investment. The positive correlation between firms' pessimism about where the business environment is going and uncertainty is highest for changes in external demand; suggesting firms are particularly sensitive to this issue (Figure 19a). The correlation between uncertainty and expectations of adverse changes in their trade relations is most pronounced among firms in Western and Northern Europe, larger firms, manufacturing firms, and those that are digital and/or have recorded strong growth over the past three years (Figure 19b).

Figure 18
Barriers to investment by country

	Demand	Staff with the right skills	Energy costs	Digital infrastructure	Labour market regulation	Business regulation	Adequate transport infrastructure	Availability of finance	Uncertainty
AT	56	87	64	50	71	73	44	41	66
BE	37	82	64	40	61	62	47	33	75
BG	42	86	63	34	59	60	51	40	76
HR	55	88	76	53	74	80	47	44	83
CY	62	81	94	67	67	74	63	74	96
CZ	54	96	69	29	65	68	42	43	80
DK	34	79	33	23	36	31	24	23	60
EE	58	84	44	17	54	43	28	44	78
FI	65	80	41	21	54	54	28	36	73
FR	41	73	56	39	68	64	39	43	78
DE	43	85	62	53	61	62	44	37	58
EL	75	68	81	58	81	95	67	76	95
HU	35	69	46	19	50	33	24	31	54
IE	55	77	72	54	60	64	55	50	83
IT	53	61	61	53	75	69	60	60	98
LV	76	95	85	55	77	82	60	60	95
LT	60	80	69	41	63	59	35	48	74
LU	21	77	38	21	51	43	33	29	45
MT	63	97	70	43	58	57	66	51	68
NL	23	71	27	14	33	43	21	22	40
PL	61	91	82	47	72	66	53	64	79
PT	51	77	80	43	77	81	46	48	86
RO	51	73	68	34	72	67	75	55	83
SK	63	86	81	45	83	76	55	61	80
SI	53	85	66	31	68	63	49	38	70
ES	66	67	70	54	69	78	56	58	83
SE	39	78	47	26	39	45	32	30	70
UK	55	79	67	52	61	63	53	41	88
US	48	82	61	42	62	66	42	33	70

Source: *EIBIS 2019.*
Base: *All firms (excluding don't know/refused responses).*
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 major obstacle).*

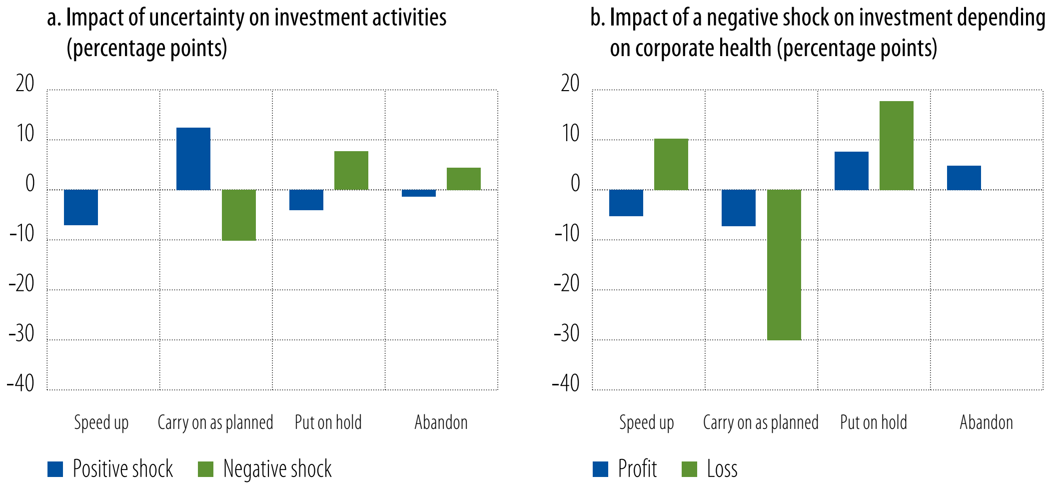
Figure 19
Uncertainty and firm priors



Source: EIBIS 2019 online module.
Base: All firms (excluding don't know/refused responses).
Question: If you were to estimate: how likely is it that the return on your project will be adversely affected by…?

Uncertainty weighs on firms' investment activities. While few people doubt that uncertainty can have negative repercussions on firms' investment activities, it is hard to demonstrate that this is the case. First of all, uncertainty is a notoriously difficult concept to measure (Baker et al., 2016). Second, even if it can be measured, it is very difficult to isolate its causal effect on firms' investment activities. To overcome these problems, EIB economists carried out an experiment where they challenged firms' expectations for a specific investment project (Box B). Their study found that a negative shock to firms' expectations led to a marked drop in the likelihood that they will carry out their investment project as planned, and an increase in the likelihood that they will either put it on hold or abandon it (Figure 20a). These effects are asymmetric, as negative shocks have a greater impact on weaker firms (Figure 20b).

Figure 20
The effect of uncertainty on investment



Source: *EIBIS 2019 online module.*
Base: *All firms (excluding don't know/refused responses).*
Note: *Panel a shows the response of firms if they are told that their project assessment was too optimistic (negative shock) or too pessimistic (positive shock). Panel b shows how the effect of a negative shock differs for firms that are profitable and firms that are not.*

Box B
Estimating the impact of uncertainty on firms' investment decisions

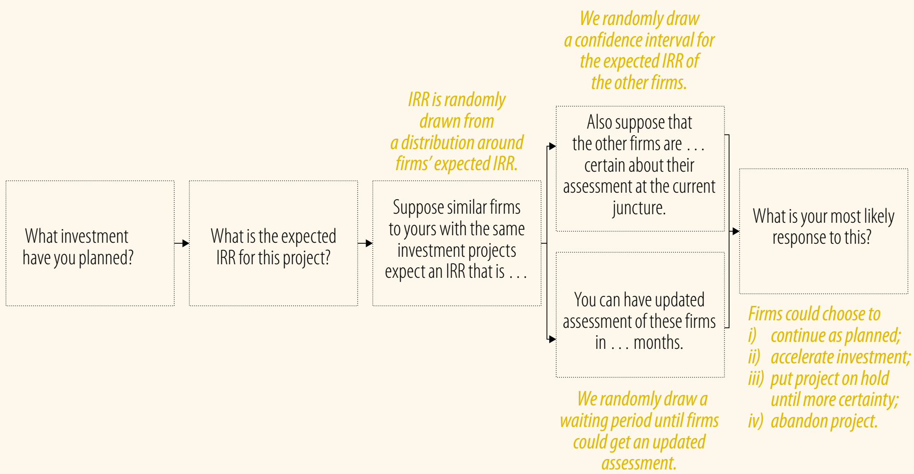
Uncertainty has become a key economic variable in recent years. Apart from a growing body of academic literature on the topic (e.g. Bloom, 2017 and Amore and Minichilli, 2018), several institutions have recently made explicit reference to uncertainty as a driver of the business cycle (e.g. in the latest forecasts from the World Bank, IMF and European Commission).

Despite this development, the empirical evidence regarding the effect of uncertainty on firms' investment activities remains limited. It is largely based on shocks to the environment in which firms operate (rather than to firms directly) as well as narrow country or sector settings.

To overcome these shortcomings, EIBIS 2019 invited firms to take part in an online follow-up. As part of this follow-up, firms were asked about their planned investment activities and expected internal rates of return (IRR). In a second step, their assumptions were challenged by providing them with information about the reported IRR of other firms with similar investment projects.

The answers of the other firms were randomly chosen so that some firms in the sample would be told (by chance) that their own assessment was over-confident and others that it was under-confident. Participants in this experiment were informed that the assessments by the other firms were not real, but were asked to still take them at face value and provide their most likely response (illustration in Figure B.1).

Figure B.1
Experimental set-up to test the effect of uncertainty on investment



Note: *The figure illustrates the flow of the experiment. At the end of the EIBIS telephone interview, all firms were invited to take part in the online module. Detailed results of the exercise will be published in a forthcoming EIB Working Paper (Brutscher, P.B., Tonev, I.D.).*

This approach has several strengths vis-à-vis other studies: first, uncertainty relates directly to firms' beliefs regarding their investment projects, rather than some broader economic or political variable. This makes it possible to quantify how individual firms are affected. Second, the shocks to firms' expectations are exogenous by design. This excludes the possibility that whatever link we identify between firms' over and under confidence and their investment decisions might be due to anything other than shock.

A third strength of this experiment is that it spans firms active across the entire European Union and all sectors covered by the EIBIS.[11] Fourth, given the rich information available on all firms that take part in the follow-up survey due to their participation in the EIBIS, the experiment enables investigations on the heterogeneity of the effect of uncertainty on investment decisions for different types of firms.

Finally, the experiment is not only designed to study the effect of uncertainty on whether firms go ahead with a certain investment project, but also allows for the possibility that they could accelerate a project or put it on hold in the light of heightened uncertainty. This is important when it comes to better understanding the link between uncertainty and pent-up investment.

The analysis of this experiment suggests that an increase in uncertainty has a major negative effect on firm investment decisions. This effect tends to be stronger when the shock is negative than when it is positive. The results also tend to be stronger the more dispersed are the assessments of the other firms.[12] Weaker firms respond more strongly to negative shocks.

Estimated quantitative effects are fairly large: a negative shock to the firms' internal rate of return by one standard deviation leads to an 8.8 percentage-point increase in the probability of the project being put on hold (i.e. a 55.5% increase) and a 4.4 percentage-point increase in the probability of the project being abandoned (a 127% increase).[13] Some of these results are illustrated in the main text.

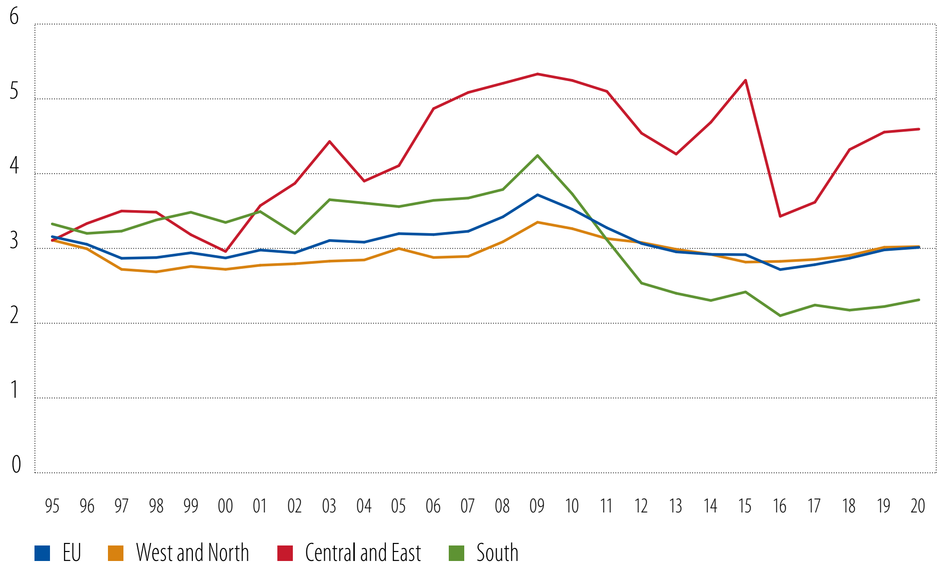
11 While participation in the online follow-up is voluntary, a comparison of survey answers between firms that took part in the follow-up and all firms in our survey shows almost no difference.
12 This is modelled by putting random confidence levels around other firms' reported IRRs.
13 More detailed results can be found in a forthcoming EIB Working Paper (Brutscher, P.B.; and Tonev, I.D.).

General government investment

General government investment in the European Union is gradually recovering after hitting a 20-year low (2.7% of GDP) in 2016. Government investment increased in 2017 (to 2.8%) and 2018 (2.9%). Despite the reversal of the negative trend that ensued after the financial crisis, government investment remains below its long-term average of 3.1% of GDP (Figure 21).[14] Southern Europe is way behind this already low rate, as high government investment in these countries before the financial crisis raised the long-term average, while the protracted period of low levels after the financial crisis is weighing on the EU average. General government investment in both Western and Northern Europe and Central and Eastern Europe is slightly above its long-term average.

The recent increase in public investment is driven by investment activities in Central and Eastern Europe and a gradual rebound in several countries in Western and Northern Europe (Figure 21). In Central and Eastern Europe, general government gross fixed capital formation increased from 3.6% of GDP in 2017 to 4.3% in 2018. Part of this increase merely reflects the beginning of a new European Structural and Investment Funds programming period (EIB, 2017). Government investment in Western and Northern Europe increased more steadily. The average investment rate in Southern Europe in 2018 was 1 percentage point of GDP lower than the long-term average: 2.2% in 2018 compared to 3.2% from 1995 to 2017.

Figure 21
Government investment by country group (% of GDP)



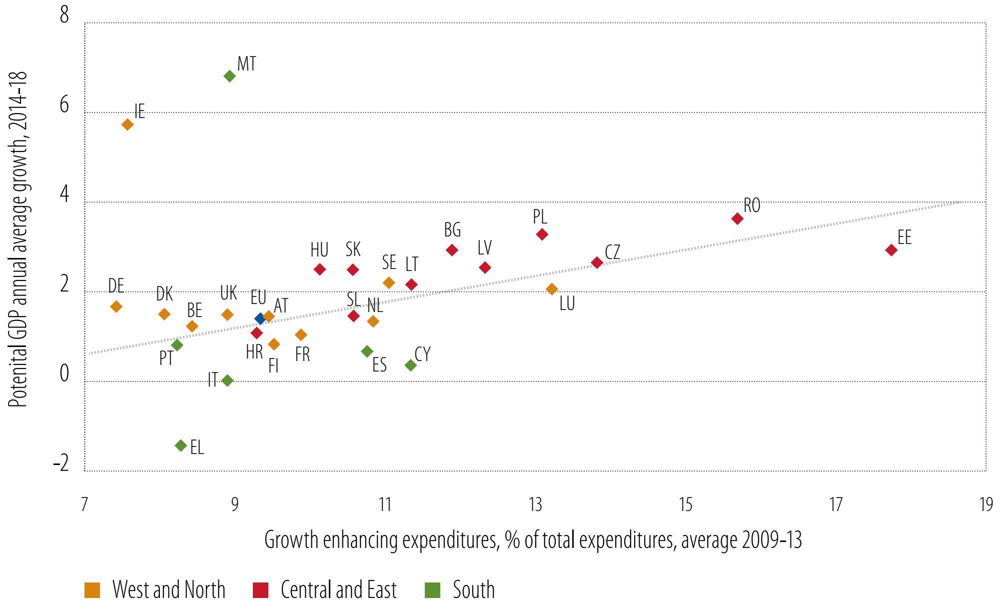
Source: *Eurostat and AMECO (European Commission).*
Note: *General government gross fixed capital formation as a percentage of GDP; forecast for 2019 and 2020. Data are missing for Croatia in 1995-2000.*

The composition of government expenditure is of prime importance (Figure 22). In addition to investment expenditures, other government expenditures (such as capital grants and R&D expenditures) enhance economic growth. In the European Union, these growth-enhancing expenditures declined from 10.3% of total expenditure in 2008 to 8.8% in 2013.[15] Countries with a more growth-oriented government

14 Average computed for 1995-2017.
15 Growth-enhancing expenditures here refer to the sum of gross fixed capital formation of the general government, capital grants and R&D expenditures (EIB, 2018).

expenditure structure (Central and Eastern European countries, for example) have recorded slightly higher potential GDP growth since 2014. However, this also reflects the more growth-oriented composition of government finances in lower-income economies and the fact that these countries are catching up with higher incomes in the rest of the European Union.

Figure 22
Growth-enhancing expenditure and annual growth of potential GDP



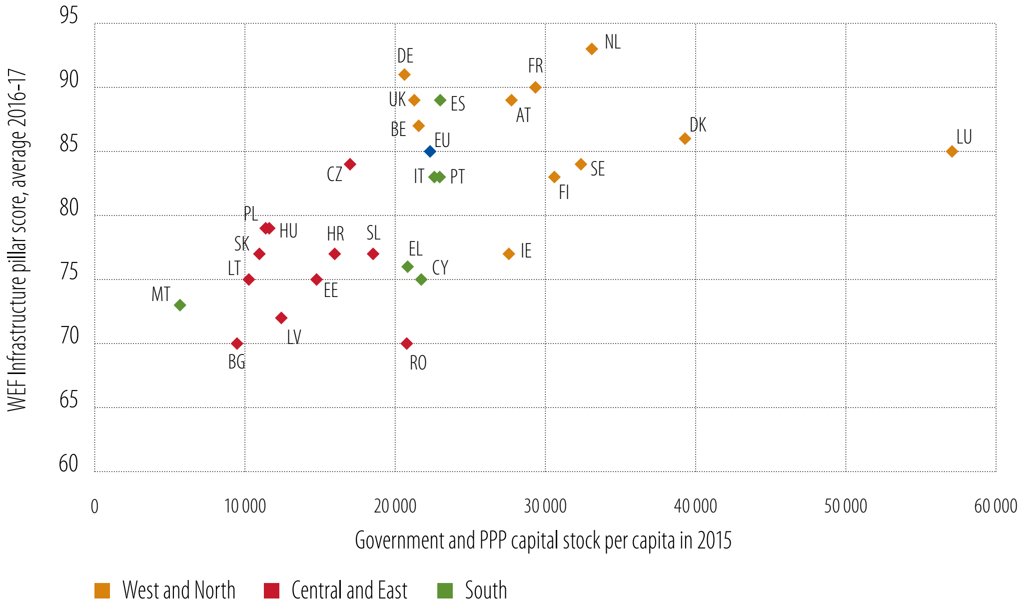
Source: *AMECO (European Commission), Eurostat.*
Note: *This chart reports the average growth-enhancing expenditure, including (i) gross fixed capital formation in all government functions; (ii) investment grants in all government functions; and (iii) total expenditure (except gross fixed capital formation and investment grants) in R&D and basic research.*

The EU budget contributes to growth-enhancing measures, too. The EU budget is of limited size when compared to the European economy and EU government budgets, representing only 0.9% of EU GDP and 1.9% of total general government expenditure in Member States. However, its magnitude in 2017 (EUR 113 billion) was more than one-fifth of total growth-enhancing expenditures carried out by governments in the European Union (EUR 526 billion), providing crucial support to investment in infrastructure, innovation, agriculture and the environment, in particular in cohesion countries.

Capital stock accumulation grew slowly, except in Central and Eastern Europe. In the European Union, the growth of government capital stock, including the stock resulting from public private partnership (PPP) projects, halved in 2010-2015 (4.5%) compared to 2005-2009 (9.1%). On a per capita basis, capital stock accumulation nearly stalled in Southern Europe at an average of 0.4% in 2010-2015. It grew slowly in Western and Northern Europe (1.4%) and increased substantially in Central and Eastern Europe (16.1%), with low capital levels in these countries behind the rapid growth. The slow increase in government capital stock accumulation after the crisis has accompanied a decline in perceived infrastructure quality in Europe, as reported by the World Economic Forum (WEF).

Levels of government capital stock per capita, including public-private partnerships, are correlated with infrastructure quality, although the large quality gaps among countries with similar levels of capital stock suggest that efficient spending is also crucial for quality. (Figure 23).

Figure 23
Quality of infrastructure and government capital stock per capita

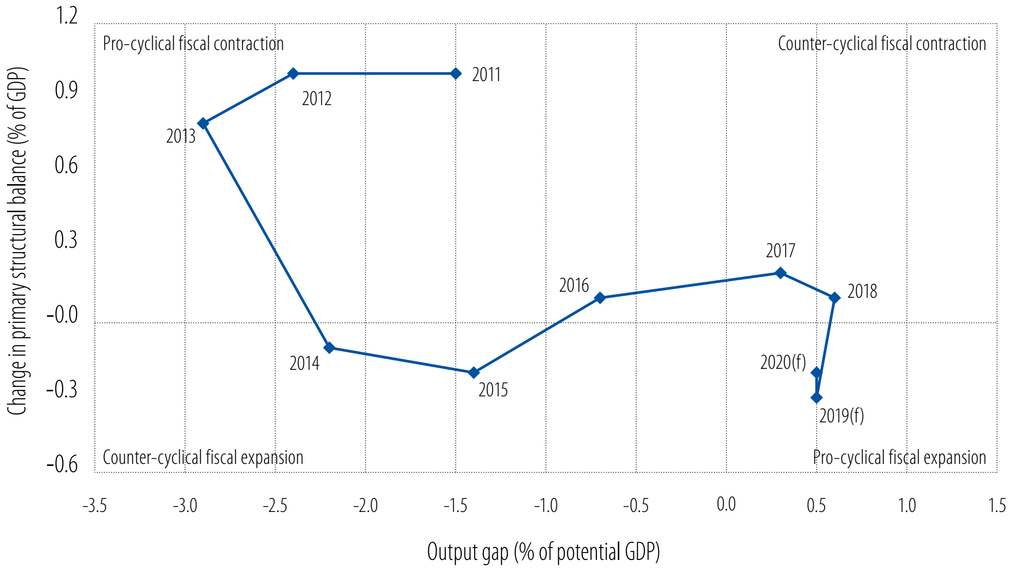


Source: *IMF, World Economic Forum.*
Note: *This chart reports the average score of the infrastructure pillar for the WEF Global Competitiveness Index in 2016 and 2017 and public and PPP capital stock per capita in 2015 in 2011 (in International USD to reflect purchasing power).*

The anticipated fiscal expansion will not trigger a pick-up in public investment. In recent years, the fiscal stance of the European Union has been broadly neutral: yearly changes of the structural primary balance in 2014-18 are close to or below 0.2% of GDP. In 2018, the structural primary surplus increased by 0.1 percentage points to 1% of GDP, which amounted to a mild fiscal contraction. In 2019, however, the structural primary surplus is expected to decline to 0.7% of GDP, with a (pro-cyclical) fiscal expansion. European Commission fiscal forecasts suggest that, despite the positive fiscal outlook, public investment will increase only slightly in 2019 and 2020 (to 3% of GDP).

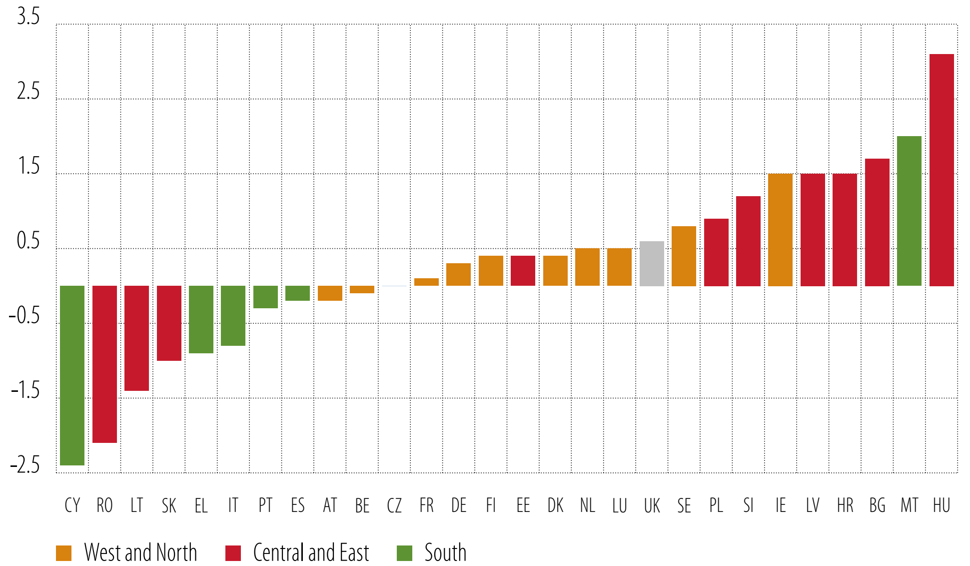
Government investment is gradually regaining its importance in national budgets (Figure 25). In 2019 and 2020, capital spending will account for a larger share of government budgets in most EU countries compared to 2015-2018, in particular in Hungary, Malta and Bulgaria. However, the general re-prioritisation of government expenditures towards investment is very slow. Government investment as a percentage of current expenditure in the European Union is expected to remain almost stable in 2019 and to increase only marginally in 2020, suggesting no drastic change in the composition between current outlays and gross fixed capital formation.

Figure 24
Fiscal stance in the European Union



Source: *AMECO (European Commission).*
Note: *Output gap as difference between actual and potential gross domestic product. Forecasts for 2019 and 2020.*

Figure 25
Capital expenditure as a % of current expenditure, change of average 2019-2020 relative to average 2015-2018 (percentage points)



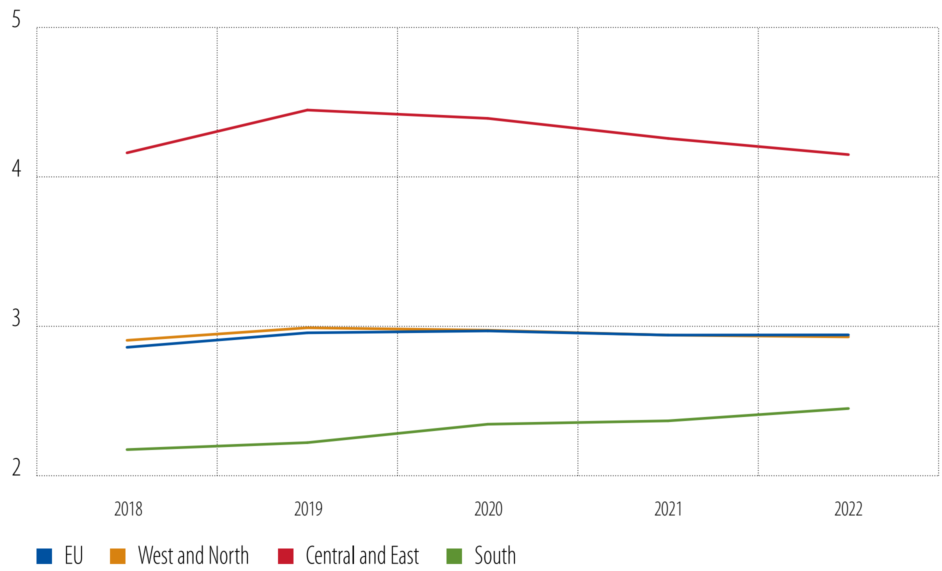
Source: *AMECO (European Commission).*
Note: *Forecast for 2019 and 2020.*

From a medium-term perspective, government investment is projected to remain below its long-term average. The Stability and Convergence Programmes submitted during the 2019 European Semester show a steady outlook for government investment in the medium term.[16,17] Budgetary plans report aggregate government investment of around 2.9% to 3% of GDP in Europe in 2019-2022, below the long-term average of 3.2%.

Southern European countries will witness an increase in public investment in the medium term (Figure 26). In these countries, investment will increase from 2.2% in 2019 to 2.5% of GDP in 2022. Central and Eastern European countries, on the other hand, are expecting a reduction of public investment from 4.4% of GDP in 2019 to 4.1% in 2022. Consequently, the overall dispersion of public investment levels among European countries will narrow significantly.

Figure 26

Gross fixed capital formation of the general government in the European Union (% of GDP)



Source: *2019 Stability and Convergence Programmes.*

The past 20 years may not be the best guide for current investment needs. Assuming that current government investment needs are not very different from the average over the past 20 years, it can be concluded that investment gaps exist mostly in Southern Europe. This report, however, provides evidence that investment needs may be higher due to structural changes. Addressing large investment needs in infrastructure (Chapter 2 in this report), climate (Chapter 4), and digitisation and innovation (Chapter 3) should be a policy priority if the European Union is to remain at the forefront of the global economy.

Current very low interest rates, along with a slowing economy, make it an ideal time to address large government investment gaps, at least in countries that can afford it. There is a large body of academic literature on the positive effects of government investment on demand and long-term growth (Jong-A-Pin and De Haan, 2008; Pereira and Andraz, 2013; and Bom and Ligthart, 2014). Within this literature, several studies find that debt-financed investment may have further positive effects on short-term demand in countries with sufficient resources, especially if accompanied by accommodative monetary

16 Stability and Convergence Programmes. Every April, the EU Member States are required to lay out their fiscal plans for the next three years. This exercise is based on economic governance rules in the Stability and Growth Pact, which aim to prevent the emergence or exacerbation of fiscal difficulties.

17 The European Semester is a cycle of economic and fiscal policy coordination within the European Union. It is part of the European Union's economic governance framework. Its focus is on the six-month period from the beginning of each year, hence its name, the 'semester'.

policy (IMF, 2014 and De Jong et al., 2017). With interest rates currently below the rate of GDP growth and projected to stay low for some time, moderate debt-financed investment by governments should not have a material impact on government debt to GDP ratios and should increase long-term growth. Ultimately, however, the long-term effects of government investment depend on its effectiveness and the productivity of government capital (also emphasised in Blanchard, 2019).

Inequality and economic growth in the European Union

Globalisation, skill-biased technological change and the rise of the knowledge economy with its focus on intangible investments have driven economic growth in the European Union and around the world. Higher growth has made the majority of people better off, but at the same time the benefits of this higher growth are distributed very unevenly. A disproportionately large share of it has gone to the super-rich, while poorer people have received a relatively small share, if at all. This uneven distribution creates tensions in societies, especially in those where social mobility is relatively low and equality of opportunity is not always guaranteed. Such tensions threaten to reduce technological progress, the competitiveness of firms, international trade and economic openness. Understanding income inequality and addressing its consequences are therefore of the utmost importance for investment and economic growth. The aim of this section is to provide a broad characterisation of inequality in the European Union, considering interpersonal inequality, spatial inequality and equality of opportunity through social mobility.

Income inequality between individuals

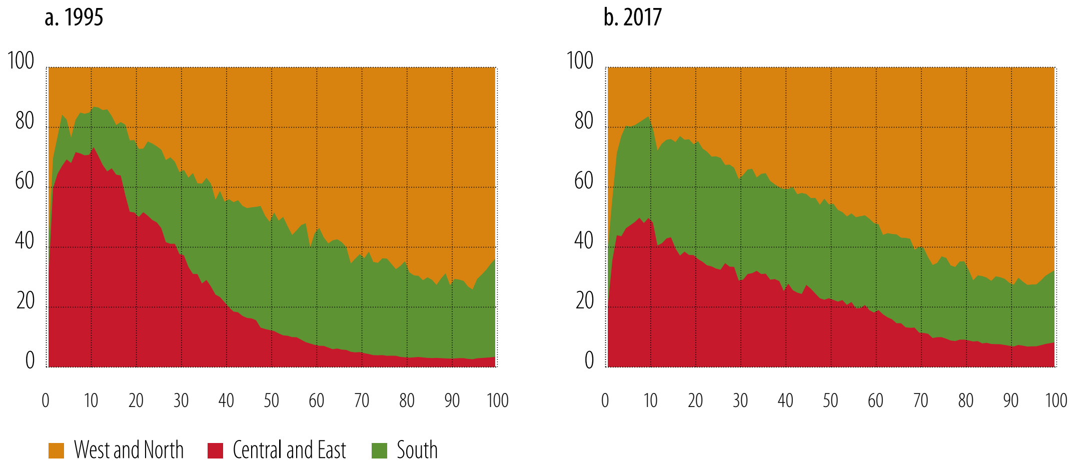
Real GDP per capita in the European Union grew around 40% from 1995 to 2018. This growth is not evenly shared. Pre-tax incomes in the bottom 10% of the EU income distribution increased only 16% over this period, i.e. an average of 0.7% per year. The pre-tax incomes of the top 1%, in contrast, increased 50% or nearly 2% per year, on average. Outcomes differ within different countries in the European Union, but the general trend does not change – top earners increased their incomes more than the bottom ones.

There have been several notable changes to EU-wide income distribution since 1995. In a fictional world where all Member States of the European Union had exactly the same income distributions, Figure 27 would have been composed of three rectangles with heights that are equal to the share of the population of each country group in the EU total. Flatter curves in the figure would therefore translate into more similar income distributions. Based on this observation, there are three notable developments. The income distributions in Southern and Central and Eastern Europe have become more similar, while the distribution in Western and Northern Europe remained broadly constant across percentiles. The direct consequence is that the share of Southern European residents in the lowest quartile of the distribution increased, compensating for the decline of the share of Central and Eastern Europe.[18] The reverse occurred between the 40 and 80 percentile. This means that, at an EU level, the decline in incomes in Southern Europe offset the rise in incomes in Central and Eastern Europe.[19]

18 The lowest quartile here refers to the lowest 25% of the income distribution.

19 The caveat is that this conclusion is based on pre-tax incomes rather than on disposable incomes. Redistribution in Southern Europe appears to be higher than in Central and Eastern Europe (Figure 31), and this may reduce the impact of divergent trends in pre-tax incomes as evidenced in Figure 27.

Figure 27
Geography of EU income inequality, 1995-2016



Source: World Inequality Database.

Income inequality trends in the European Union are not in line with the targets set by the Sustainable Development Goals (SDG). Goal 10 aims to reduce inequality within and among countries in ten different areas. Among them, goal 10.1 sets a measurable target for the growth rate of household expenditure/ income per capita. By 2030, the income of the bottom 40% of the population should grow at a higher rate than the national average.

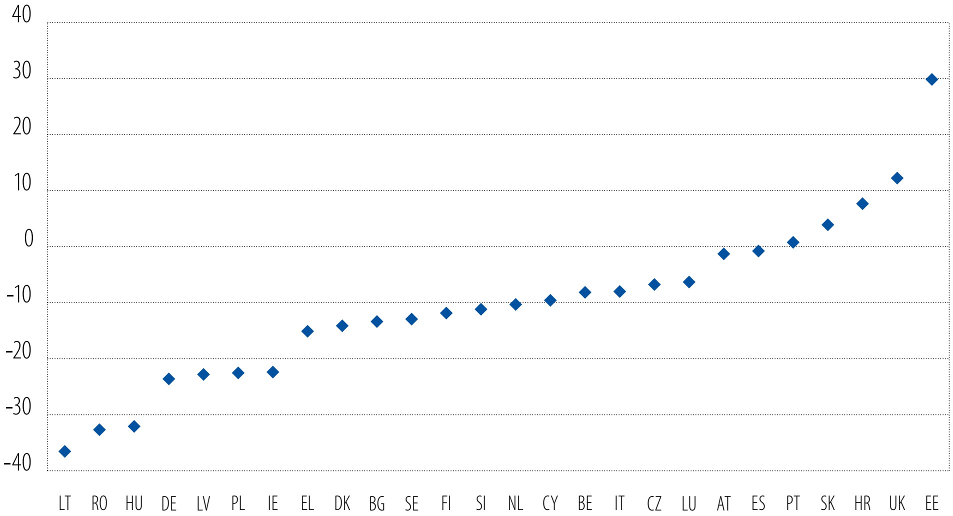
In contrast to SDG 10, in most EU countries, the average income of the bottom 50% of the income distribution grew less from 1995 to 2016 than average total national income (Figure 28). Put differently, incomes in the upper half of the distribution grew faster than incomes in the lower half, increasing income inequality. In some cases, the growth differential exceeds 20 percentage points, which is substantial. The divergence within country groups is another remarkable feature. It is common wisdom that inequality increased significantly in countries in Central and Eastern Europe because they started the early 1990s with very equal income distributions. Indeed, most countries from this region have experienced record increases in income inequality. Still, in Slovakia, Croatia and Estonia, incomes from the lower half of the distribution grew faster than those in the upper half.

From 1995 to 2016, income growth was distributed very unevenly in every EU region (Figure 29). In all three regional groups, incomes in the top 1 percentile of the distribution grew substantially more than those in the bottom 10% over the 21-year period, with a difference of 15 percentage points for Southern Europe, 22 percentage points for Western and Northern Europe, and 36 percentage points for Central and Eastern Europe. These gaps did not open steadily over time and there are three periods with distinct patterns, as noted in Blanchet et al. (2019), who studied European inequality since 1980 [20] and made a distinction between the period before and after 2000. In the two decades before 2000, the average income of the bottom 50% grew significantly slower than that of the top 10%. Following 2000, however, both periods before and after the financial crisis were associated with stagnating or moderately declining income inequality. This was not enough to reverse the gains before 2000, though.

20 In addition to EU members, countries include Switzerland and some countries from the Western Balkans.

Figure 28

Growth of the bottom 50% of the pre-tax income distribution compared to the growth of national pre-tax average income (percentage points)



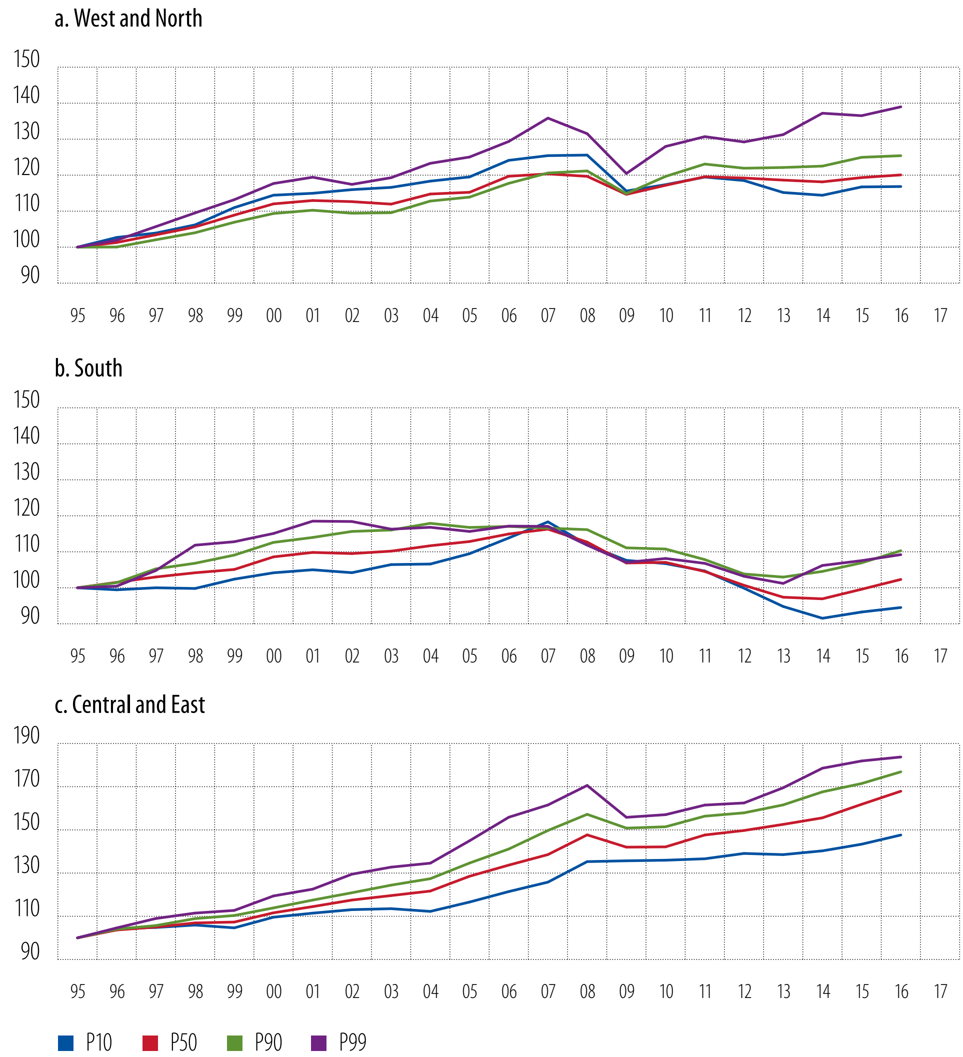
Source: World Inequality Database.

The financial crisis affected lower-income groups more, especially in countries in Southern Europe. Central and Eastern Europe bounced back first, followed by Western and Northern Europe. Countries in Southern Europe were the last to recover as the effects of the financial crisis were particularly strong. As a result, the rise of the median income in these countries, which had been growing since 1995, was practically wiped out. Worse, the bottom 10% still has not returned to the 1995 level. In Central and Eastern Europe, the bottom 10% has stagnated since 2009. In Western and Northern Europe, incomes below the top 10% of the distribution stagnated.

Growing income inequalities put pressure on people in the lowest income group. In 2004, the bottom 20% of income earners were more than three times likely to be deprived in one or two out of three poverty-related categories, e.g. living in a household without enough work, than the average earner in any of the EU country groups (Figure 30).[21] The risk of such deprivation remained stable or only slightly improved by 2018. These findings indicate that between-country convergence based on average income would not be sufficient to significantly reduce inequalities between citizens with different positions in the income distribution.

21 The categories are: severe material deprivation, at risk of poverty or living in a household with low work intensity.

Figure 29
Pre-tax income at different percentiles of the income distribution by country group
(index 1995=100)

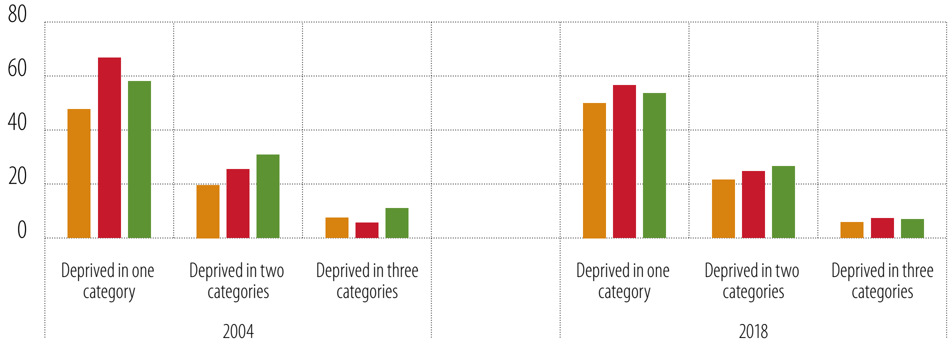


Source: *World Inequality Database.*

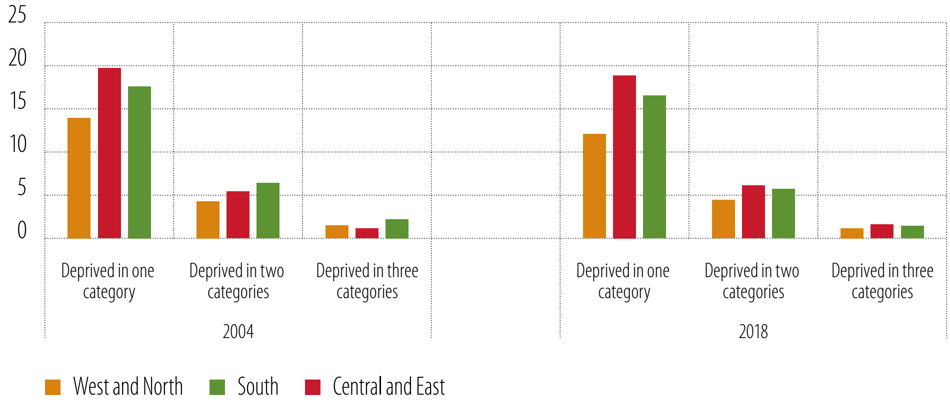
Europe's income redistribution significantly flattens income inequality. Blanchet et al. (2019) show that in 2017, the ratio of incomes in the top 10% of the income distribution to the bottom 50% was 23% higher for pre-tax income than for post-tax income in Southern and in Northern Europe (Figure 31). In Western Europe redistribution reduces this ratio by 29%, while in Central and Eastern Europe the ratio declines by just 15%. The redistribution of incomes through taxes and transfers was therefore highest in Western Europe and lowest in Central and Eastern Europe.

Figure 30
Risk of poverty and social exclusion

a. People in the lowest 20% at risk of poverty, severe material deprivation or living in a household with low work intensity (% of total)

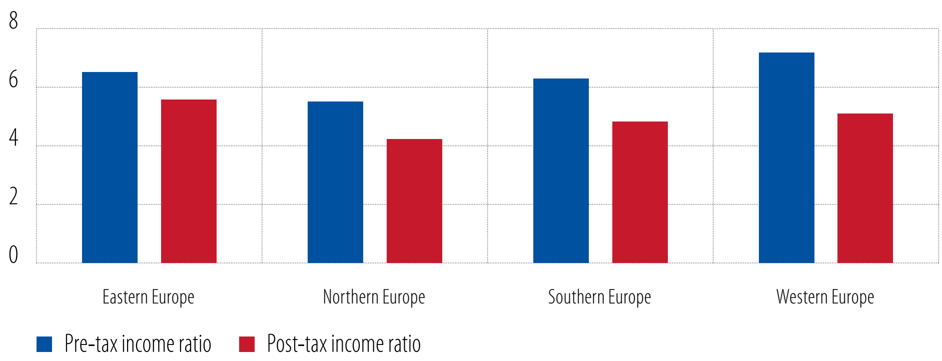


b. People at risk of poverty, severe material deprivation or living in a household with low work intensity (% of total)



Source: *Eurostat*
Note: *The first quintile group represents 20% of the population with the lowest income, and the fifth quintile group represents the 20% of the population with the highest income (an income greater than the fourth cut-off value).*

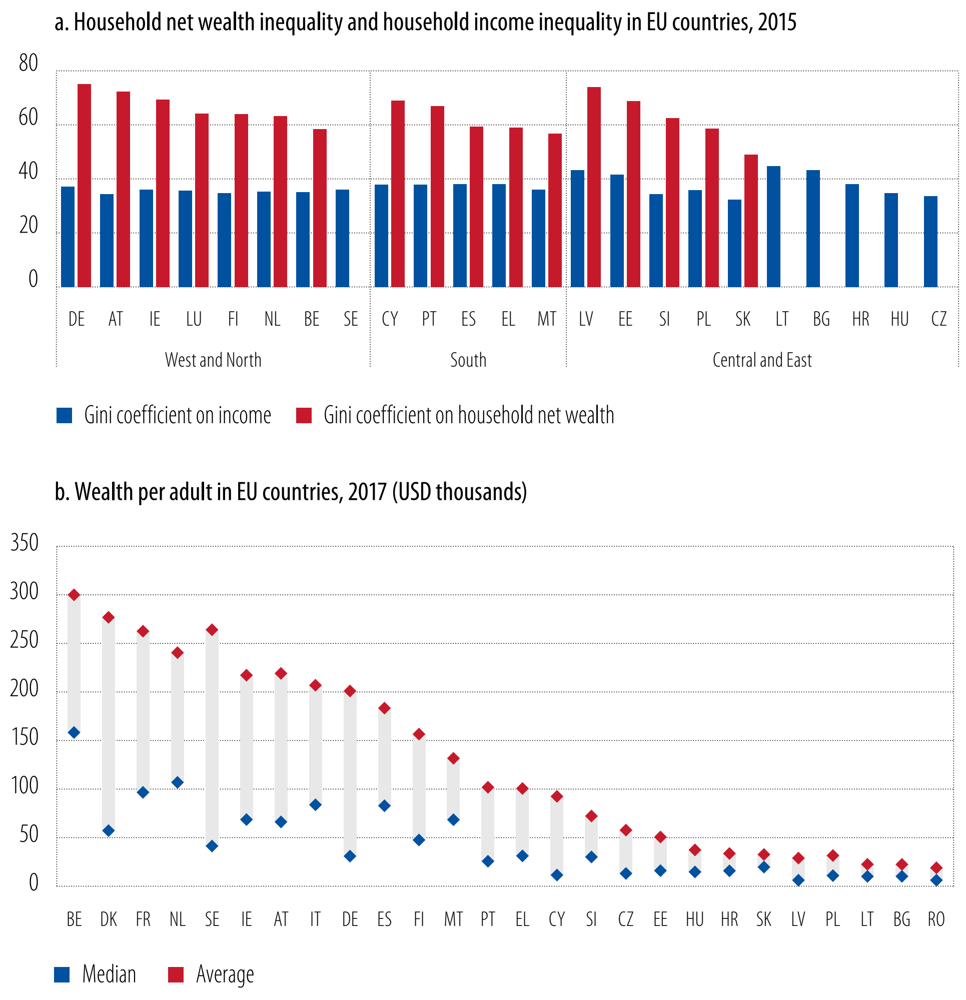
Figure 31
Ratio of the top 10% to the bottom 50% of the income distribution before and after taxes and transfers



Source: *Blanchet et al. (2019). In 2017, the top 10% earned 7.2 times more on average than the bottom 50% before taxes and transfers, and 5.1 times more after taxes and transfers. See www.wid.world/europe2019 for data series and technical details.*

Wealth inequality is significantly higher than income inequality in the European Union (Figure 32a). Using Household Finance and Consumption Survey data, Iara (2015) found that the wealthiest 10% of households hold 50% of total wealth while the bottom two deciles own a little over 3%.[22] The Global Wealth Report (2018) confirms high wealth inequality in EU Member States by comparing average and median wealth. Higher average than median wealth means that the distribution of wealth is tilted towards the higher levels, meaning that the small group at the top of the wealth distribution holds a disproportionately high share of total wealth. Indeed, average wealth exceeds median wealth in all EU members. Moreover, in some countries like Sweden, Denmark and Germany, it can be more than five times as high (Figure 32b).

Figure 32
Wealth inequality is higher than income inequality



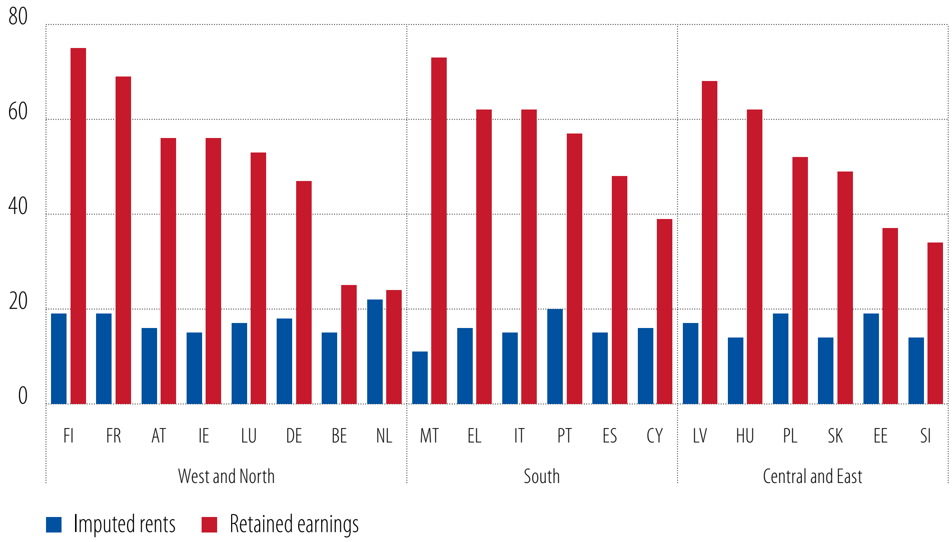
Source: Eurostat and Credit Suisse – The Global Wealth Report 2018.

Rising wealth inequality breeds more income inequality as wealth also generates income for its holders. A significant share of top 10% pre-tax income is derived from returns on assets – real estate and equity. Although most redistribution policies focus more on incomes than on wealth, wealth provides a significant share of the income of richer Europeans. In all EU countries, earners in the top 10% receive

22 Eurosystem Household Finance and Consumption Survey, 2010.

more imputed rent (from owning real estate) than they should for their percentage of the population, while their share in the retained earnings of corporations is more than five times (Figure 33).

Figure 33
Share of imputed rents and retained earnings accruing to earners in the top 10% of the income distribution



Source: *World Inequality Database and European Union Statistics on Income and Living Conditions.*
Note: *The top 10% pre-tax income earners (excluding both imputed rents and retained earnings) in Austria have earned 16% of all imputed rents in the economy. They have also earned 56% of retained corporate earnings.*

Spatial inequality

The spatial distribution of income within countries and across regions is an important determinant of social cohesion.[23] Technological progress and innovation concentrate economic activity in large cities and metropolitan regions. Cities offer better-paid jobs and more opportunities for career development. The resulting agglomeration increases prosperity in capital cities and large metropolitan regions but causes a relative decline elsewhere, putting pressure on social cohesion within countries (Rodgríguez-Pose, 2018).

Regional income inequality in the European Union declined until the financial crisis, rose sharply in the aftermath and has been gradually returning to pre-crisis levels.[24] The variation in regional GDP per capita declined steadily until the financial crisis (Figure 34a), with regions in Central and Eastern Europe accounting for most of this decline. The variation in GDP per capita in EU regions, excluding Central and Eastern Europe, declined very little, however (Figure 34b). The relative differences in EU regions increased sharply after the financial crisis, but have been gradually returning to pre-crisis levels since the beginning of the economic recovery in 2013. Once again, most of this decline was in Central and Eastern Europe (Figure 34). Variation in disposable income, which takes redistribution into account and measures incomes more directly, follows a similar pattern but has declined faster over the past 20 years.[25]

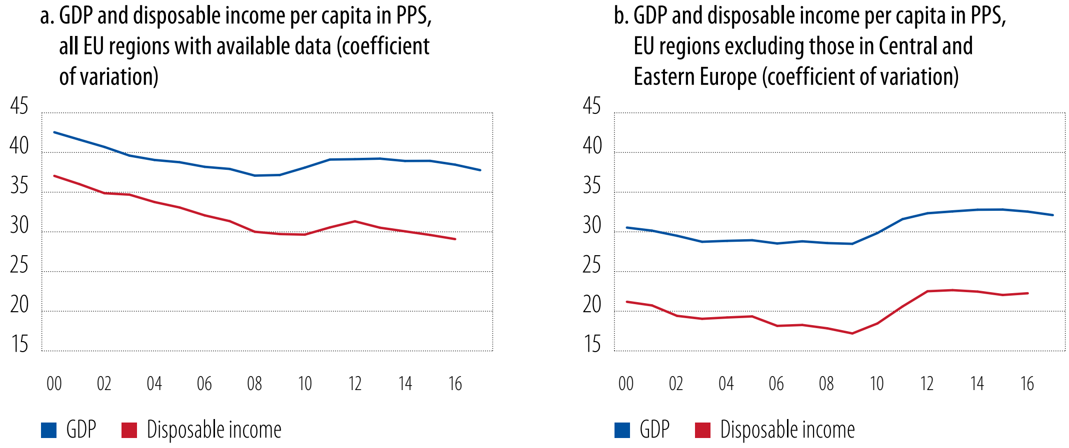
23 Regional cohesion is a major European policy objective. Almost one-third of the total EU budget for 2014-2020 was earmarked for regional cohesion policy.

24 A common measure for studying the spatial distribution of income in the European Union is regional GDP per capita, adjusted for differences in price levels across countries. For this purpose, GDP is measured in an artificial currency unit called purchasing power standard (PPS). A unit of income measured in PPS buys the same amount of goods and services in every country.

25 The two measures differ due to three main factors. First, cross-regional commuters contribute to GDP in the region they work, but to disposable income in the region where they live. Second, residents need not be shareholders in the businesses operating in a region and therefore some of the income generated leaves and some is received from economic activity in other regions. Finally, redistribution through taxes and transfers also drives a wedge between regional GDP and regional disposable income.

Figure 34

Regional inequality in the European Union measured by the coefficient of variation of GDP per capita in purchasing power standard (PPS) and disposable income per capita in PPS

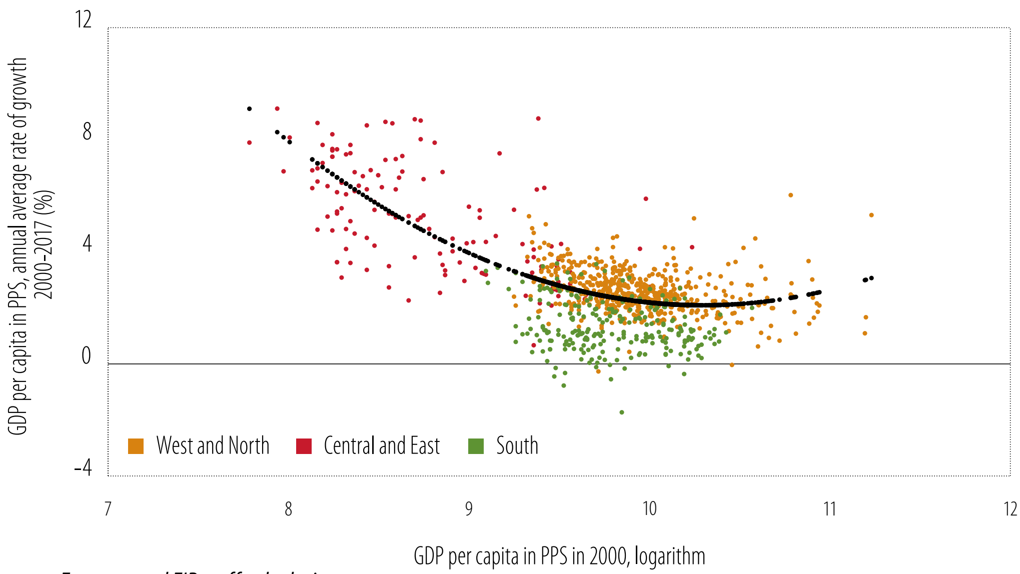


Source: *Eurostat and EIB staff calculations.*
Note: *Data for France, Lithuania, the Netherlands and Poland are missing. Calculations in panel a are based on NUTS2 regions, while panel b is based on NUTS3. The dash line in panel b is a second-order polynomial regression.*

The financial crisis has accentuated the relative decline of regional incomes in the middle of the regional income distribution (Figure 35). While poor regions and a few very rich regions in the European Union have grown very quickly over the past 20 years, many regions in the middle of the regional income distribution have stagnated. In a recent paper (Roses and Wolf, 2018), these laggard regions are characterised as "industrial losers." They developed quickly in the past through heavy industry and mining and prospered up until the early 1970s. Since then, they have started a gradual decline in relative incomes as new globalisation forces eroded the competitiveness of their firms. The financial crisis accentuated this relative decline.

Figure 35

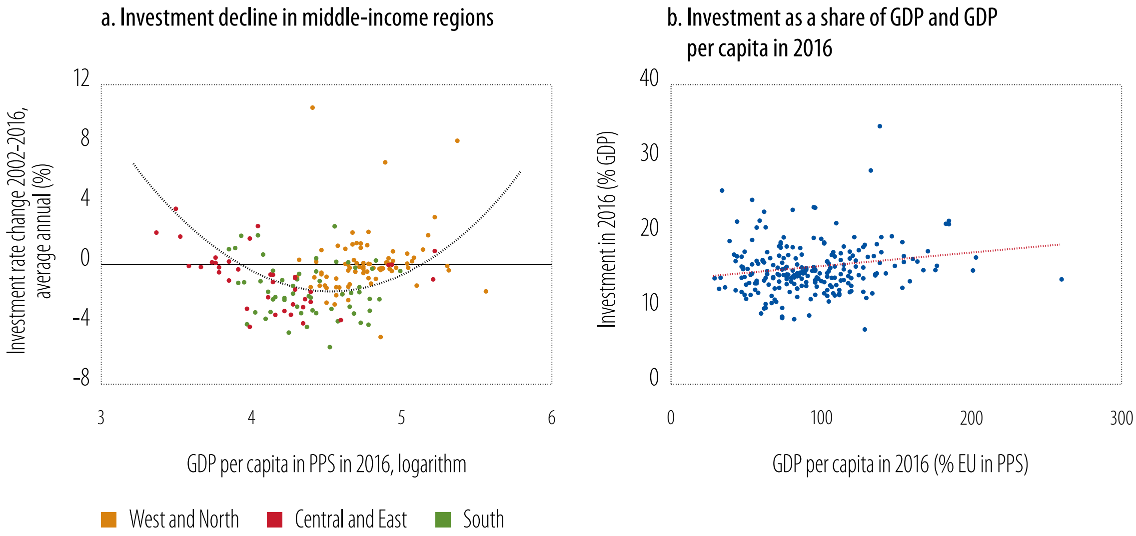
Convergence of EU regions, measured by GDP per capita in PPS



Source: *Eurostat and EIB staff calculations.*
Note: *Data are for NUTS3 regions in PPS per capita. No data for France, the Netherlands, Poland and Lithuania. The black line plots a quadratic polynomial regression.*

The relative decline in GDP per capita in these regions coincides with declining investment rates. Poorer regions need higher investment rates to ensure that they are able to close the gap with richer ones. This was broadly the case before 2008, but the relationship changed after the financial crisis when investment as a share of GDP in poorer regions fell below that of richer regions, at least on average (Figure 36b). Furthermore, richer regions increased investment rates relative to the early 2000s, signalling a continuing rise in regional inequality.

Figure 36
Investment rates and GDP per capita



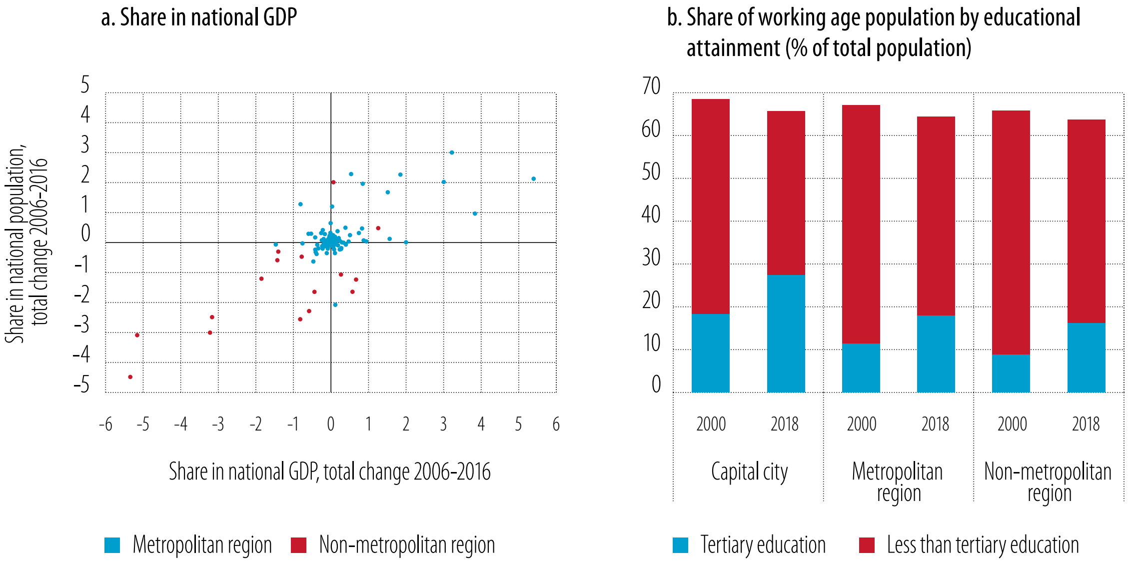
Source: *Eurostat and EIB staff calculations.*
Note: *Data for France, Lithuania, Netherlands and Poland are missing. Calculations are based on NUTS2 regions. The dash line in panel a is a second-order polynomial regression. The dash line in panel b is a linear regression line.*

Government investment also appears weaker in less well-off regions, except in Central and Eastern Europe. Chapter 2 of this report and EIB (2017, 2018) argue that government investment is not sufficient in areas in relative decline. While decreasing populations and economic activity may justify the lack of investment, that dearth also reduces the economic potential of these regions and fosters further economic decline.

The new economy, which is based on knowledge-intensive industries and the accumulation of intangible capital, gave fresh impetus to already very successful areas within the European Union, but also created some newly successful regions. High-technology and knowledge-intensive industries cluster in big cities and agglomerations and concentrate high-skilled, non-routine and creative jobs there, attracting highly skilled workers (Storper, 2018). As a result, many large cities and metropolitan regions have significantly increased their share of the national working age population and national economic activity, mostly at the expense of other regions (Figure 37a).[26] In addition, capital cities have seen the largest increase in their share of the highly educated workforce and overall shares of working age populations. Their share is well above the average in other metropolitan regions and regions without big cities (Figure 37b).[27] The financial crisis spurred the relative rise of cities and metropolitan regions as knowledge and industries based on intangible assets proved more robust and bounced back more quickly.

26 Eurostat defines metropolitan regions as NUTS3 regions or a combination of NUTS3 regions, which represent agglomerations of at least 250 000 inhabitants.
27 The height of the bars in Figure 37a shows the share of the working age population in the total population.

Figure 37
Share of working age population and GDP of metropolitan regions



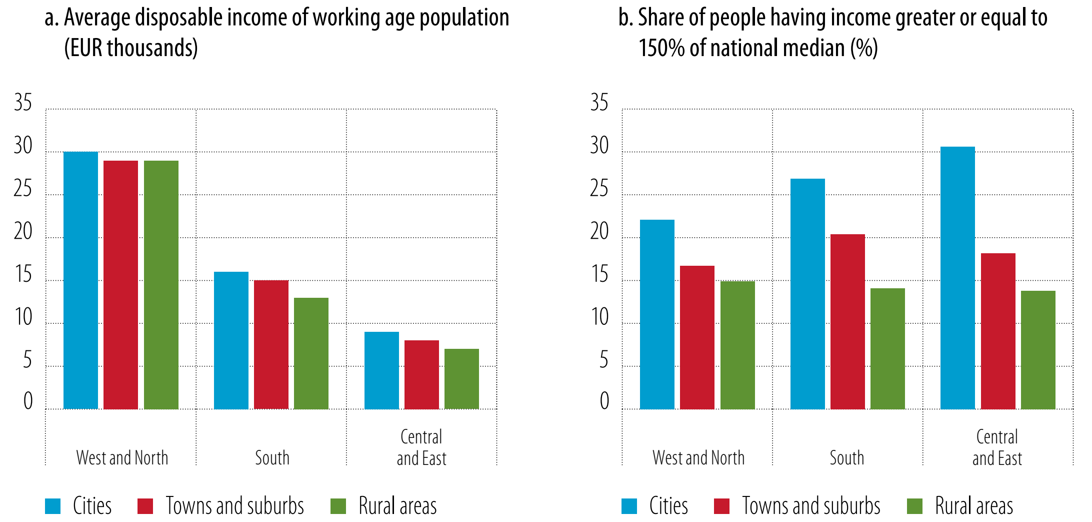
Source: Eurostat and EIB staff calculations.

Incomes in cities are higher than in less densely populated areas, and cities are home to a higher share of very high earners.[28] The concentration of high-skilled, non-routine jobs in cities results in higher incomes for city residents (Figure 38). This increases spatial inequality between densely populated areas and everywhere else, as well as inequality within the city. Furthermore, a high population density and the presence of many individuals with very high earnings increase cities' property prices and rents. The increases are substantial in the most successful metropolitan regions. The higher density of residents generates other negative external factors like congestion and pollution that reduce quality of life and well-being.

Higher housing costs may offset higher incomes in cities, especially for people who are not top earners. Housing costs have been rising across most of Europe over the past 20 years, claiming an ever bigger share of household budgets. Households living in cities in Southern, Central and Eastern Europe spend more of their income on housing and utilities than people in less densely populated areas (Figure 39a). This hurts people with lower incomes the most: the share of people spending more than 40% of their income on housing is significantly higher in cities than in towns, suburbs and rural areas (Figure 39b).

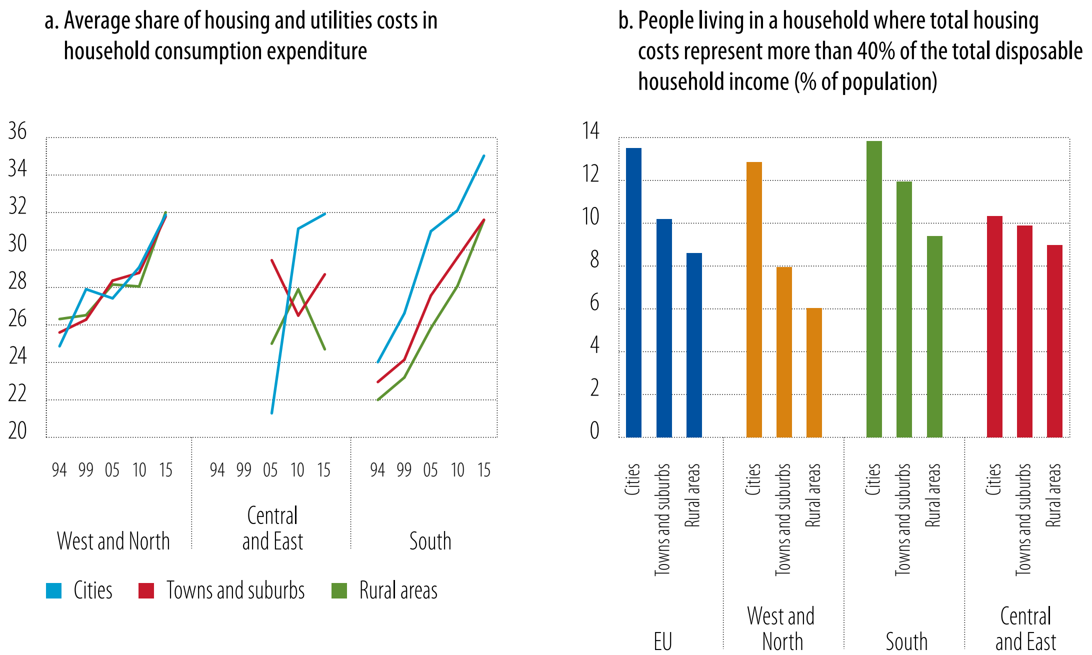
28 In Eurostat's definition, cities are densely populated areas (at the municipal level) with more than 50% of the population living in urban centres. In contrast, rural areas (or municipalities) are those where more than 50% of the population lives in rural grid cells. Towns and suburbs are defined as municipalities where less than 50% of the population lives in rural grid cells and less than 50% of the population lives in urban centres.

Figure 38
Residents of urban agglomerations have higher incomes



Source: *Eurostat and EIB staff calculations.*

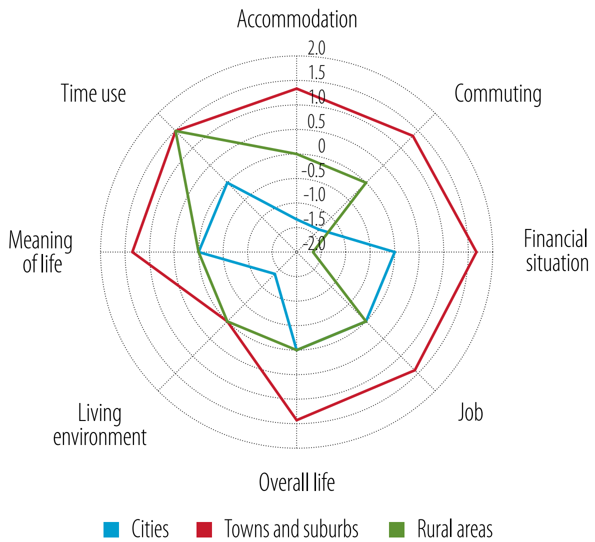
Figure 39
Housing costs offset some of the spatial income difference



Source: *Eurostat and EIB calculations.*

Discontent may aggravate perceived inequality. The lower satisfaction of city dwellers with different aspects of their lives counterbalances the differences in incomes between big cities and other areas (Figure 40). City dwellers are considerably less satisfied with their living environment, commuting situation and time use. They are also less likely to be satisfied with their financial situation, job and overall life than people living in towns or suburbs.

Figure 40
Average rating of satisfaction by degree of urbanisation (% deviation from national average)



Source: *Eurostat and EIB staff calculations.*
Note: *The values of the satisfaction index for each category on the figure are computed as percentage deviations from the national average.*

Intergenerational social mobility

Equality of opportunity for succeeding in life has an intergenerational element. The economic and social position of an individual's family may prevent them from realising their educational or occupational potential. Barriers to intergenerational mobility may result in an inefficient allocation of talent and skills and reduce economic growth and competitiveness. Social mobility is not just a matter of societal and cultural norms and preferences. It has measurable impacts on a range of indicators from lifetime earnings, health status, life satisfaction and well-being to skills, composition of the labour force, firms' performance, and economic growth.

Inequality, both interpersonal and spatial, may become very persistent and deeply entrenched in societies with low social mobility. Low social mobility means that subsequent generations are not very likely to change their income position compared to their parents. Inequality therefore increases, even when it results from relatively short-lived factors, and may last a long time or even become permanent. Conversely, in societies with high social mobility, temporary changes are quickly offset within one or two generations. Social mobility is not easy to measure, however. A number of measures capture different aspects of social mobility (Box C).

The prospect of upward mobility across generations is an important factor for motivation, well-being and life satisfaction. In contrast, as pointed out in OECD (2018), higher risks of downward mobility tend to reduce well-being and life satisfaction. Moreover, OECD research suggests that the perception of equal opportunities makes social conflict less likely and reduces economic discontent, while the opposite holds true for stagnant societies, where a feeling of social exclusion is strengthened.[29] Other studies point to the importance of attributes shaped during childhood in determining life outcomes. As stated in Heckman and Mosso (2014), at least 50% of the lifetime earnings variation between individuals is due to attributes determined by age 18.

29 Inclusive growth is a key pillar of the Europe 2020 strategy. It is possible when employment is high and societies and territories are cohesive. The Europe 2020 strategy regards equality of access and opportunity as a means to achieve social mobility.

Box C

Measuring intergenerational social mobility

Social mobility is a complex concept, and gains or losses in economic and social status between parents and their children can be measured in a number of ways. Income is a close measure of intergenerational mobility. Educational attainment, occupation and health also contribute to social and economic status. While all of these factors are important determinants of social mobility, they might vary differently over shorter and longer periods. This study focuses on patterns of social mobility over longer periods, and does not cover intra-generational mobility.

Compared to income and education, occupational classes are a more robust measure of societal status. Occupational classes are related to other dimensions of status such as social connections, education and wealth, but are more stable over time. Income level, wealth or education, in contrast, may display more fluctuations. Analysing movements across occupational classes between generations gives a good indication of intergenerational social mobility.

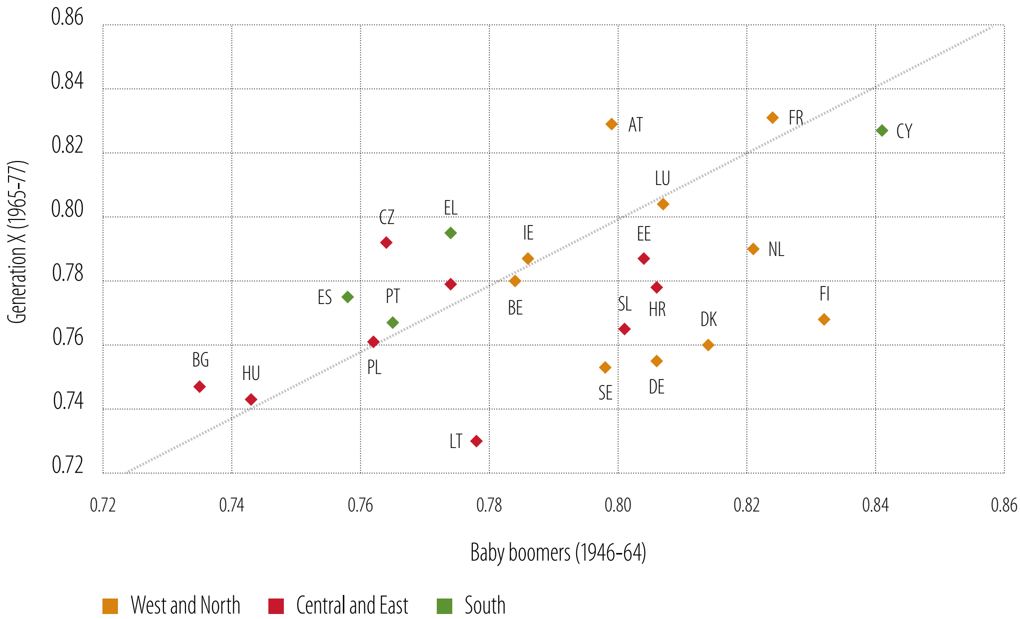
Absolute social mobility in occupations is a widely used measure to capture actual parent-to-child mobility between occupational classes. Absolute social mobility refers to the share of people whose occupation is at a different level to that of their parents, summing up both upward and downward mobility. However, this measure does not differentiate between individual and societal level movements. Instead, it is associated with large-scale changes in society or on the labour market, such as the increase of service jobs coinciding with the decline of blue-collar employment, or more recently, with the hollowing out of middle-income and mid-skill jobs due to technological changes.

Relative social mobility considers the probability of a child moving away from their parent's position in the social hierarchy, often measured in occupation or income, which determine social class and position. Relative social mobility is not affected over time by changes in the class structure. The degree of relative social mobility indicates social openness or the degree of equality of opportunity. Relative social mobility can account for the mobility occurring as a result of structural changes. It captures the real chance of a person to escape their social background, regardless of the large-scale changes happening in society. Fair societies are associated with high relative social mobility, which avoids the social reproduction of inequalities and enables the efficient allocation of skills and human capital.

Absolute and relative social mobility are complementary indicators, capturing different aspects of social mobility. On the one hand, social mobility in absolute terms refers to societal progress by considering the nature and the extent of structural changes (e.g. in occupations) taking place in society. On the other hand, social mobility in relative terms captures the chance of a person to move between positions in the distribution of occupation, income, education, or health, thus promoting equal opportunities on an individual level. In developed economies such as the EU members, relative mobility becomes more important, as overall economic progress slows.

Absolute social mobility, a common measure of social mobility (Box C), decreased for Generation X compared to the previous generation in most EU Member States with data available (Figure 41). Declines are evident in most countries from Western and Northern Europe as well as Central and Eastern Europe. Conversely, in Southern Europe, only Cyprus saw a decline in absolute social mobility from an already very high level. These results seem to go against the conventional wisdom that Nordic countries are the European champions of social mobility. However, the caveats of this measure of absolute social mobility should be recognised. For example, it cannot isolate the effects of structural shifts in society, like the movement from manufacturing to service-dominated economic activity (Box C).

Figure 41
Absolute social mobility rates across cohorts in the EU



Source: *EIB calculations based on European Social Survey (ESS, waves 1-5, 2002-2010) data published in Table A3: Absolute mobility rates across cohorts for 24 EU Member States from Eurofund (2017).*
Note: *The upward and downward mobile movements of cohorts were added together to get absolute social mobility rates for EU countries.*

The relative social mobility of Generation X is higher than that of the Silent Generation across all three country groups (Figure 42a).[30] However, most of the increase relative to the Silent Generation (1925-1945) had already occurred for Baby Boomers. When compared to the Baby Boom generation, social mobility has actually declined for Generation X in Western and Northern Europe and remained unchanged in the other two country groups. Within country groups, there are differences both in Western and Northern Europe and in Central and Eastern Europe. In Belgium, Denmark, Finland, Greece, the Netherlands and Slovakia, relative social mobility increased over three cohorts (Figure 42b). At the same time, Baby Boomers and Generation X experienced a decrease in relative social mobility in Austria, Bulgaria, Estonia and France.

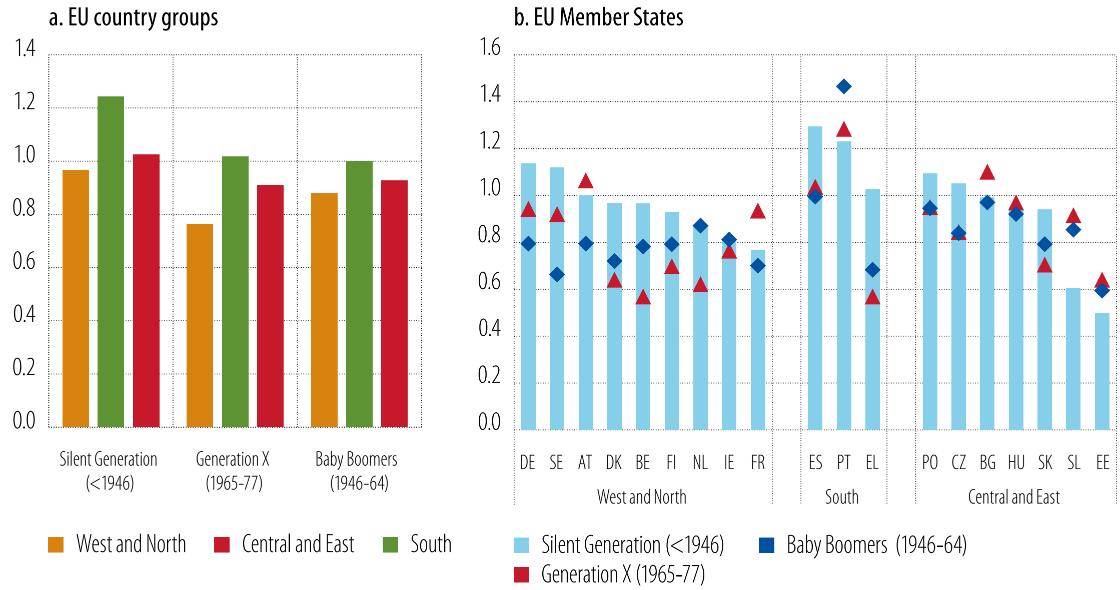
The openness and fairness of a society have directly measurable impact for educational and health outcomes as well as for income mobility. As pointed out by OECD (2018), these and other prospects of mobility contribute to well-being and life satisfaction in various ways, and are positively associated with civic and democratic participation, as well as social cohesion.

Intergenerational earnings mobility is negatively associated with income inequality. Earnings fluctuate more across generations when income inequality is lower, notably in the Nordic countries of Western and Northern Europe (Figure 43). Similar patterns can be seen in other dimensions of social mobility such as occupation (Figure 42b), but also in educational mobility.

30 Figure 42 shows the declining intergenerational persistence of occupational class, implying higher social mobility.

Figure 42

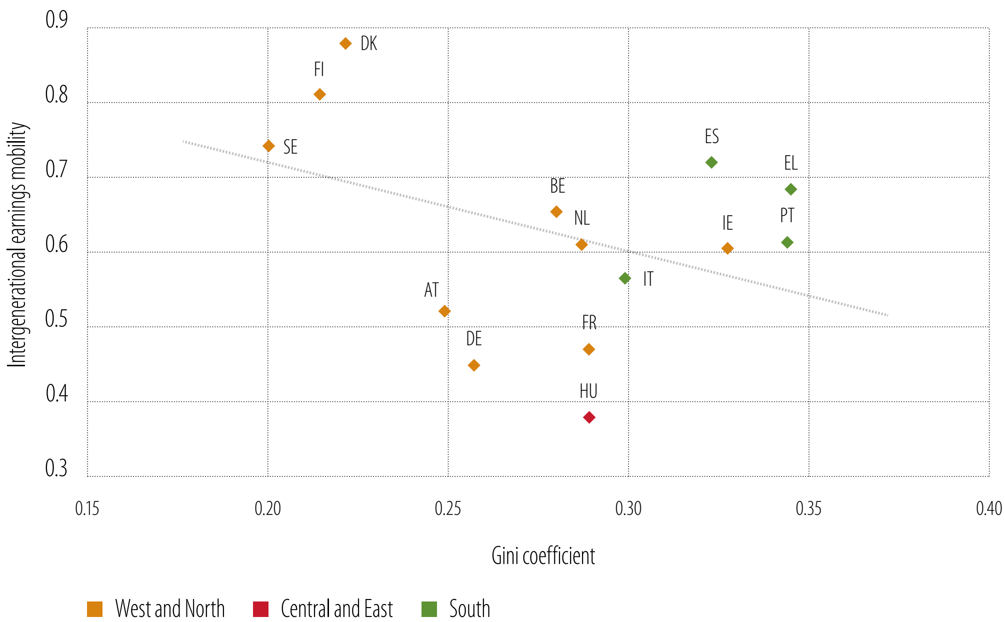
Relative social mobility in the EU measured by relative persistence in occupational class



Source: *EIB calculations based on European Social Survey (ESS, waves 1-5, 2002-2010) estimation results published in Eurofund (2017).*
Note: *Values are coefficients of a log-multiplicative model (Unidiff) referring to the relative likelihood of European Social Survey respondents of differing class origins and belonging to different cohorts arriving at different class destinations. The model estimates the common multiplicative factor by which the odds ratios for the separate mobility tables change, and it is fixed to 1 for one cohort in one country as a reference (in this case the Silent Generation in Austria). Country population referring to 2018 is used as a weighting for panel a.*

Figure 43

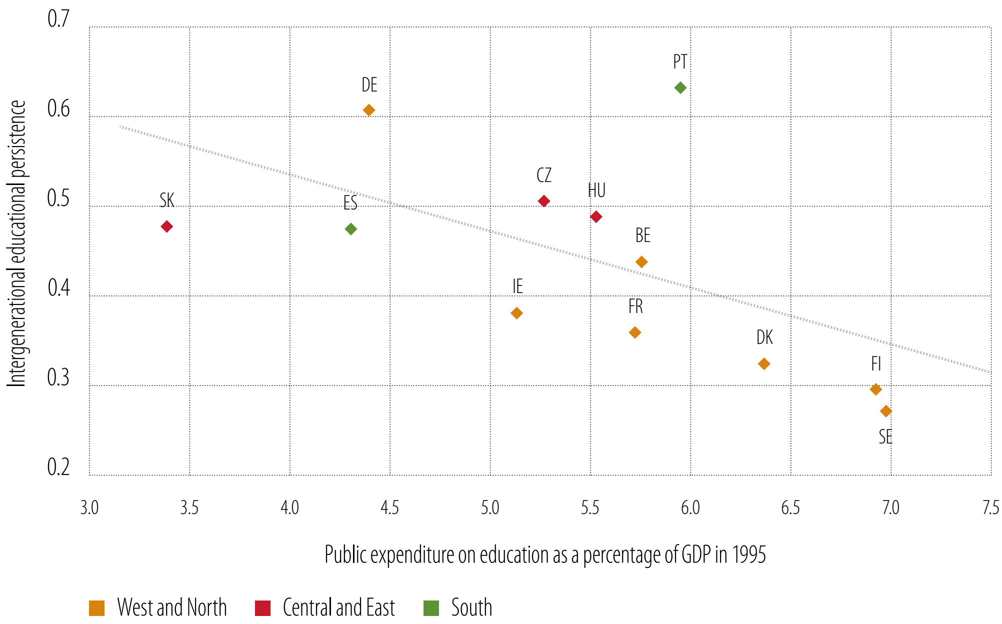
Income inequality and intergenerational earnings mobility



Source: *OECD (2018b).*
Note: *Intergenerational earnings mobility is estimated as 1 minus the intergenerational earnings elasticity of fathers and sons. Gini coefficients, which measures inequality, refer to years from the mid-1980s to early 1990s.*

Public expenditure on education is positively associated with higher levels of educational mobility (Figure 44). Countries in Central and Eastern Europe and Southern Europe are characterised by higher educational persistence, while most countries in Western and Northern Europe display higher intergenerational educational mobility. Additionally, in countries with higher income inequality, family income typically influences access to quality education, as living in neighbourhoods with better schools costs more. Thus, children from low socio-economic backgrounds not only end up with lower educational attainment, but also have lower skills at any given level of education.

Figure 44
Educational mobility and public expenditure on education in EU countries



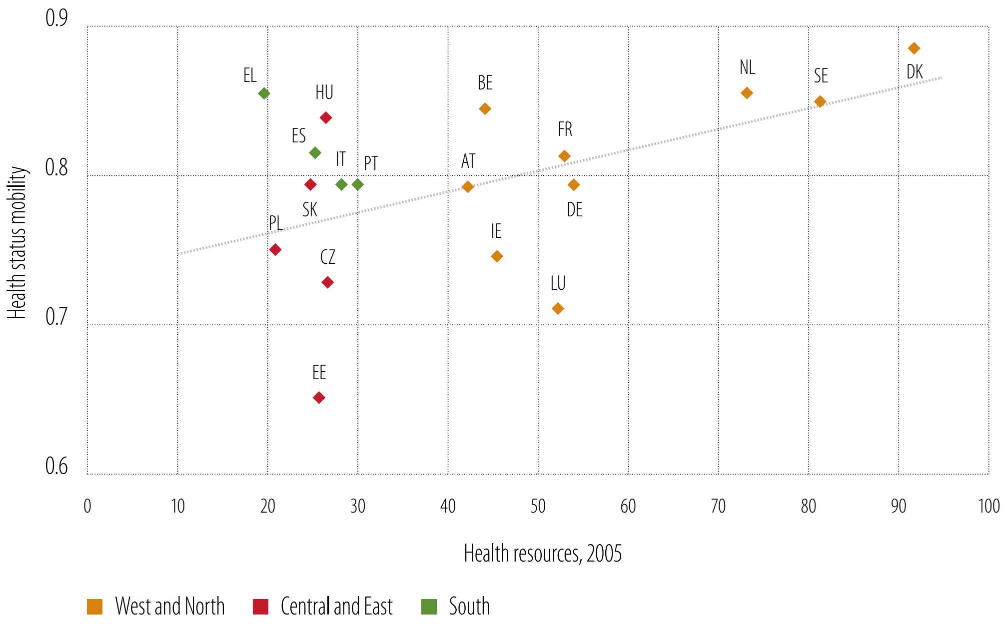
Source: *OECD (2018b), based on European Social Survey data.*
Note: *Persistence was estimated as a regression coefficient between parents' and children's years of schooling at ages 30 to 55.*

Health status, or a person's sense of their own physical health, changed less from one generation to the next in countries with lower employment in the health and social employment sectors. Nordic countries stand out from the rest of the European Union as having the highest mobility of health status and devoting the most resources to health (Figure 45). Countries in Western Europe are in the middle in both measures, while Southern, Central and Eastern European countries record the lowest values. Health inequalities are also correlated with a number of dimensions of socio-economic status. In fact, health is not only improved by higher social mobility but is also a determinant of it. Conti et al. (2019) point out that future life chances are already influenced before birth, as early child development is affected by prenatal health.

Children growing up in EU countries with higher levels of income inequality experience worse outcomes in a number of areas such as health, educational attainment and behaviour (Figure 46). In times of increasing income inequality (in the aftermath of the financial crisis), children are more exposed to poverty and material deprivation than the population as a whole. Toczydlowska et al. (2016) found that the unequal growth rate in child income across the distribution is a factor contributing to the increase in child income inequality at the lower end of the distribution.[31] Countries with greater inequality among children at the lower end of the distribution have lower levels of child well-being and higher levels of child poverty, with higher income inequality overall.

Figure 45

Public spending on health and health mobility in EU countries



Source: *OECD (2018b).*
Note: *Intergenerational health mobility is measured as 1 minus intergenerational health persistence, which is estimated as the regression coefficient between parents' and children's self-assessed health status. Health resources refer to total health and social employment per 1 000 people in 2005.*

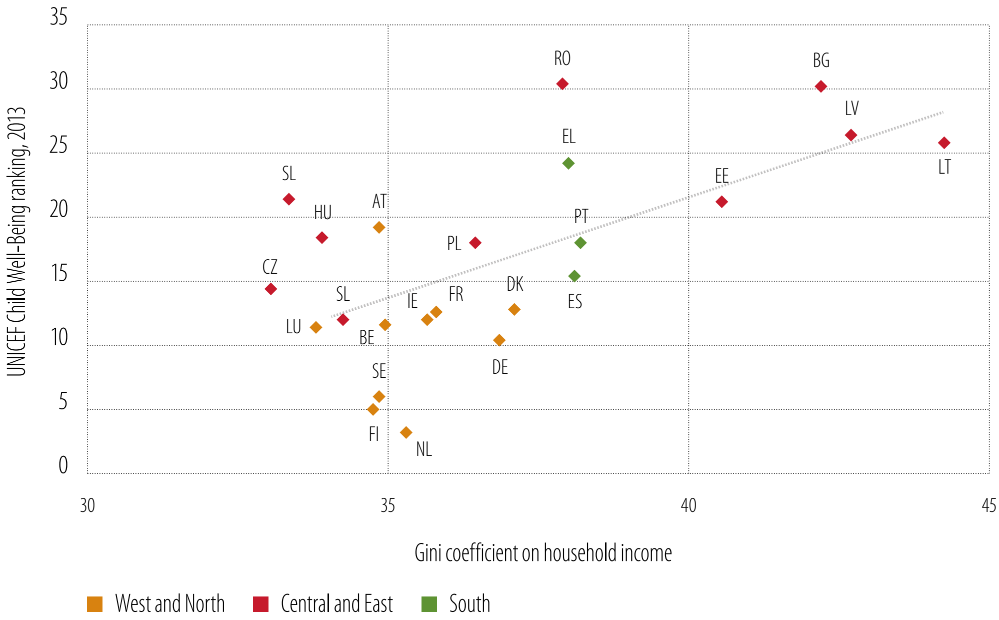
The importance of public interventions and spending cannot be stressed enough in crucial areas associated with social mobility. Labour market interventions and public policies aimed at building skills from early childhood to adulthood may be able to stop the vicious circles of negative risks over generations.[32] Social transfers have a positive role in reducing income differences for children and adults in EU countries. Targeted policies can benefit the adults of the future who depend heavily on both the resources of their family and the postal code they are born into. However, efficient and effective public spending is also badly needed to promote social mobility in countries that lag behind the most.

31 The analysis uses disposable household incomes for households with children aged 0 to 17, equivalised using the modified OECD scale, and assessed at the individual level of the child. Each child is attributed a share of the disposable income of the household, adjusted for household needs.

32 Chapter 9 of this report elaborates further on this topic.

Figure 46

Child well-being and household income inequality in the EU



Source: *UNICEF Office of Research (2013) data and EIB calculations based on Eurostat income, consumption and wealth – experimental statistics.*

Note: *The overall UNICEF Child Well-Being ranking is based on the average ranking for five aspects of child well-being: material well-being, health and safety, education, behaviours and risks, housing and environment. Lower numbers indicate a better ranking. The Gini coefficient refers to household population. Values are averages of 2010 and 2015, where available.*

Conclusion and policy implications

The EU economy is entering a phase of increased uncertainty about near-term growth prospects. Increasing tensions between countries on international trade issues in 2018, along with the slowdown of the Chinese economy, significantly affected demand for European exports. As a result, manufacturing output declined or stagnated across the European Union and in the United States. These developments, along with an uneven and increasingly uncertain Brexit process, contributed to rising uncertainty. The good economic performance of the services sector meanwhile may not last very long. Unless manufacturing recovers, it may trigger a slowdown or outright economic recession.

Slowing manufacturing and growing uncertainty will likely affect investment performance in the European Union. The weakening environment outlook had a limited impact on corporate investment in 2018 and early 2019. The situation is likely to change, though, as firms incorporate expectations of a deteriorating economic outlook into their investment plans and investment slows down later in 2019 and 2020.

Many governments have relaxed their fiscal stance and put more emphasis on investment in their budget plans, but this may be insufficient to meet investment needs in the medium term. Such a shift is necessary to address the increasing investment needs related to climate change mitigation and adaptation, infrastructure and innovation. It should not be short-term and piecemeal, but rather well grounded in medium-term national investment programmes that address these needs. With interest rates at historical lows and monetary policy accommodative, such investment plans should be frontloaded as much as possible by increased government borrowing, where fiscal space allows. A renewed emphasis on government investment may also help address the likely economic slowdown.

Governments should provide incentives for the private sector to achieve policy targets, in addition to increasing their own capital expenditures. Elevated uncertainty is constraining private sector investment, especially in key policy areas like R&D and innovation, climate change mitigation and digitalisation. Government policies should be revised to align private sector incentives with medium-term policy targets and structural needs. Policies should include standardising regulations for public-private partnerships to encourage the private sector's involvement in large capital-intensive projects. Policies should also include setting an effective price on carbon emissions and incentivising the adoption of technology and digitalisation.

Rising interpersonal income inequality is a threat to social cohesion, despite the mitigating effect of redistributive systems. The excessive share of national income growth accruing to the super-rich at the expense of poorer people is creating tensions in societies. While income redistribution and the provision of high quality public services can deal with rising inequality to a certain extent, it remains a persistent problem. The situation is exacerbated by low social mobility and unequal opportunities. Such tensions threaten to limit technological progress, the competitiveness of firms, international trade and economic openness. This will ultimately reduce economic growth and the size of the pie to be distributed.

Spatial income inequality is an important policy issue that requires non-standard and highly customised approaches. Technological progress and innovation lead to a geographic concentration of economic activity, improving the fortunes of large cities and leading to the stagnation and relative decline of smaller towns and rural areas. While the advances might increase overall national prosperity, growing spatial inequality puts pressure on social cohesion within countries. Not everyone is willing or able to move to large cities, and even if this were possible, congestion, pollution and intercity inequality may result in lower rather than higher social welfare. Therefore, it is not enough to assume that agglomeration is the efficient outcome and that policies should only ensure peripheral regions be provided with basic public services and social safety nets. Policymakers will have to focus on improving the fortunes of left-behind regions, finding ways to exploit their economic potential. For instance, Rodriguez-Pose and Wilkie (2018) provide evidence that less developed regions in the United States and Canada innovate more than their European counterparts. The gap stems from the ability of Canadian and US regions to absorb young skilled workers and to encourage the transfer of knowledge within those regions.

Improving social mobility is essential to addressing growing income inequality, but no easy solutions exist to increase social mobility. High social mobility is key to fairness and economic efficiency. It reduces income inequality across generations by diffusing its effect in subsequent generations. Improving equality of opportunity goes a long way towards increasing social mobility by weakening the link between the social status of children and that of their parents. At the same time, equal opportunity strengthens the link between social status and individual ability and effort. To increase equality of opportunity, policymakers should focus on:

- Improving access to and quality of education, as educational attainment is closely related to social status. While many governments focus their efforts on tertiary education, they should recognise that primary and secondary education are just as important.
- Improving health care and access to high quality health services, as health is found to be an important determinant of socio-economic status.
- Improving child wellbeing, because children's success in life is strongly influenced by conditions in early childhood and even before birth.

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Chapter 2

Infrastructure investment in the European Union

Recent years have seen a marked decline in infrastructure investment. At 1.6% of gross domestic product (GDP), investment activities in 2017 were markedly below their pre-crisis levels. Initial data for 2018 suggest, at best, a modest improvement in the coming years.

Accompanying the decline in volumes is a re-allocation of investment away from modernisation activities. As infrastructure investment activities decline, the purpose of this investment changes, leading to a rise in the relative importance of replacement investments and a fall in the share of investment in capacity expansion and modernisation.

Opportunities are being missed. Our hypothesis is that smart infrastructure, i.e. combining physical infrastructure with digital technologies, enhances the potential benefits of infrastructure, raises efficiency and helps limit negative externalities. In addition, given the low costs of many smart applications compared to constructing new infrastructure, smart investments are likely to be very cost effective. While supported by overall demand, corporate infrastructure investment remains hampered by weak government investment. This is due to synergies and complementarities between government investment (e.g. transmission lines) and corporate investment activities (e.g. power plants) in the infrastructure sector.

Modernisation activities in the corporate infrastructure sector suffer from a too static regulatory framework. Firms operating in the infrastructure sector lag behind those in other sectors in the adoption of digital technologies, and so far there is no sign of them catching-up. One reason for this, we argue, is that the incentives in the current regulatory framework to adopt digital technologies are largely limited to efficiency improvements. Little consideration is given to using digital assets to fundamentally transform how infrastructure services are delivered.

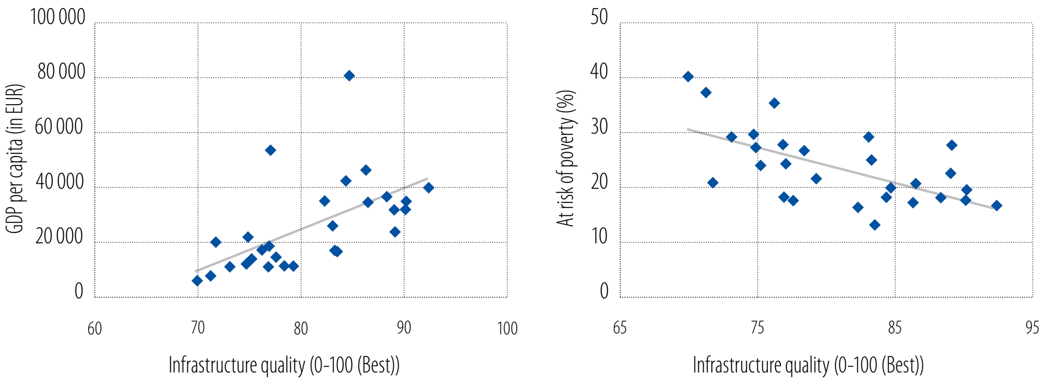
Tentative signs of a recovery are emerging in the weakened public-private partnership (PPP) market. The modest upward trend in activity is being driven by investment activities in Western and Northern Europe and, in particular, by investment activities in broadband networks. While this is a welcome development, policymakers need to ensure economic viability going forward. This means that careful attention must be paid to future demand, including the forward compatibility of technologies, which can be particularly challenging in high-tech sectors that continue to evolve swiftly or in regions facing demographic challenges.

Introduction

The longer-term economic performance of the EU economy rests on the availability of adequate infrastructure. As Adam Smith wrote in *The Wealth of Nations* (1776), one of the basic responsibilities of the "sovereign or commonwealth" is to provide an adequate structure of public works to "facilitate the commerce of society." A large part of the empirical literature considers the intricate links between economic growth and infrastructure quality (Figure 1; Calderón and Servén, 2014; European Commission, 2016)

Figure 1

Infrastructure quality and economic/social outcomes



Source: Eurostat.

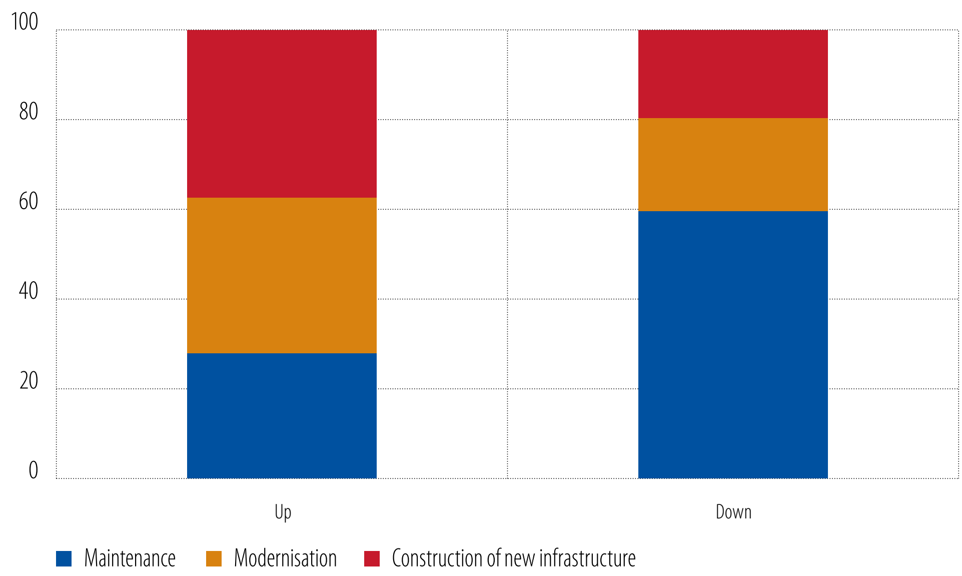
The provision of adequate infrastructure is also critical for regional and social cohesion. Recent work suggests a positive relationship exists between infrastructure quality and regional convergence as well as various micro-level measures of social inequality (Calderón and Servén, 2014; Bajar, 2018; Hooper et al., 2018), with particular importance placed on the provision of social infrastructure.

Against this background, recent trends in infrastructure investment are worrying. From 2009 to 2017, Europe saw a 15% decline in overall infrastructure investment activities (as a share of GDP). This decline was more pronounced in regions with poor infrastructure quality, thus reinforcing infrastructure investment gaps and raising concerns about the effect not only on economic competitiveness but also on economic and social convergence within the European Union (EIB, 2018a).

The decline in infrastructure investment in recent years has been accompanied by a smaller share going to modernisation activities, thus diminishing the adequacy of infrastructure in relation to evolving demands (Figure 2). The EIB Investment Report 2018 (EIB, 2018a) highlighted the fact that regions exhibiting falling infrastructure investment levels typically shift their investment goals from modernisation and/or building new capacity to mere maintenance (EIB, 2018a). This suggests a potential "double squeeze" on infrastructure standards, through an overall decline in investment activities combined with a shift from modernisation to maintenance.

The purpose of this chapter is to review the latest developments in infrastructure investment activities in the European Union with a focus on investment in smart infrastructure. The aim is to go beyond reporting sheer volumes to also take the qualitative aspects of investment carried out by the various types of infrastructure promoters into account. First, we provide an overview of recent investment trends. The next section introduces the concept of smart infrastructure, while the following part focuses on smart infrastructure as a policy priority of municipalities based on the EIB Municipalities Survey 2017 (EIB, 2017). We then explore the link between smart infrastructure and corporate infrastructure investment, and discuss public-private partnerships (PPPs) as an alternative vehicle of infrastructure procurement, noting their increasing relevance for broadband networks, the backbone of wide-ranging and interconnected smart infrastructure. The last section provides policy conclusions.

Figure 2
Purpose of infrastructure investment in the next five years
(share of municipalities in %; base 2017)



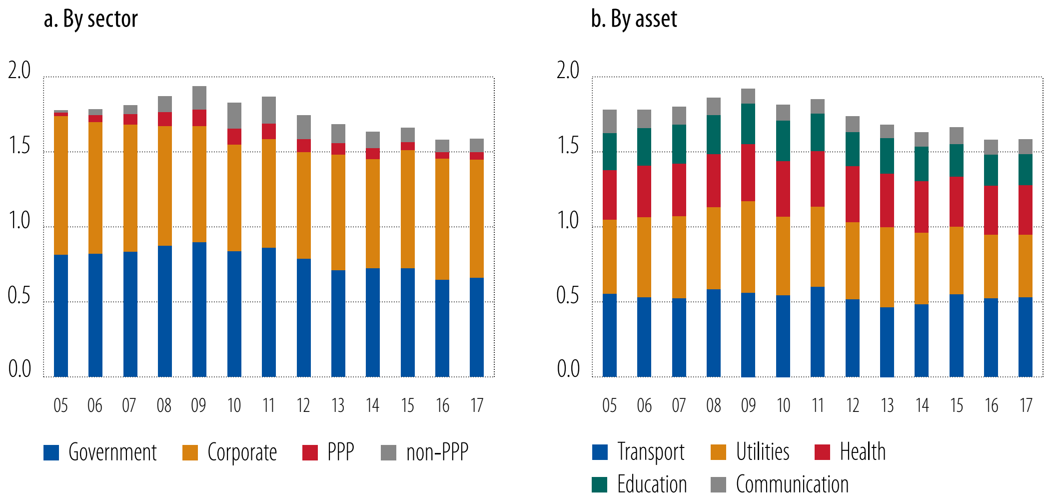
Source: *EIB Municipalities Survey 2017.*
Question: *Looking ahead to the next five years, will the largest share of your spending on infrastructure in each of these areas be for maintenance and repair, modernisation or the construction of new infrastructure?*

Recent trends in infrastructure investment

Infrastructure investment remains weak and lags behind the economic recovery. Infrastructure investment stands well below its pre-crisis levels. After some positive initial signals, the 2017 data were once again disappointing: 1.6% of GDP (Figure 3). Weak government infrastructure investment and investment activities by public-private partnerships are the main drag on overall infrastructure investment in the European Union. The transport and (to a lesser extent) utilities sectors were the hardest hit by the crisis, with no recovery in sight in either case.

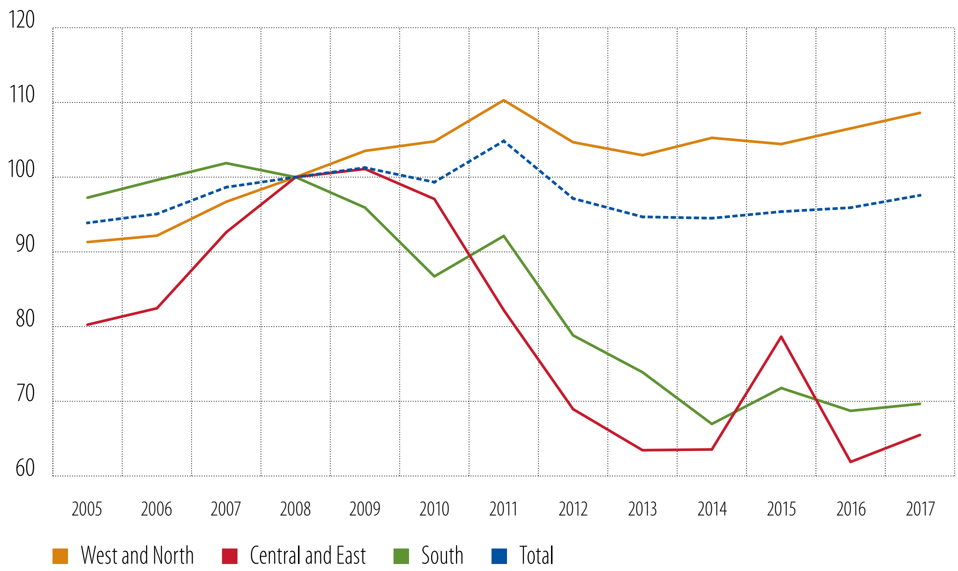
Infrastructure investment remains below its pre-crisis levels. The comparison with 2008 levels is most striking for the countries of Central and Eastern Europe, where current investment levels are around 35% lower than before the crisis, followed by Southern Europe (with 30% lower investment levels). Real infrastructure investment has surpassed 2008 levels in Western and Northern Europe, but even there investment rates (i.e. investment as a share of GDP) lag behind their pre-crisis levels.

Figure 3
Infrastructure investment (% of GDP)



Source: *EIB Infrastructure Database (IJ Global, EPEC, Eurostat).*
Note: *Data missing for Belgium, Croatia, Lithuania, Poland and Romania. EU average excludes the United Kingdom. Slight deviations from the 2018 results are due to a refinement in the estimation of depreciation in government infrastructure investment.*

Figure 4
Infrastructure investment (by region, 2008 = 100)



Source: *EIB Infrastructure Database (IJ Global, EPEC, Eurostat).*
Note: *Data missing for Belgium, Croatia, Lithuania, Poland and Romania. The EU average excludes the United Kingdom.*

There are at least three arguments for why these persistently low levels of infrastructure investment activity fall short of requirements (EIB, 2018a):

1. Data from the EIB's 2017 Municipalities Survey show that one-third of municipalities consider investment to have been deficient. Perceived gaps are bigger among larger municipalities and most pronounced in Italy, the Baltics and the United Kingdom, where, on balance, nearly 50% of municipalities report underinvestment.

2. Regions with relatively weak infrastructure tend to underinvest more often. The Municipalities Survey shows that, of the 33% of municipalities reporting the weakest infrastructure relative to their country-group average, 45% report underinvestment (EIB, 2018a). This is twice the share observed within the top 33%.

3. Finally, in a series of micro-level analyses, the EIB Investment Report 2018/2019 shows that new infrastructure continues to generate large economic rents (EIB, 2018a). Specifically, contrary to the view of diminishing returns, it shows that firms' responsiveness to growth opportunities in Europe continues to rise with the provision of new infrastructure.

A bottom-up estimation suggests an overall infrastructure investment gap of about EUR 155 billion per year (EIB, 2018a). The European Union has set policy goals that it wishes to achieve by 2030 in various areas, including climate and energy[1] and broadband penetration. A bottom-up estimation suggests that to meet the objectives related to infrastructure, additional investments of EUR 155 billion per year will be necessary. If the dynamics in infrastructure investment do not reverse, this target will become increasingly hard to achieve.

Going beyond volumes: smart infrastructure

Digital technologies are transforming virtually all economic sectors. New ways of connecting people and machines and of collecting, storing and making sense of data are working their way into every part of our economy. This does not so much concern shopping, watching movies or searching for information, but rather transport, manufacturing, farming and government. An increasing body of literature studies the drivers and constraints of digital adoption among consumers and the business sector. Thus far, however, little is known about the applications of digital technologies when it comes to infrastructure.

Smart infrastructure is the result of augmenting physical infrastructure with digital capacity (Guizani and Anan, 2014, and the Cambridge Centre for Smart Infrastructure and Construction, 2016). These technologies generally entail the collection of data in real time, thus enabling an interaction between infrastructure, users and service providers, facilitating near real-time information on changes (United Nations, 2016). Automation and artificial intelligence along with sensors, data sharing and analytics augment infrastructure with potentially significant economic and social benefits. Examples of smart infrastructure in this sense include traffic management systems, smart street lights and self-repairing electricity grids. To illustrate the application of digital technologies, Boxes A-C provide case studies in the transport, energy and health sectors.

Combining physical infrastructure with digital technologies can improve services, raise efficiency and reduce externalities. Services can be improved by increasing capacity and enhancing service quality; cost savings bring about efficiencies; and improved measurement and management can reduce redundancies, increase system stability, and limit the impact on the environment (Table 1). For instance, capacity enhancements may occur through better traffic management in transport, or upgraded smartphone networks. Water and energy network service quality can be improved by using sensors that

1 For an extensive discussion of the EU 2030 targets related to energy, see Chapter 3.

reduce the risk of network failures, and better health services can be provided through the use of remote diagnostics. Cost savings can occur if smart street lights consume less energy or smart meters enable automatic billing. Finally, the environment can also benefit from less energy consumption, better air pollution management and the need for less power generation because of smart energy management.

Table 1

Potential benefits of smart infrastructure

	Capacity enhancement	Service quality enhancement	Cost savings	Environmental sustainability
Transport	Traffic management systems increase vehicle flow.		Smart streetlights reduce maintenance costs and energy consumption.	Air pollution management through smart meters.
Water		Sensors identify maintenance needs, prolong life-time and reduce leakage.		
Energy		Self-healing grids detect and address failures quickly without human intervention.	Automatic billing through smart meters.	Smart energy management enables higher share of renewable energy and reduces power generation needs. Smart meters reduce energy consumption.
ICT	Upgrade from 4G to 5G offers more capacity and allows rapid near-field communications.		Efficiency gains in mobile spectrum usage reduces need for telecom towers.	
Health		Smart meters at home alert hospitals in case of risk.	More efficient health services through remote diagnostics and interventions, and surgical robots.	
Education	Blended learning maximises interaction time with teachers.	Digital classrooms can result in new teaching methodologies, better learning outcomes.	Digital classrooms reduce need for teachers and classrooms.	

Source: National Infrastructure Commission, 2016. The impact of technological change on future infrastructure supply and demand. Report. Ogie et al., (2017). Smart infrastructure: an emerging frontier for multidisciplinary research, Smart Infrastructure and Construction, Volume 170, Issue SC1.

Frequently, smart enhancements will deliver several of these benefits at the same time. For instance, augmenting an existing road with smart infrastructure can improve the traffic flow and increase safety; smart meters in water networks can reduce maintenance costs and reduce water leakage; and new information and communication technology (ICT) infrastructure can expand capacity and improve services with faster connections.

Box A

Transport

Smart transport infrastructure collects, uses and shares real-time data from sensors, detectors and autonomous drones to optimise transport networks (United Nations, 2016). Improvements can be achieved in terms of road network reliability, traffic flows, safety, cost reductions and environmental sustainability (Table 1).

The English M25 Smart Motorway All Lane Running (SMALR) scheme highlights smart transport infrastructure's ability to deliver multiple benefits at the same time. Implemented in 2013, the scheme replaces the old three lane plus hard shoulder scheme by exploiting all lanes of the highway, including the physical hard shoulder. Through digital signalling connected to a control centre, the system enables algorithms and operators to control traffic and automatically adjust signalling and the number of lanes in case of emergency. As a result, congestion has become less frequent, average speeds have increased and the speed differential between lanes has been reduced (Highways England, 2018).

Barcelona's Metro line 9/10 is another example of how smart transport infrastructure can improve safety and service quality for millions of people. Completed in 2016, the new line 9/10 has 52 stations over 47.8 km – making it the longest driverless line in Europe – and operates in a densely populated area. By combining an automatic train control system with connected platform screen doors, trains can operate autonomously. The safety of the autonomous line is ensured through algorithms that use radar and cameras (Wang et al., 2016). In addition, the overall user experience is improved by connecting trains. LED screens display train schedules and mobile applications provide passengers with real-time information about their journeys.

Smart transport infrastructure can also result in cost savings, as with smart street lights in Monheim am Rhein in Germany. This connected lighting system cuts costs by switching off the lights when sensors detect that traffic has stopped in rural areas (Müllner and Riener, 2011). In addition, the street lights facilitate maintenance by automatically reporting failures (GSMA, 2017). This results in faster network failure resolutions and greater reliability. Finally, the lights are dimmable and enable the municipality to remotely adjust the light colour.

Box B

Health

Smart health infrastructure exploits and shares data to improve decision-making and detect health threats. Examples of smart health infrastructure include sensors, meters and detectors, medical robots and connected health equipment (Chen et al., 2018).

Robots support medical and administrative staff in many hospitals. They enable surgeries with faster recovery, greet and assist patients, propose diagnostics, carry heavy loads and manage medication storage. For instance, the da Vinci surgical robot assists surgeons with their operations in thousands of hospitals across the world. It has a high definition vision system, its own mechanical wrists and special instruments, enabling surgeons to perform highly precise operations. Doctors therefore conduct less invasive surgeries, leading to shorter hospital stays, fewer complications, less need for narcotic pain medicine and minimal scarring (Taylor et al., 2016; Chen et al., 2017; Peters et al., 2018).

Robots also help hospitals through the autonomous storage, management and distribution of medicines. For instance, the ARX Rowa Speedcase efficiently uses the space in hundreds of hospitals in the United Kingdom to manage drug storage. Once installed in a room, the robot makes dense storage possible as no human intervention is needed, and manages medicines based on their barcodes

(Goundrey-Smith, 2008). Adopting the technology results in a 50% reduction in distribution errors and an increase in the efficiency of the distribution process, enabling staff to devote more time to near-patient services (Brice et al., 2006; Goundrey-Smith, 2012).

Smart meters measure households' electricity and gas consumption and detect potential threats. The European Union is encouraging the replacement of at least 80% of electricity meters with smart meters by 2020 (European Commission, 2017). Although the initial purpose of smart energy meters was to facilitate meter reading and billing, they are also increasingly used to identify urgent medical issues. Using learning algorithms, smart meters can identify individuals' energy consumption patterns and detect anomalies in their habits (Chalmers et al., 2015). They can therefore detect potential threats to elderly people living alone, such as sleep disorders or a slow loss of autonomy.

Smart cards increase the efficiency of health care and improve patient safety. They make it possible to store, share, and access specific data and applications (Oltean, 2011; Smart Card Alliance, 2013). Belgium, Australia and Austria are among the countries that use smart cards to uniquely identify patients. There are many expected outcomes encouraging the digitalisation of health identification. First, smart cards reduce prescription errors and administrative costs, and speed up the process of admission to health centres and the procedures for getting health care reimbursements and obtaining prescribed drugs. In addition, they facilitate the portability of medical records, enabling access to each patient's medical records at all health centres, instead of having specific medical records at each centre (Devlies et al., 2010). However, such a system also presents potential threats in the event of a security breach (Tunstall, 2017). For example, a hacker could access a patient's entire medical record by entering a smart card, which would violate the principle of medical confidentiality.

Box C

Energy

Smart energy infrastructure employs digital technology to enable the interplay between generation, storage and distribution, and consumption of energy. The enhanced information supports sustainability by reducing energy production, facilitating the integration of renewable energy sources and increasing grid resilience. The shift to renewable energy production introduces important challenges to a grid, including decentralisation and volatility of production, which dynamic management and storage capacity can help mitigate. By analysing the base loads and latency of new capacity and the drawdown of storage, the system can optimise a network's ability to meet demand. To this end, it employs sensors, smart meters and grid networks.

Energy efficiency solutions for buildings include the use of new materials and technologies to enable façades and windows to generate energy while also reducing waste. For instance, the incorporation of digital technologies and innovative materials into buildings can provide them with partial or full energy autonomy by converting natural light into energy while limiting the heat created. Using an autonomous system, tiny photovoltaic cells built into windows produce solar energy while self-adjusting curtains or electrochromic glass[2] enable screens to keep the buildings at an ideal temperature. In California, the use of such systems reduces electricity consumption for lighting and cooling by about 26% and 20%, respectively, while producing renewable energy in parallel (Baetens et al., 2010; Sun et al., 2019).

Smart meters and thermostats also help to distribute and use energy more efficiently. According to the campaign Smart Energy GB, smart meters allow for more precise electricity bills and a better understanding of each consumer's use (Zheng et al., 2013). By understanding their electricity use, individuals can make more appropriate decisions to reduce consumption and thus achieve cost

2 Glass changing from clear to opaque to capture less heat within the building.

savings. Smart meters also make it possible to create flexible tariffs that would help regulate supply and demand (Hargreaves et al., 2010). However, although some studies have shown that smart meters enable individuals to learn about their energy consumption, to date such systems have only provided limited reductions in energy consumption in the long term (Hargreaves et al., 2013).

Self-healing grids help to provide reliable energy supply to thousands of households in Rotterdam in the Netherlands. Our daily lives depend to a large extent on a stable supply of electricity; access to the internet, financial services and hospitals could for instance be severely affected in the event of power outages (Pathak, 2013). In such cases, physically controlled centres are usually able to detect the location of failures, but they must then dispatch experts to the site to more accurately locate and repair the defective element. Rotterdam, with the support of the grid operator Stedin Group, therefore decided to launch a self-healing electricity grid in 2012. More specifically, seven remote terminal units were installed in the grid, with these automatic units detecting if a fault has occurred on the network and exchanging information with other units (Coster et al., 2013). By communicating, the units are then able to automatically locate the fault by diagnosing the failure and isolating part of the network pending repair. As soon as this is done, the network can be safely powered up again, resulting in power outages of less than 30 seconds on the parts of the network not directly affected.

Investment in smart infrastructure has often been found to be cost effective. The relatively low capital intensity of these investments (compared to, say, capacity expansion investments) as well as the substantial cost savings that come with many smart applications (Xiong, X., 2018) make these investments particularly interesting. Our own analyses confirm this view. We find that (local) governments with funding constraints often turn towards smart solutions when filling investment gaps.[3]

Alongside the many potential benefits that can be generated from rendering infrastructure smart, there are new challenges and potential negative consequences that need to be managed (The Royal Academy of Engineering, 2012). Smart infrastructure often entails comprehensive data collection and analysis, which need to be conducted in a manner consistent with privacy standards. Moreover, smart infrastructure entails specific vulnerabilities. For instance, the degree to which local disruptions can cascade across interconnected systems needs to be limited. There is also a risk that the digital components of smart infrastructure might be hijacked or exposed to cybercrime. Finally, the rapidly changing nature of digital technologies can limit the planning horizon, whereas infrastructure typically requires long-term thinking. As an example, integrated sensors may reach their expiration date more quickly than the physical infrastructure they are imbedded in. Furthermore, new digital technologies could enable cheaper alternatives that lead to a sudden and unexpected drop-off in demand for certain infrastructure, thus rendering it unprofitable. Technological advances could also lead to seismic shifts in social organisation and related infrastructure demand: for instance, rural connectivity could reverse the trend of concentrating economic activities in big cities.

Government sector

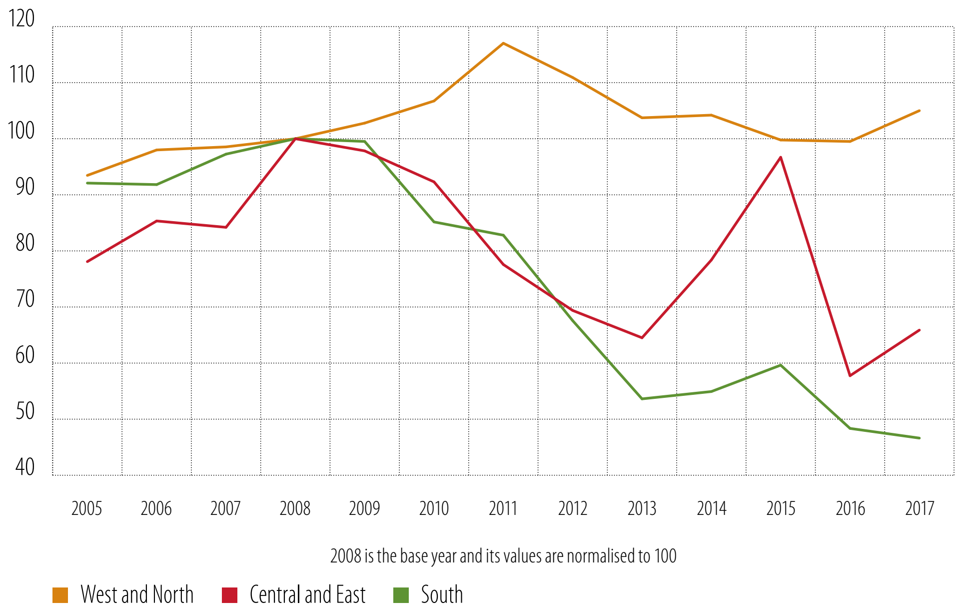
Government accounts for most of the decline in overall infrastructure investment since 2009. Government infrastructure investment declined by 0.5% of GDP from 2009 to 2017, a decline that was proportionally larger than the fall in overall public investment. Government infrastructure investment accounts for the biggest share of total infrastructure investment in transport (80% of total infrastructure investment) and education (90%) – the sectors most affected by the contraction. The share of government investment is lower in other sectors, from 55% in health to 10% in ICT.

3 For a detailed analysis and also the role of trust in this context, see EIB and European Bank for Reconstruction and Development, Working Paper Brutscher et al. (forthcoming).

The fall in government infrastructure investment was most pronounced in EU countries most exposed to the crisis (Figure 5 and EIB, 2018a). In many countries, the downward pressure on government infrastructure investment exerted by the need to tighten budgets was accompanied by a strong shift within the remaining budget from capital expenditure, notably investment, towards current expenditure, reflecting the concurrent rise in social spending.

Figure 5

Government infrastructure investment (index)



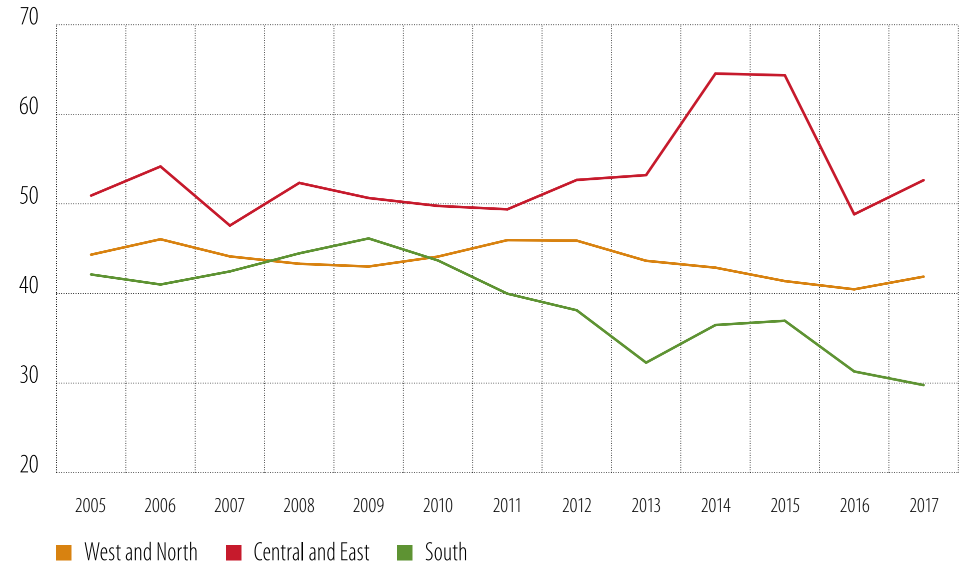
Source: *EIB Infrastructure Database (IJ Global, EPEC, Eurostat).*
Note: *Data missing for Belgium, Croatia, Lithuania, Poland and Romania. EU average excludes the United Kingdom.*

Government infrastructure investment shows little sign of a rebound, regardless of the improvement in many countries' fiscal and economic fortunes. The fiscal stance of the European Union was broadly neutral from 2014 to 2017. In 2018, the structural primary surplus increased, but only marginally (by 0.1% of GDP). Despite the improved fiscal situation, government infrastructure investment looks set to remain weak. In fact, with the exception of Central and Eastern Europe, the government share of total infrastructure investment is below pre-crisis levels (Figure 6).

Regional governments are at the heart of the decline in infrastructure investment. They cut their infrastructure investment activities disproportionately in the past ten years. Overall, regional and local investment accounts for more than half of overall government infrastructure investment. Cuts in transfers from the central government can explain part of the investment reduction (EIB, 2018a).

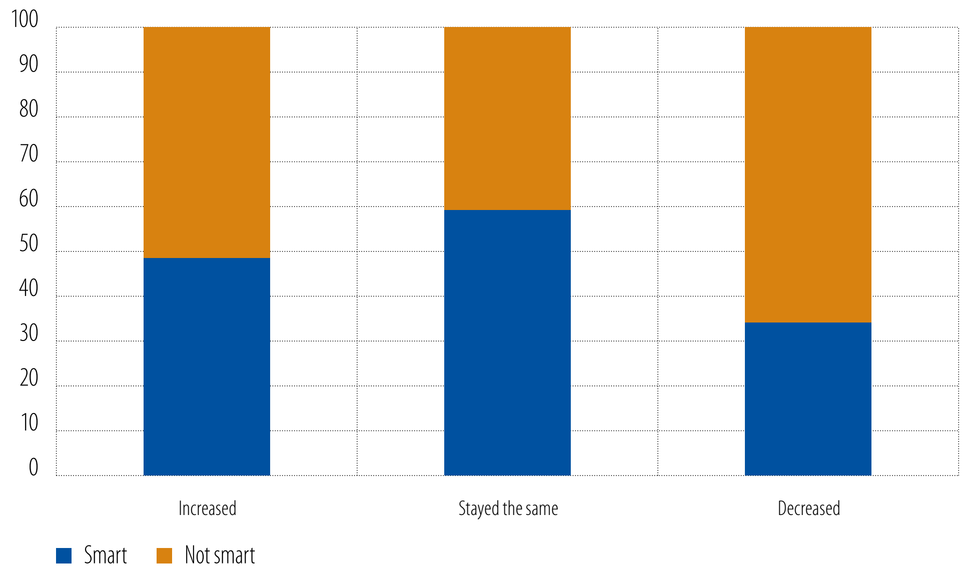
Weak government investment risks undermining the transition towards smart infrastructure for the future (United Nations, 2016; EIB, 2018b; OECD, 2018). As argued above, regions with falling infrastructure investment often shift their investment away from modernisation (Figure 2). In addition, municipalities that cut their infrastructure investment tend to identify the adoption of smart technology as less of a priority (Figure 7). Delays in adopting smart infrastructure may thus entail substantial long-term socio-economic costs (see below).

Figure 6
Government infrastructure investment share



Source: *EIB Infrastructure Database (IJ Global, EPEC, Eurostat).*
Note: *Data missing for Belgium, Croatia, Lithuania, Poland and Romania. EU average excludes the United Kingdom.*

Figure 7
Investments in smart technology as a policy priority in the last five years (in %)



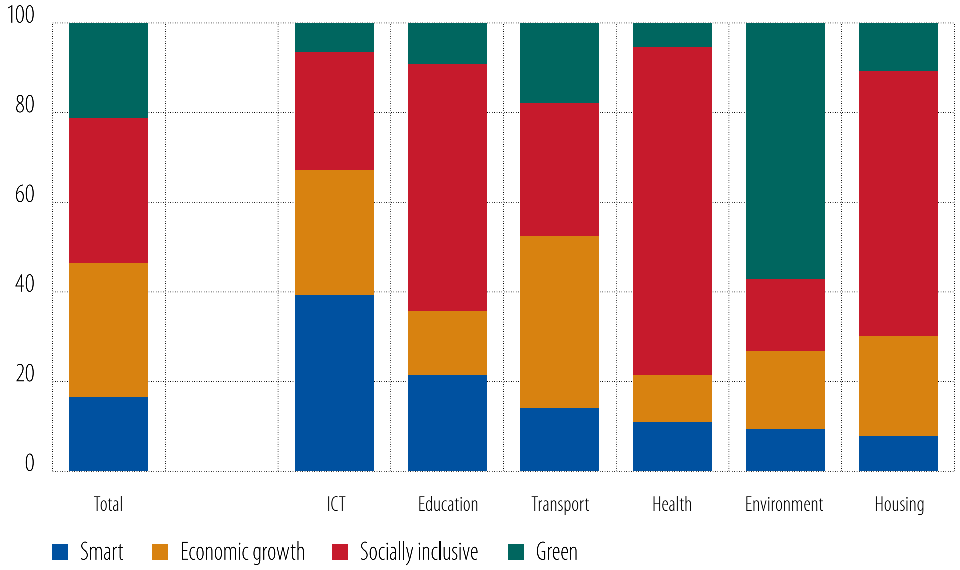
Source: *EIB Municipalities Survey 2017.*
Question: *From the following, what would you say will be the main priority of [municipality] in [sector] over the next five years? Investment in green infrastructure; smart infrastructure; socially inclusive infrastructure; infrastructure that boosts economic growth; no investment planned.*

Government investment into smart infrastructure

The EIB Municipalities Survey 2017 (EIB, 2017) enables us to better understand the drivers of and obstacles to investing in smart infrastructure.[4] The survey asked municipalities about their investment priorities, including i) making infrastructure greener, ii) smarter, or iii) socially more inclusive or iv) boosting economic growth. Overall, 17% of municipalities report ambitions to make their infrastructure smart (Figure 8). The share of municipalities with smart ambitions varies substantially across sectors. The share is particularly high in ICT, and fairly small in education and social housing. In the following we consider a municipality to have smart ambitions if it names "smart" as being a policy priority for at least one of the six infrastructure sectors.

Figure 8

Smart as a policy priority and investment in infrastructure over the last five years (in %)



Source: *EIB Municipalities Survey 2017.*
Question: *From the following, what would you say will be the main priority of [municipality] in [sector] over the next five years? Investment in green infrastructure; smart infrastructure; socially inclusive infrastructure; infrastructure that boosts economic growth.*

Some European metropoles have engaged in smart-city strategies. Typically these cities have ambitions that go beyond just smart infrastructure for one particular project or sector. Key themes related to a smart city include smart people, smart mobility, smart economy, smart living, smart governance and smart environment (Box D). Smart ambitions that go beyond just one project or sector are likely to entail substantial benefits in terms of synergies, lessons learned and making full use of the digital transformation.

4 The six infrastructure sectors covered by the EIB Municipalities Survey are urban transport, health, education, environment, social housing and ICT. The EIB Municipalities survey was administered by telephone (in the local language) in 2017. It targeted mayors, treasurers and/or municipalities' chief civil engineers. It took on average (median) 20 minutes to complete. Fieldwork took place between April and August 2017. As part of the survey, 555 municipalities were interviewed in all 28 Member States, split across 12 countries/country groupings covering all EU countries. For more details on the EIB Municipalities Survey 2017, see EIB (2017).

Box D

Smart cities

A smart, sustainable city is an innovative city that uses ICT and other means to improve quality of life, efficiency of urban operations and services and competitiveness, while meeting the needs of present and future generations in economic, social and environmental terms (International Telecommunication Union, 2014). This goes far beyond just infrastructure. Several efforts are currently underway to develop comprehensive key performance indicators for smart cities. Smart infrastructure is the foundation for all key themes related to a smart city, including smart people, smart mobility, smart economy, smart living, smart governance and smart environment. However, a given smart city solution cannot simply be transposed from one geographic region to another. Smart infrastructure concepts must be adapted to the local context and meet local development needs. Context, culture and economy all play a role in this process (United Nations, 2016).

The EIB utilises a broader and multi-dimensional framework to define smart cities and regions by introducing a Smart Region Index. The Smart Region Index, which was first developed and applied to Central Europe, focuses on aspects related to economic dynamics and innovation, environmental sustainability, quality of administration, accessibility, human capital and quality of life. This approach has the advantage of enabling the exploration of the underlying factors that cause the particular gaps. The analysis shows that Central Europe lags behind the European Union for mobility, governance and quality of life. Furthermore, the report presents an in-depth review of the performance of capital and non-capital regions in Central, Eastern and South-Eastern Europe and supports the consensus that regional disparities within countries are relatively large (EIB, 2018b).

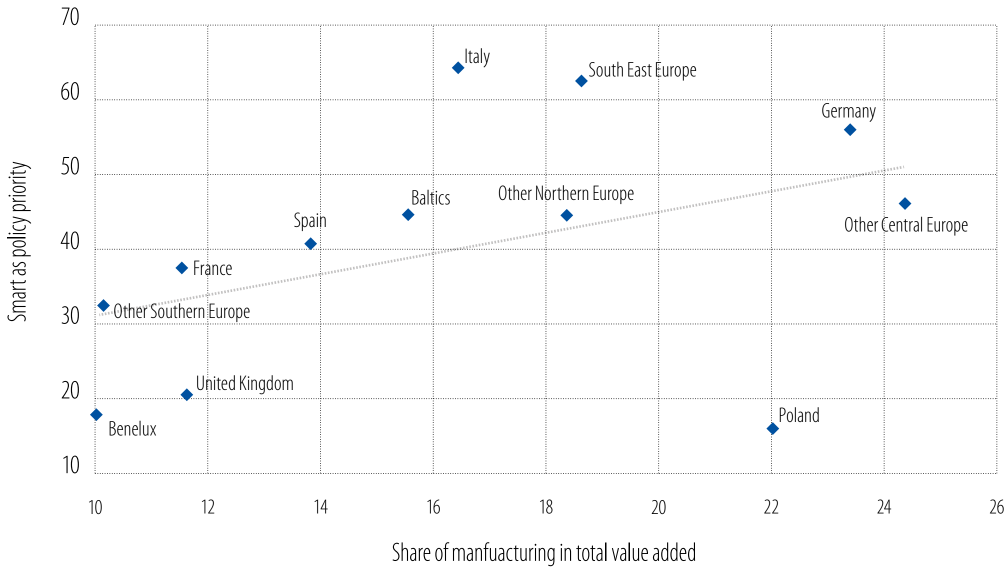
Evidence suggests that limited access to finance has a negative impact on municipalities' investment activities. Central, Eastern and South-Eastern Europe municipalities are therefore dependent on the European Structural and Investment Funds. As a result, the reforms of EU funding in the post-2020 Multi-Annual Financial Framework will be of crucial importance for the financial situation of municipalities in the future. Regional coordination and prioritisation of projects is also an important aspect that needs to be improved (EIB, 2018b).

Smart infrastructure ambitions and their determinants

Countries with comparatively large manufacturing sectors more often report smart infrastructure as a policy priority (Figure 9).[5] A notable exception is Poland where many municipalities report smart ambitions, despite a fairly small manufacturing sector. The positive association between smart ambitions and the size of the manufacturing sector may reflect stronger pressure from local industry to make infrastructure smart. As discussed in more detail below, the use of robots is particularly pronounced in the manufacturing sector. Because of their readiness to adopt the latest technologies, these companies may lobby more strongly for smart infrastructure within their commune.

5 Due to the limited number of observations, smaller countries are merged into groups (EIB, 2017). Overall 12 countries/country groups are considered: France (36 observations), Germany (30), Italy (30), Spain (30), Poland (30), United Kingdom (35), Other Northern Europe (92; Austria, Denmark, Finland, Ireland, Sweden), Other Southern Europe (58; Cyprus, Greece, Malta, Portugal), Other Central Europe (67; Czech Republic, Hungary, Slovakia, Slovenia), South-Eastern Europe (56; Bulgaria, Croatia, Romania), Baltics (45; Estonia, Latvia, Lithuania) and Benelux (46; Belgium, Netherlands, Luxembourg).

Figure 9
Smart infrastructure ambitions and manufacturing



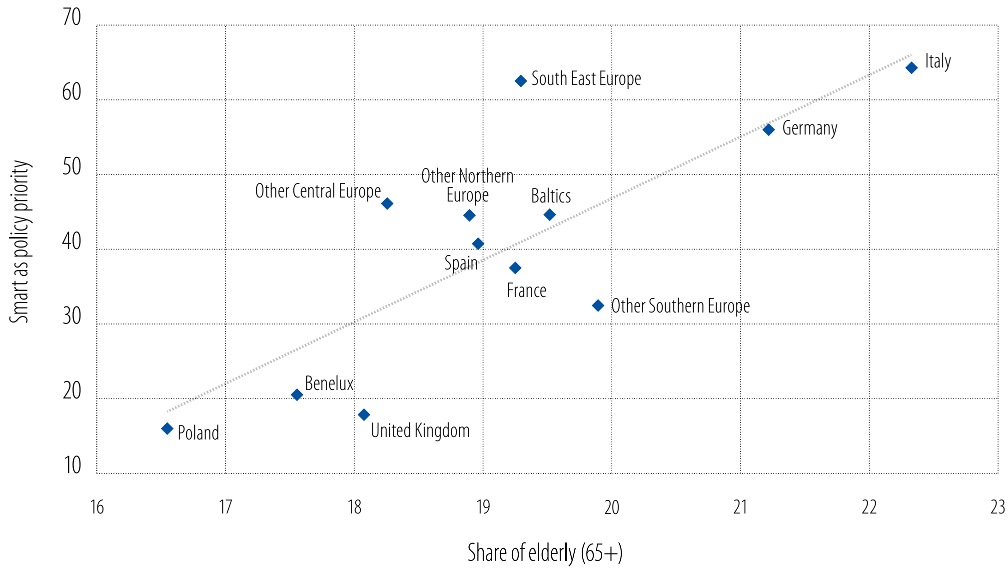
Source: Eurostat, EIB Municipalities Survey 2017.

Demographic change seems to be an important determinant for municipalities with smart infrastructure ambitions (Figure 10). Countries with a high share of elderly people are more likely to report smart as a policy priority for at least one infrastructure sector. One reason may be that countries with ageing societies see a need to quickly adapt their infrastructure to fast-changing requirements and facilitate access to infrastructure. The infrastructure adaptation comes on top of sectoral shifts triggered by demographic change (ILO and OECD, 2019). For instance, an ageing society is commonly associated with declining investment needs in education, but increasing needs in health.

National fiscal frameworks seem to be another important determinant of municipalities' ambition to invest in smart infrastructure. Specifically, municipalities that are fully or partially responsible for infrastructure investment are more likely to have smart ambitions (Figure 11). The higher propensity of municipal governments to pursue smart infrastructure if they have more responsibilities is in line with the literature on decentralisation (Kappeler et al. 2012; Sole-Olle and Sorribas-Navarro, 2012). Local governments are likely to better anticipate the needs of the local population. This may also make them more aware of the necessity to adapt infrastructure to future needs.

Figure 10

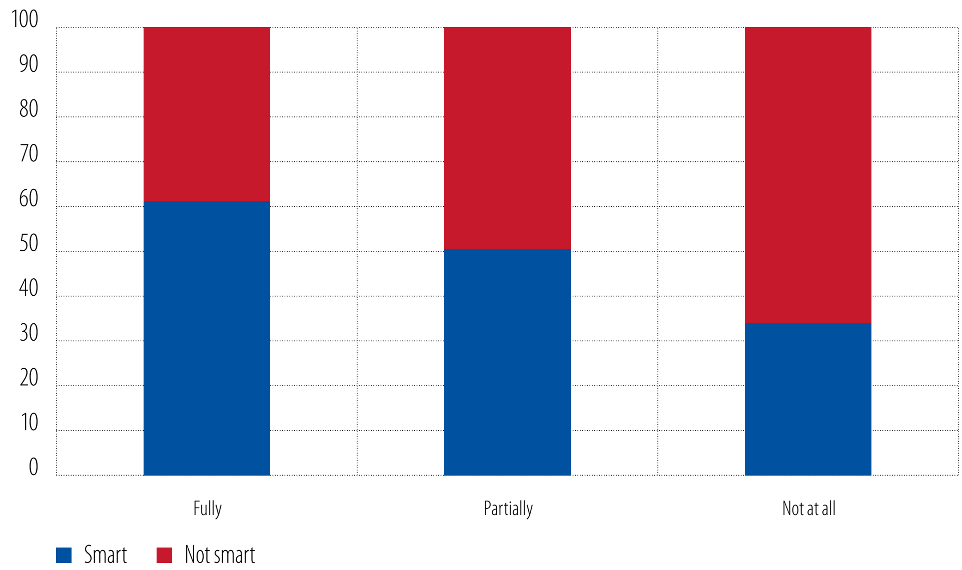
Smart infrastructure ambitions and demographic change



Source: Eurostat, EIB Municipalities Survey 2017.

Figure 11

Smart ambitions and responsibility for infrastructure (% of municipalities)



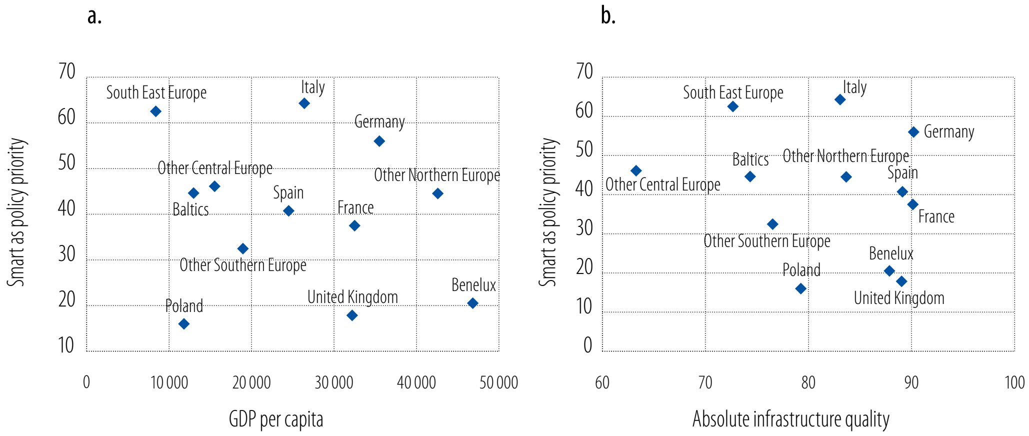
Source: EIB Municipalities Survey 2017.

Note: Share of municipalities that respond "fully", "partially", or "not at all" responsible to the question "Can you tell me your municipality's legal responsibility when it comes to infrastructure investment activities".

Smart infrastructure ambitions are not limited to certain income levels. Notably, the association between smart ambitions and GDP per capita is weak (Figure 12, Panel a). Moreover, there seems to be a weak association between smart ambitions and the quality of the existing infrastructure stock (Figure 12, Panel b). These findings suggest that cities expect to benefit from investments in smart infrastructure across the income spectrum and independently of the quality of the existing infrastructure stock. Smart infrastructure seems to be able to address the needs of both cities at relatively low levels of development and frontier cities. The relatively low capital intensity of many smart applications compared to putting in place new physical infrastructure may be one reason for this phenomenon.

Figure 12

Smart ambitions, GDP per capita and infrastructure quality



Source: EIB Municipalities Survey 2017 and Eurostat.

Barriers to smart infrastructure investment

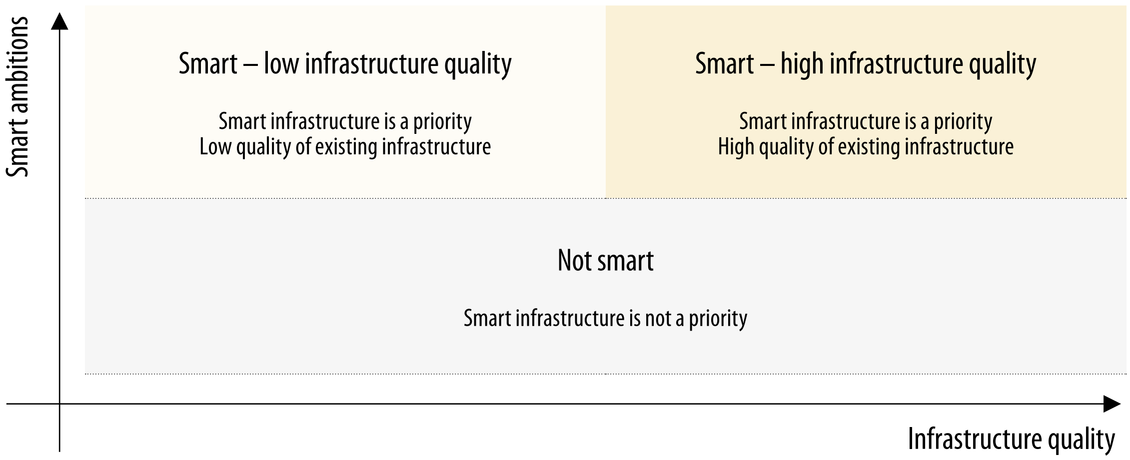
Municipalities that invest in smart infrastructure may face very different obstacles to their infrastructure investment activity than others. For instance, smart ambitions may entail different requirements for technical capacity. Moreover, regulatory constraints may affect projects differently depending on the digital content of an infrastructure project. This section takes a closer look at barriers to investment for municipalities with smart ambitions.

Obstacles to smart ambitions may vary depending on the quality of the existing infrastructure stock. As shown in Figure 12, Panel b, there is no clear association between infrastructure quality and smart ambitions. Nonetheless, municipalities with smart ambitions that have poor quality infrastructure may face very different challenges compared to those with high quality infrastructure. First, municipalities with high quality infrastructure may have already invested in smart infrastructure in the past and therefore have gained important experience in how to identify and implement smart projects. As information on smart infrastructure is not readily available, overall infrastructure quality appears to be a reasonably good proxy. The quality of infrastructure also matters because it is inversely associated with other socio-economic challenges with repercussions on perceived barriers to investment (EIB, 2018a). Notably, municipalities with poor infrastructure quality tend to be less densely populated and characterised by a lower GDP per capita; and those municipalities more often report financial constraints and technical capacity as major barriers to their infrastructure activities.

To analyse the obstacles to investment in smart infrastructure in more detail, municipalities are classified into three groups. Two variables are used for the classification: the ambition of a municipality to make its infrastructure smart; and self-reported infrastructure quality (Figure 13). Again, smart refers to municipalities that report smart infrastructure as a policy priority for at least one sector. Infrastructure quality at a municipal level is based on self-reported infrastructure quality in the EIB Municipalities Survey 2017 (EIB, 2017). To eliminate country biases in self-assessments, quality scores are expressed as relative deviations from the country or regional mean. The three groups are:

I. **Smart – high infra quality:** Municipalities with smart as an infrastructure priority for the next five years in at least one sector that report high infrastructure quality relative to the country mean;
II. **Smart – low infra quality:** Municipalities with smart as an infrastructure priority for the next five years in at least one sector that report low infrastructure quality relative to the country mean;
III. **Not smart:** Municipalities that do not report smart as an infrastructure investment priority for the next five years for at least one sector. Some of these municipalities report that the quality of their existing infrastructure is high and some report that it is low. To reduce the complexity of the analysis (which focuses on smart infrastructure), these two groups are reported together.

Figure 13
Classification: smart ambition and infrastructure quality



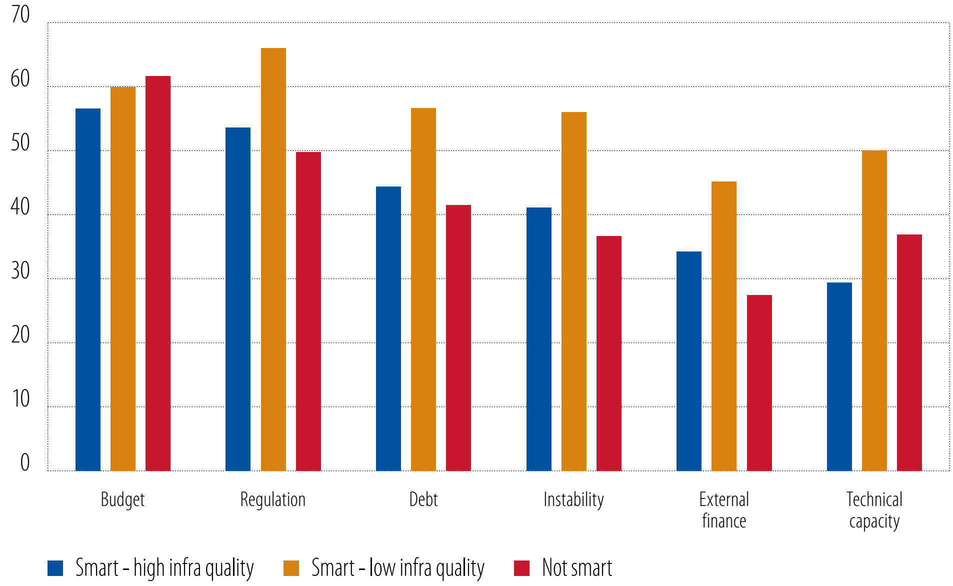
Municipalities that invest in smart infrastructure suffer from a number of investment barriers (Figure 14). Municipalities with smart ambitions cite regulation, debt ceilings, instability and lack of access to external finance more often than municipalities without smart ambitions. The positive association between obstacles and smart ambitions suggests that many obstacles are perceived as more binding constraints for municipalities that implement smart infrastructure projects. One reason could be that smart infrastructure projects are more demanding in terms of financing, technical capacity and regulatory requirements.

Most barriers are reported particularly often by municipalities with smart ambitions and poor infrastructure stock. This is particularly the case for regulation, instability, technical capacity and external finance (Figure 14). Poor infrastructure quality tends to be associated with municipalities perceiving more obstacles to investment, as discussed in detail in the EIB Investment Report 2018 (EIB, 2018a). However, smart ambitions add to the perception of most obstacles as binding constraints. This is evidenced by the blue and brown bars in Figure 14, which both exceed the red bar for most obstacles. The red bars represent an average across municipalities with no smart ambitions but different infrastructure qualities.[6]

6 Even when subdividing municipalities with and without smart ambitions into those with high and low infrastructure quality, it is confirmed that smart ambitions in many cases result in a higher perception of obstacles. To avoid excessive complexity, the results for these four groups of municipalities are not reported in Figure 11.

Figure 14

Major obstacles to infrastructure investment (% of municipalities by smartness as policy objective for infrastructure investment)



Source: *EIB Municipalities Survey 2017.*
Question: *To what extent is each of the following an obstacle to the implementation of your infrastructure investment activities? Is it a major obstacle, a minor obstacle or not an obstacle at all? Balance between revenues and operating expenditure; limit on amount of debt the municipality can borrow; access to external finance (excluding funding from other government bodies); technical capacity to plan and implement infrastructure projects; length of regulatory process to approve a project; political and regulatory stability. Results for coordination between regional and national policy priorities not shown.*

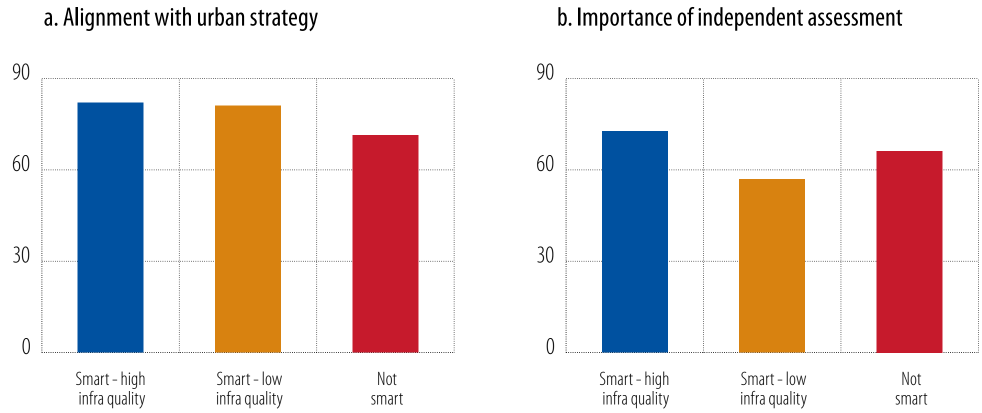
Strong technical and administrative capacities are key to ensuring smart infrastructure projects are planned and implemented efficiently. A comprehensive assessment of the costs, benefits and alignment with the region's strategic orientation of projects is key for any infrastructure project (ESPON, 2017). For smart projects, this is likely to be even more important because of their innovative nature and the often limited experience of authorities with such projects. Planning and implementing smart infrastructure projects requires additional skills and the ability to assess the latest technological developments and their potential to make infrastructure smart (United Nations, 2016).

Municipalities that invest in smart infrastructure tend to engage more often in independent assessments of their infrastructure projects (Figure 15, Panel a). At the same time, they are more likely to consider the outcome of independent assessments as important when taking decisions on projects (Figure 15, Panel b). This suggests that municipalities that invest in smart infrastructure are more aware of the need for sound project selection. Further efforts are needed to spread best practices and ensure that all municipalities conduct independent assessments of a project's costs and benefits and effectively use the outcomes of these assessments in their decision-making processes.

Funding constraints may hold back investment in smart infrastructure. Lack of access to external finance is identified as a major constraint more often by municipalities that invest in smart infrastructure (see Figure 14). Municipalities that invest in smart infrastructure seem to be constrained in their access to external finance by the amount of funding needed (reported by 8% of municipalities) and administrative procedures (6%). Conversely, the number of available external financing sources, maturity and interest rates seem to be less important constraints.

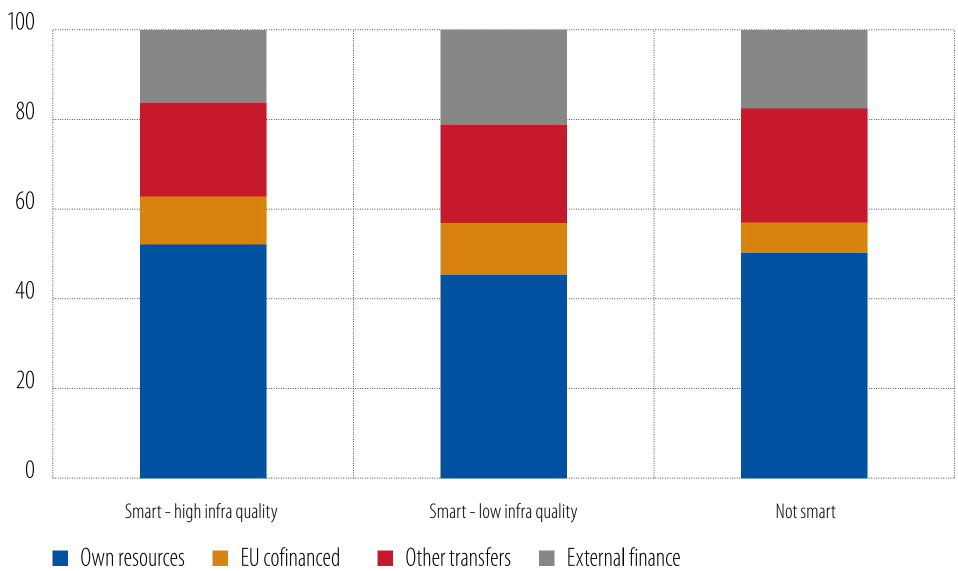
As to the funding mix of infrastructure projects, municipalities that invest in smart infrastructure tend to benefit more often from EU funds (Figure 16). The higher share of EU funding may reflect the focus of EU funds on new and innovative projects. However, there are also important differences in the funding of municipalities with smart ambitions depending on the quality of their existing infrastructure. Notably, those with high quality infrastructure tend to use more external and less internal funding, which may reflect their stronger exposure to overall financing constraints.

Figure 15
Independent assessment of projects



Source: EIB Municipalities Survey 2017.
Question: Share of municipalities that respond "always" or "frequently" to the question "Before going ahead with an infrastructure project, do you carry out an independent assessment of …?" Panel b reports the share of municipalities that respond "critical" or "important" to the question "And how important would you say are the results of the independent assessment/s when deciding whether or not to go ahead with a project?"

Figure 16
Sources of infrastructure financing (% of municipalities)



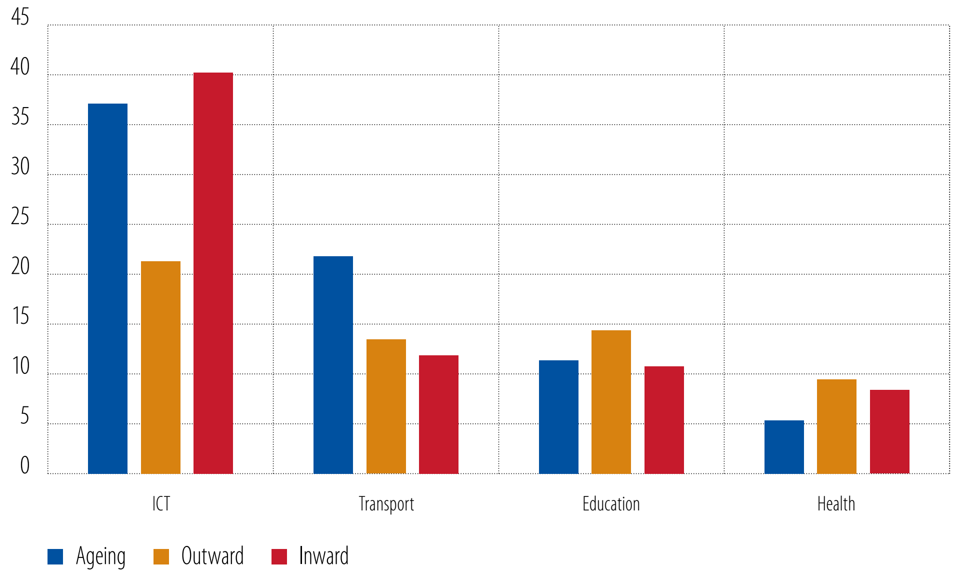
Source: EIB Municipalities Survey 2017.
Question: Can you tell me approximately what proportion of your infrastructure investment activities are financed by: own resources; EU co-financed programmes; other transfers from regional or national governments; external finance (i.e. bank finance or capital market finance).

Sectoral differences matter for smart ambitions

Smart ambitions differ across sectors. Sectoral differences in smart ambitions may reflect different needs, varying degrees of complexity of smart infrastructure projects across sectors and sector-specific characteristics. These characteristics may include ownership structures, regulatory requirements and technical readiness.

The same drivers can be stronger for some sectors and weaker for others. For instance, when it comes to demographic trends, inward migration seems to be associated more often with smart ambitions in ICT (Figure 17). If ageing is an important demographic driver, smart ambitions are articulated in transport and ICT comparatively often. Outward migration is associated with smart ambitions in the health and education sectors.

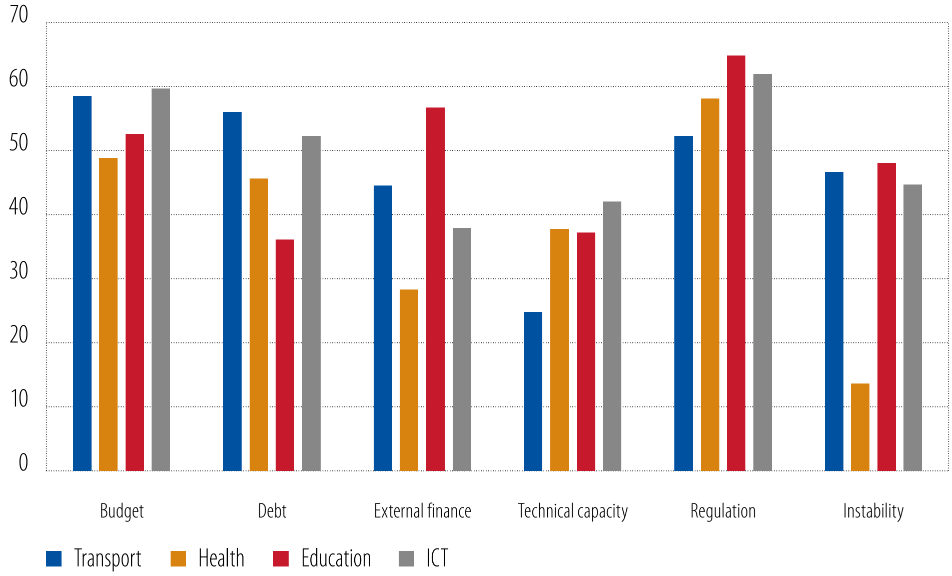
Figure 17
Smart ambitions and obstacles
(% of municipalities with smart ambitions that report obstacles as major constraints)



Source: *EIB Municipalities Survey 2017.*
Question: *To what extent do each of the following impact the demographic situation in your municipality? Low fertility; an ageing population; outward migration; inward migration.*

As is the case for barriers, financial constraints seem to matter disproportionately for transport (Figure 18). At the same time, regulation seems to matter more for education and ICT. The awareness of technical capacity constraints seems to be particularly pronounced among municipalities with smart ambitions in the ICT sector, while external finance is a major issue for education. These results broadly hold when directly comparing municipalities with smart ambitions with those municipalities without smart ambitions (not shown in Figure 15).

Figure 18
Smart ambitions and obstacles
(% of municipalities with smart ambitions that report obstacles as major constraints)



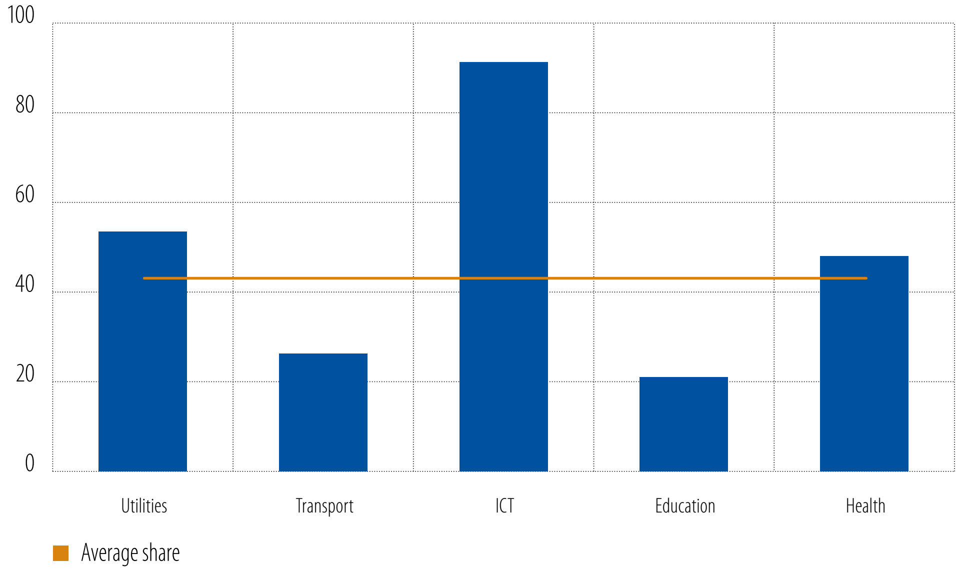
Source: *EIB Municipalities Survey 2017.*
Question: *To what extent is each of the following an obstacle to the implementation of your infrastructure investment activities? Is it a major obstacle, a minor obstacle or not an obstacle at all? Balance between revenues and operating expenditure; limit on amount of debt the municipality can borrow; access to external finance (excluding funding from other government bodies); technical capacity to plan and implement infrastructure projects; length of regulatory process to approve a project; political and regulatory stability. Results for coordination between regional and national policy priorities not shown.*

Corporate sector

Corporate infrastructure investment accounts for about 40% of overall infrastructure investment in the European Union. The share of corporate investment varies significantly across sectors (Figure 19): while it accounts for most infrastructure investment in ICT (representing 91% of total infrastructure investment) and the utilities sector (53%), the corresponding shares in transport and education are much lower (less than 30% of overall infrastructure investment). The health sector is characterised by a relatively even split of infrastructure investment activities coming from the corporate and government sectors.

Figure 19

Corporate infrastructure investment (average share from 2011 to 2017, in %)



Source: *EIB Infrastructure Database, EIB Economics Department calculations.*
Note: *Average share from 2011 to 2017, in %.*

Recent developments in corporate infrastructure investment

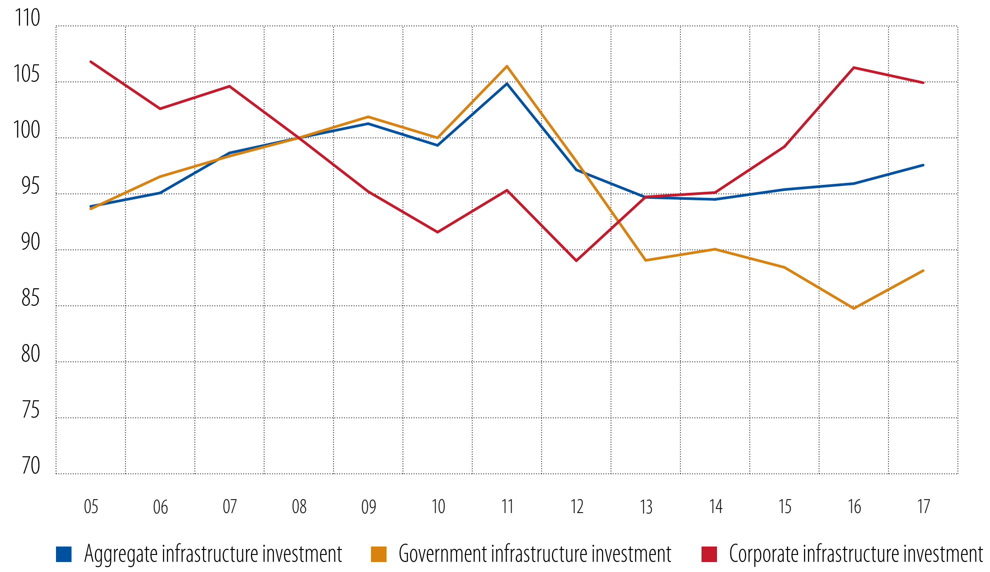
Corporate infrastructure investment has outperformed government infrastructure investment in recent years. (Figure 20). In 2017, infrastructure investment activities by the corporate sector stood at about 105% of their 2008 levels (in real terms). This compares to about 88% for the government sector. The recovery in corporate infrastructure investment activities took off in 2012, after four years of negative or very sluggish growth. The dynamics of corporate infrastructure investment activities are therefore comparable to those of the corporate sector overall (Chapter 1).

The recovery in corporate infrastructure investment still lacks breadth, however. This is true both in terms of regions and the number of sectors the recovery spans. Infrastructure investment activities in Western and Northern Europe have been relatively stable. Although the recovery in corporate infrastructure investment in Southern Europe has been slower, it managed to surpass its 2008 levels (in real terms) after a strong pick-up in in 2016. Corporate infrastructure investment activities in Central and Eastern Europe has only just started to recover after four years of decline. At 70%, investment activities are still a long way short of their 2008 levels in this region (Figure 21, Panel a).

Among the sectors in which infrastructure investment accounts for at least 40% of overall investment activities, only health has grown strongly in recent years. Corporate infrastructure investment activities in utilities and ICT, on the other hand, remain weak compared to their 2008 levels (Figure 21, Panel b).

Figure 20

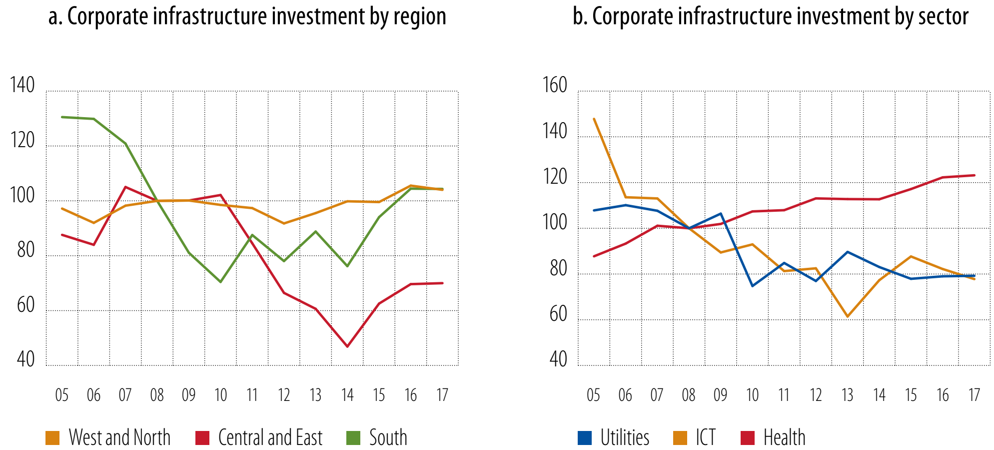
Infrastructure investment (real, indexed to 100 in 2008)



Source: *EIB Infrastructure Database, EIB Economics Department calculations.*
Note: *Gross fixed capital formation (GFCF) series are deflated and weighted by the respective countries' GDP.*

Figure 21

Corporate infrastructure investment (real, indexed to 100 in 2008)



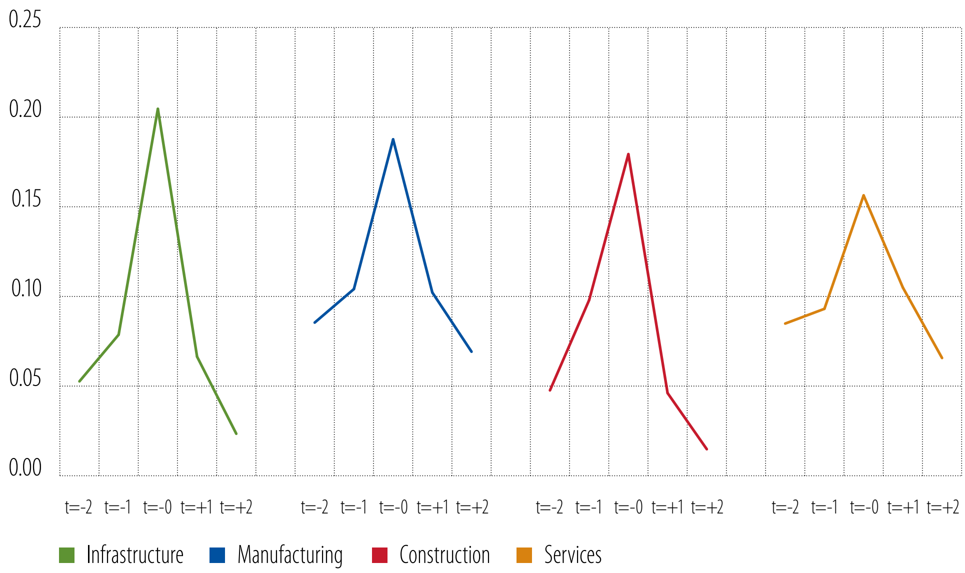
Source: *EIB Infrastructure Database, EIB Economics Department calculations.*
Note: *Western and Northern Europe: Austria, Denmark, Finland, France, Ireland, Germany, Luxembourg, the Netherlands, Sweden; Southern Europe: Cyprus, Greece, Italy, Malta, Portugal, Spain; Central and Eastern Europe: Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Slovakia, Slovenia.*

Determinants of corporate infrastructure investment

The key driver of the pick-up in corporate infrastructure investment is strengthening demand. Using a micro-dataset of about 10 000 infrastructure firms in the European Union (EIB, 2018a), we find that corporate investment activities in infrastructure are strongly positively correlated with (contemporaneous) changes in sales growth. The elasticity of investment to demand is comparable across different infrastructure sectors and also consistent with results from a similar analysis on non-infrastructure firms, suggesting few differences in the interplay of sales growth and corporate investment activities both within the infrastructure sector and between infrastructure firms and other firms (Figure 22).

Figure 22

Correlation between investment and sales growth (coefficient)



Source: *EIB Infrastructure Database used for the correlation in infrastructure, EIB EIBIS_Orbis Database used for the correlation in manufacturing, construction and services, EIB Economics Department calculations.*

Note: *Correlations for each sector are given for a span starting from two periods before (t=-2) and going to two periods after (t=+2) a current period (t=0).*

Access to finance is also (largely) supportive of investment activities by infrastructure firms. We find no difference in the responsiveness of corporate investment activities to changes in sales growth between infrastructure firms with high and low levels of cash flow. This suggests that, in line with a well-functioning financial market, firms are able to pursue new investment opportunities irrespective of their internal cash generating capabilities by relying on external sources of funding.

The main exception to this are infrastructure firms located in Southern Europe. Regressing firms' investment activities on sales growth, cash flows, an interaction term between the two, and firm and year fixed effects, we find a strong positive correlation between cash flows and firms' investment responsiveness to sales growth in this region. This is true if we use the full time frame for the estimation (spanning the years 2009 to 2017) as well as just more recent years (2012 to 2017) (Table 2).

Table 2

Determinants of investment by infrastructure firms

	(1)	(2)	(3)	(4)
Country group	All	Central and Eastern Europe	Western and Northern Europe	Southern Europe
VARIABLES	Investment	Investment	Investment	Investment
Investment (t-1)	-0.117***	-0.111***	-0.0942***	-0.135***
	(0.0119)	(0.0209)	(0.0177)	(0.0189)
Sales growth (t)	0.380***	0.224***	0.452***	0.400***
	(0.0418)	(0.0541)	(0.0764)	(0.0622)
Cash flow/total assets (t-1)	0.299***	0.203*	0.186*	0.499***
	(0.0708)	(0.104)	(0.098)	(0.179)
Sales growth (t) # Cash flow/total assets (t-1)	0.201	-0.197	0.0911	0.928*
	(0.373)	(0.379)	(0.728)	(0.57)
Government infrastructure investment (t-1)	0.0998**	0.145**	-0.00712	-0.00051
	(0.04)	(0.0685)	(0.198)	(0.0698)
Constant	0.0936***	0.0706**	0.0860**	0.173***
	(0.0143)	(0.0276)	(0.0391)	(0.0305)
Observations	36 819	6 623	18 114	12 082
R-squared	0.039	0.029	0.041	0.049
Number of firms	6 274	1 052	3 186	2 036
Year dummies	yes	yes	yes	yes
Firm fixed effects (FE)	yes	yes	yes	yes
Robust standard errors in parentheses				
*** p<0.01, ** p<0.05, * p<0.1				

Source: *EIB Corporate Infrastructure Database.*
Note: *The dependent variable is firm investment defined as the change in fixed assets. The time period of the analyses is 2009 to 2017. The symbol # denotes an interaction term, (t) denotes the time period "t", (t-1) denotes time period "t-1". The large sample size eliminates a Nickell bias. All models include firm fixed effects (FE). In parentheses we show robust standard errors clustered by firm; *, ** and *** denote statistical significance at the 10%, 5% and 1% confidence levels, respectively.*

Weak government infrastructure investment, on the other hand, continues to drag on corporate investment activities in some regions and sectors. We find a strong and statistically significant positive correlation between sector-specific government infrastructure investment activities (as a percentage of GDP) and corporate investment activities. The positive coefficient for government infrastructure investment is most pronounced in the ICT sector and the health sector as well as in Central and Eastern Europe[7] (Table 2). It points towards strong investment synergies between the government and the corporate sector in these infrastructure sectors and regions.[8]

7 The effect is unlikely to be driven by the structural funds cycle. We include a lagged variable of government investment and also year fixed effects. The two together make it unlikely for us to pick up contemporaneous funding shocks.

8 A second way government infrastructure investment and corporate infrastructure investment are often interlinked is through the strength of institutions. During the crisis, we saw several examples of governments putting pressure on national regulators to not increase (or even decrease) prices for end consumers with the aim of dampening the negative economic effects of the crisis. This came on top of marked cuts in government infrastructure investment and meant, of course, a strong disincentive for infrastructure firms to invest more (EIB, 2018a). In our regression framework, this channel should, however, be absorbed by the inclusion of country fixed effects.

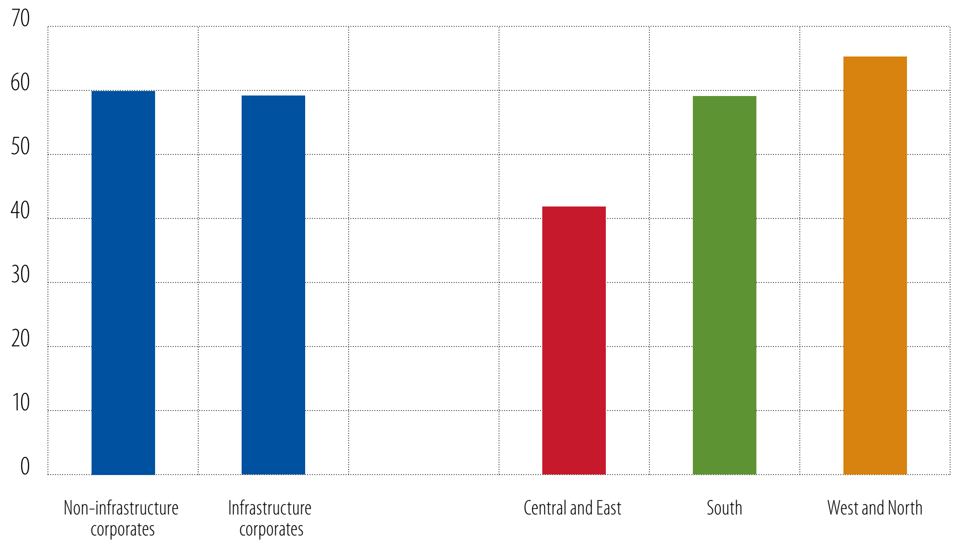
While investment by infrastructure firms is steadily improving, little is known about the composition of this investment. Specifically, little is known about the digital content of the recent pick-up in investment activities. In both the government sector and the non-infrastructure corporate sector, high investment activities often go hand in hand with investment in digital assets (Chapter 1). So far there has been little to no systematic work on whether the same is true for infrastructure firms. The following section makes an initial attempt to do this.

Digitalisation and corporate infrastructure investment

The uptake of digital technologies is about average in infrastructure firms (Figure 23). When we match our dataset of infrastructure firms with survey findings from the latest wave of the EIB Investment Survey, we find that the share of corporates that have adopted at least one digital technology is similar for those that are in infrastructure and those that are not.

Figure 23

Uptake in digital technology (share of firms, in %)



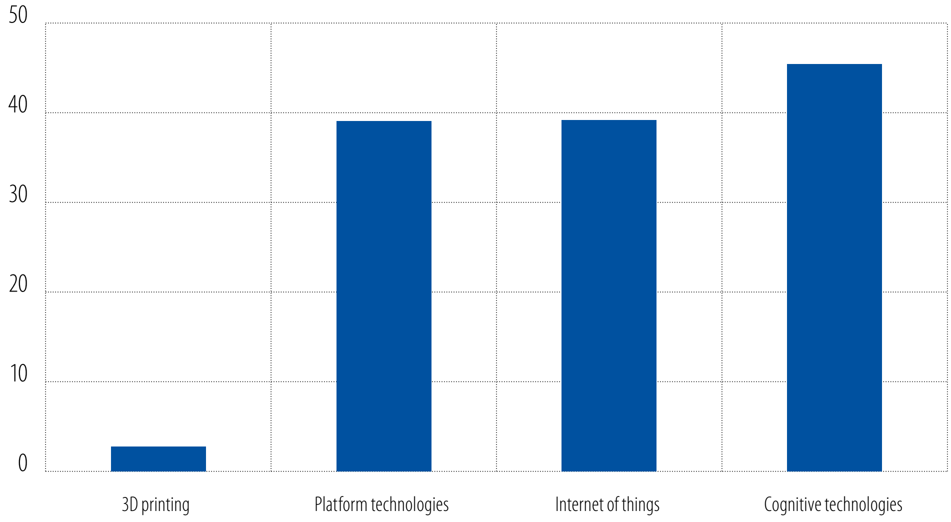
Source: *EIB EIBIS_Orbis Database, EIB Economics Department calculations.*
Note: *Share of firms adopting digital technology, by sector and region.*

Central and Eastern Europe tends to lag in the rate of digital adoption for the corporate infrastructure sector (Figure 23). A mere 40% of firms have adopted (or organised their entire business around) a digital technology in this region, which is low by comparison with 60% in Southern Europe and as much as over 65% in Western and Northern Europe.

For the digital technologies employed, infrastructure firms display a broad interest across all types of technologies (see Figure 24). While only a very small share of infrastructure firms focus on 3D printing, at least 40% are interested in platform technologies, the internet of things or cognitive technologies.

Figure 24

Uptake in digital technology (share of firms, in %)

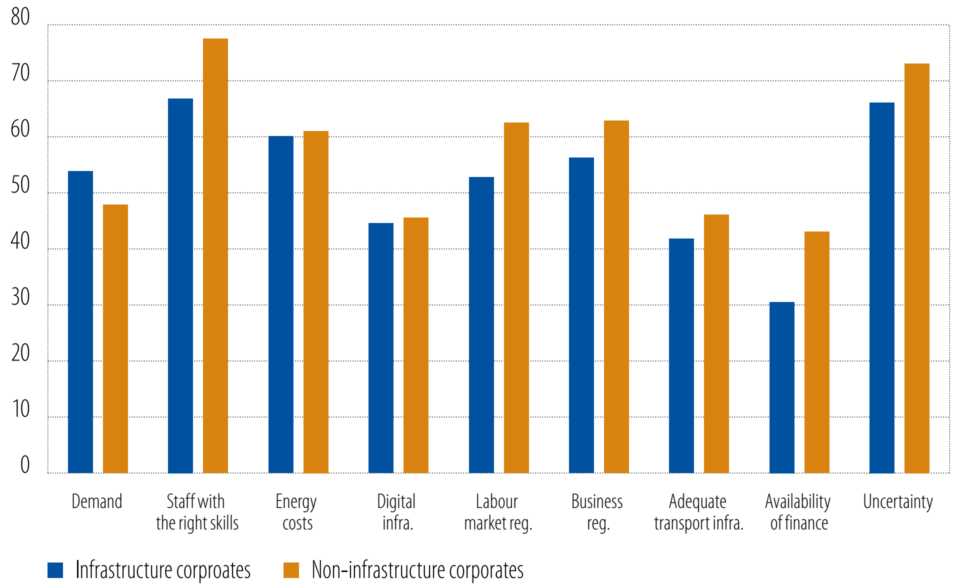


Source: *EIB EIBIS_Orbis Database, EIB Economics Department calculations.*
Note: *Share of firms adopting digital technology, by sector and region.*

The main obstacles that infrastructure firms face in their investment decisions are lack of skills and uncertainty, followed by energy costs. Even though these bottlenecks relate to their investment activities in general and not only to investment in digital assets, when we compare the share of mentions from infrastructure firms that have adopted at least one digital technology to those that have not, we find that investment barriers are even more pronounced among firms without any adoption activities to date.

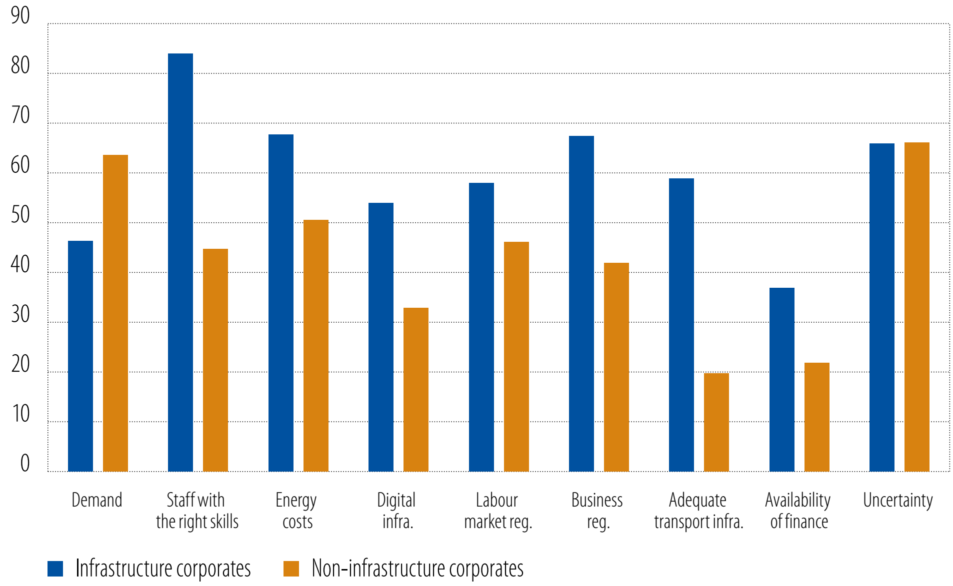
Figure 25

Investment bottlenecks: infrastructure vs non-infrastructure firms (share of firms, in %)



Source: *EIB EIBIS_Orbis Database, EIB Economics Department calculations.*
Note: *Share of firms identifying certain factors as a barrier to investment.*

Figure 26
Investment bottlenecks: digital vs non-digital infrastructure firms (share of firms, in %)



Source: *EIB EIBIS_Orbis Database, EIB Economics Department calculations.*
Note: *Share of firms identifying certain factors as a barrier to investment.*

Benefits of digitalisation of infrastructure firms

Slow digital adoption comes with an increased risk of disruption. A salient example of this is the telecoms sector, which has experienced strong downward pressure on sales volumes following the offer of free text and long distance call services from non-infrastructure firms (e.g. WhatsApp and Skype). While not directly infrastructure-related, the revenues from these services had helped to cross-fund infrastructure investment activities in the past. The drop in revenues from these services therefore negatively affects investment in new ICT infrastructure (Davies, 2016).[9] Similar risks of business model disruption exist for other infrastructure sectors (Waldron and Nokuboka, 2017).

Infrastructure corporates that adopt digital technologies are more profitable. On the other hand, we do not find evidence of a positive effect on sales growth or investment. The latter is interesting as it is at odds with experience in the non-infrastructure sector where, as seen in Chapter 1, digital adoption leads to higher sales growth and is also associated with significantly higher investment activities.

To study the link between robot/digital adoption and firm performance/firm investment, we match our micro-dataset of 10 000 infrastructure corporates with a sector-level International Federation of Robotics database to carry out two simple comparisons.

- In the first comparison, we contrast how firm performance and firm investment evolved for infrastructure firms that are active in sectors that experienced strong growth in robot adoption (relative to the sector median)[10] vs infrastructure firms active in sectors with slower growth in robot adoption.
- In the second comparison, we zoom in on the group of infrastructure firms that are active in sectors with strong robot growth. In this group, we then use a benchmark to compare the evolution of firm

9 While the decline in costs for text messaging was a clear improvement for customers, the fact that the revenues associated with the new services are booked on the income statements of large, mostly US-based tech companies implies a net loss in view of future investments in digital infrastructure (Davies, 2016).

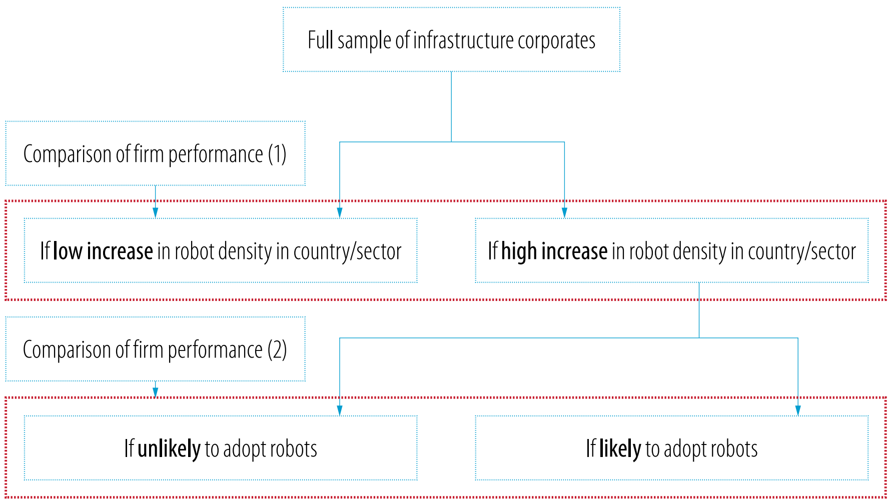
10 This is to avoid comparing across different sectors.

performance and investment for firms that are more likely to have adopted robots against that of firms that are less likely to have done so.

This second comparison helps us to strengthen the link between changes in robotisation and firm performance or investment as we are comparing firms within the same countries and sectors with each other. To identify firms that are more or less likely to have begun using robots in our sample, we rely on variables that are closely linked to robot adoption, such as stock of intangibles.

Figure 27 illustrates our approach.

Figure 27
Schematic structure of the impact of the adoption of robots



Robots can serve as a good proxy for digitalisation activities, particularly in the absence of any other related time-series information needed to study the impact of digitalisation on firm performance. Robots are defined in the International Federation of Robotics database as "automatically controlled, re-programmable, and multipurpose machine[s]." As explained in more detail in International Federation of Robotics (2016), this means that robots are "fully autonomous machines that do not need a human operator and that can be programmed to perform several […] tasks."

Despite being an imperfect measure, robot adoption is a good approximation for digitalisation efforts by infrastructure firms over time. First, our robot data includes many of the most important digital technologies available to infrastructure firms. Examples are aerial drones, gas pipe repair robots, water pipe inspection robots, automatic toll readers and other sensor based technologies, surgery robots, therapeutic robots and many others (Liu, Dissanayake, Valls Miro and Waldron, 2014; Matthews, 2017; Butler, 2018; Demaitre, 2018; Greene, 2019).

In addition, while our robot dataset does not capture all types of digital technologies, in particular those that are purely software-based, we find a close correlation between robot adoption and capital stock in software and databases. Similarly, the stock of robots in the infrastructure sector is positively correlated with the use of 3D printing, internet of things applications, and artificial intelligence applications, suggesting a high degree of overlap between the use of robots and other digital applications.[11]

11 The stock of software and databases comes from the EU KLEMS database. Data on 3D printing, internet of things applications and artificial intelligence applications comes from the 2019 EIB Investment Survey.

While a simple comparison of firm performance and investment between sectors with high robot growth vs low robot growth suggests an improvement across various measures, only firm profitability is robust in our within-group comparison. Across a series of profitability measures, we find a significantly more favourable evolution among firms active in sectors where robot adoption increased more. At first glance, sales growth and firm investment activities also seem to have fared better in these sectors and countries. (Comparison 1 is shown in Figure 28).

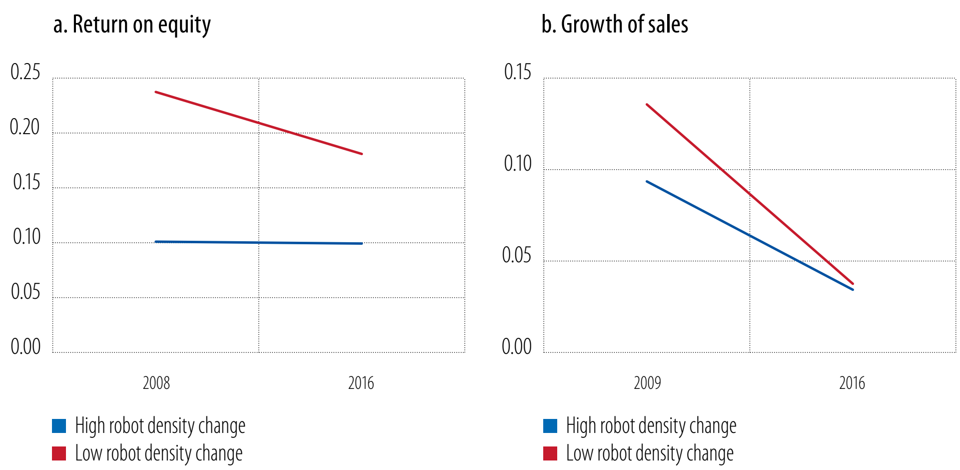
However, once we zoom in on the group of firms that are active in sectors or countries subject to higher robot adoption, only the relationship between firm profitability and robot adoption is robust. We find better profit growth for firms more likely to have adopted robots , but no measurable difference in terms of sales growth and/or investment activities between these firms and those less likely to have participated (Comparison 2 is shown in Figure 29).

Our results suggest that infrastructure firms primarily use robots and digital assets to boost efficiency, and rarely to achieve more transformational changes. At the beginning of this chapter, we outlined the various aims that digitalisation activities can help achieve in the infrastructure domain. Our findings suggest that infrastructure firms often use robot and digital technologies to pursue efficiency-centred goals; after all, steady sales and high profits point towards efficiency improvements in an environment of fixed, regulated prices. The absence of more investment (and stronger sales growth), on the other hand, indicates that the adoption of robots and digital technologies rarely leads to the development of new products or services.

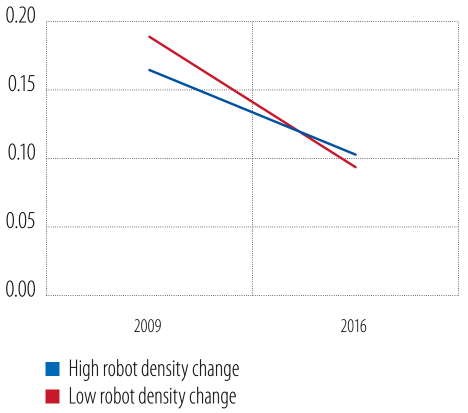
The strong focus on efficiency is favoured by (excessively) static, steady-state price regulation. In the light of new technological opportunities, it is no longer sufficient to focus on the efficient use of existing infrastructure together with replacement and reinforcement investment. Regulation should also consider disruptive innovation and infrastructure transformation. This means that regulators should adopt a more flexible approach to keep pace with and learn from market developments (including through trials and pilot projects), even if they do so temporarily to understand the benefits of new approaches.

Figure 28

Comparison 1 of firm performance/investment (mean value)



c. Investment



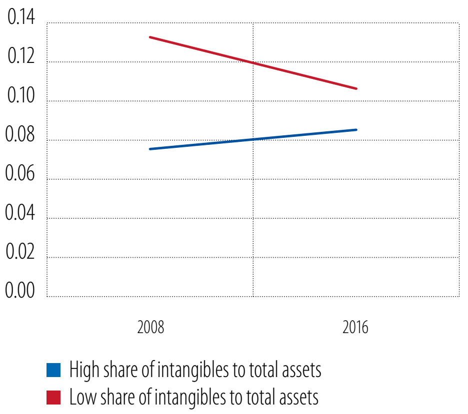
Source: *Matched EIB Corporate Infrastructure Database and IFR Robot data, EIB Economics Department calculations.*

Note: *The figures show the evolution for various firm performance and investment measures between firms active in sectors that experienced strong growth in robot density over the same time period (relative to the sector median) vs firms active in sectors that experienced weak growth in robot density.*

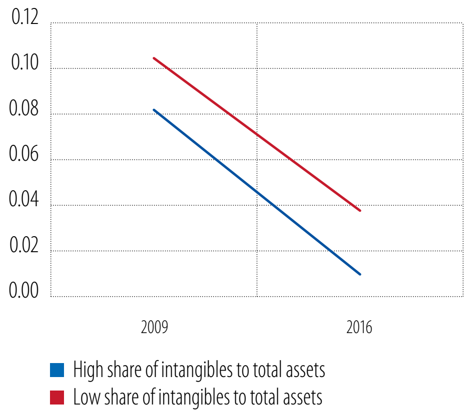
Figure 29

Comparison 2 of firm performance/investment (mean value)

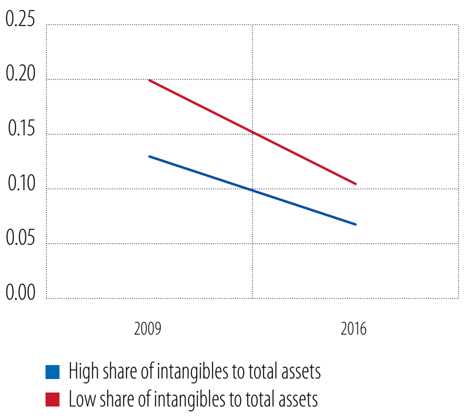
a. Return on equity



b. Growth of sales



c. Investment



Source: *Matched EIB Corporate Infrastructure Database and IFR Robot data, EIB Economics Department calculations.*

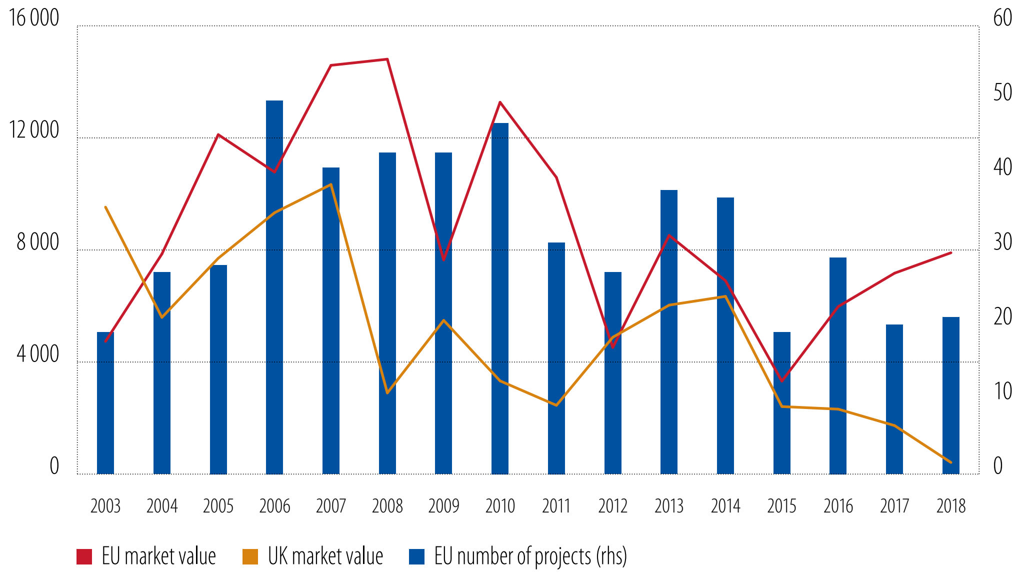
Note: *The figures show the evolution for various firm performance and investment measures between firms that are more likely to have taken part in robot adoption vs firms that are less likely to have done so. We use the stock of firms' intangible assets as a proxy for whether they are more or less likely to have taken part in robot adoption. The sample includes only infrastructure firms active in sectors that experienced a relatively strong increase in robotisation overall.*

Public-private partnerships

The EU market for public-private partnerships (PPP) has undergone significant transformation in the decade since the crisis, with a revival since 2016 marked by an increased use for broadband networks. The overall market for PPPs has shrunk and its composition has changed. Activity contracted considerably in terms of both the value and total number of projects; volumes have only started to recover since 2016 (Figure 30).

Figure 30

PPP market-size evolution



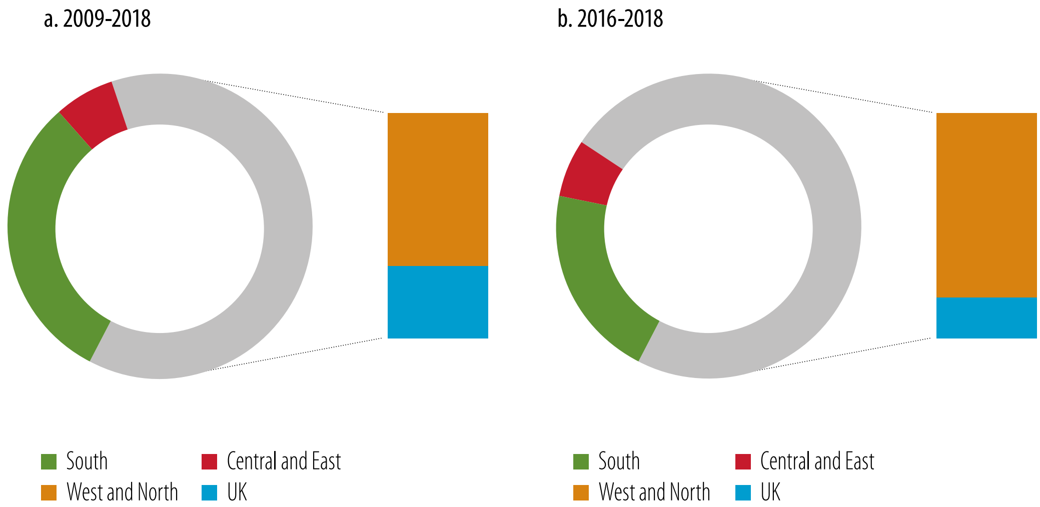
Source: *European PPP Expertise Centre.*
Note: *Total value of PPP infrastructure projects (EUR millions, lhs) at financial close per annum in the European Union and United Kingdom, together with the total number of PPP infrastructure projects in the European Union (rhs).*

The overall contraction and recent stabilisation masks major regional differences (Figure 31). The market value in Western and Northern Europe has returned to pre-crisis levels, compensating for the lack of activity elsewhere. Before the crisis, the United Kingdom was pre-eminent and served as a benchmark. Today, at a national level[12], PPPs as a procurement tool to advance certain policies have effectively been suspended, and overall volumes are declining. The PPP market in Southern Europe rivalled that of the United Kingdom prior to the crisis, but suffered a slightly larger contraction than the overall EU market. The PPP market in Central and Eastern Europe remains small, and the uptick in activity before the crisis was only short-lived.

Both fiscal constraints and the private sector have played important roles in the dynamics of the PPP market in the decade since the crisis. Tighter budgets reduced public authorities' willingness to commit funds to infrastructure projects, including future revenue streams to PPPs. In addition, the uncertainty and high financing costs that prevailed right after the crisis sharply reduced the PPP deal flow.

12 Devolved administrations, such as Scotland and Wales, have their own PPP programmes.

Figure 31
Regional distribution of PPP infrastructure investment activity (share of market value)



Source: *European PPP Expertise Centre.*
Note: *Regional shares of PPP infrastructure investment activities measured by total project cost for 2009 to 2018 and 2016 to 2018.*

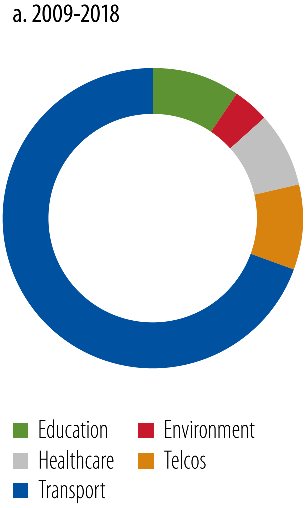
Over the last two years, the average value of PPP projects has rebounded to pre-crisis levels. This shift partially reflects considerations of economies of scale, with set-up costs for PPPs typically constituting a significant share of overall costs. In addition, these set-up costs are often highly project-specific. To the extent that smaller projects exhibit common features that allow for standardisation of processes and contracts, programme approaches and/or bundling of projects into a single procurement process can be employed to address this issue. At the same time, an evaluation of the PPP model before the project will seek synergies across the proposed bundle of infrastructure and service components. Recent developments may reflect greater recognition of this.

The PPP market has shifted towards economic infrastructure over the past decade.[13] The average cost of economic infrastructure projects, such as utilities, tends to be larger than that of social infrastructure, such as schools or hospitals. In line with this, as already mentioned, the average cost of PPP projects over the last two years has rebounded to pre-crisis levels. Since 2016, there has been a marked increase in the use of PPPs for the delivery of infrastructure and services via large infrastructure networks, such as broadband internet, in countries including France, Greece and Austria (Figure 32).

Among the noteworthy features of these projects is the extension of coverage of high-tech infrastructure to disparate regions, which supports regional cohesion and connectivity. At the same time, providing coverage to disparate regions is typically costlier than it is to urban areas. To ensure economic viability, compensatory measures may be helpful. These can include regulatory pricing or some form of subsidy, possibly on the cost of financing. Given the rapid pace at which technology continues to evolve, such large projects represent substantial investments with ancillary risks, including compatibility with future technologies. Assessing these before the project starts is always challenging and can be particularly important for PPPs, considering the long-term nature of these contracts.

13 When the figures include the United Kingdom, which focused on smaller, social infrastructure PPPs, recent average project values are as high as any time in the past two decades.

Figure 32
Sectoral distribution (share in EUR)



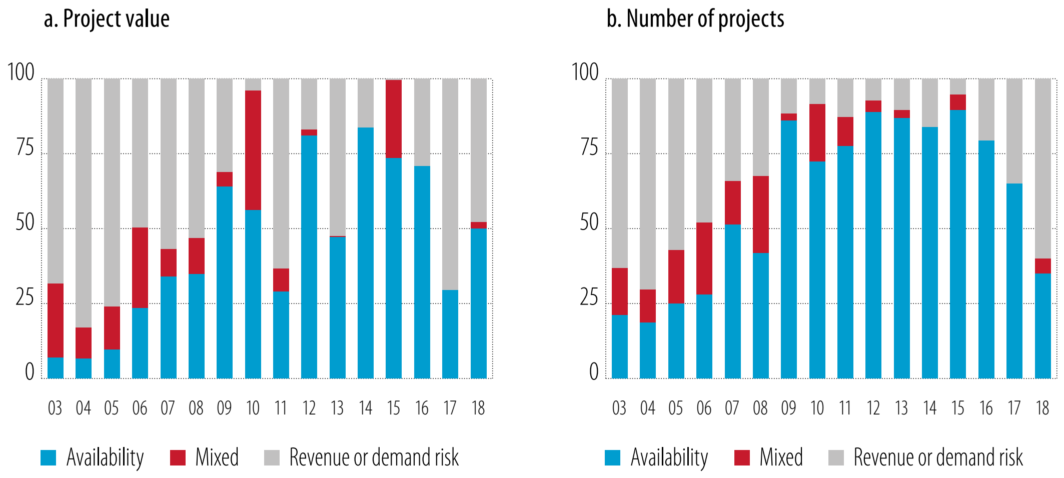
Source: *European PPP Expertise Centre.*
Note: *Distribution across sectors of infrastructure investment by value of PPPs at financial close. European Union, 2009-2018 and 2016-2018.*

As regards compensation models employed, the last three years have seen a renaissance of user-pay models, notably for larger projects (Figure 33). Leading up to and following the fiscal crisis, the proportion of government-pay (availability-payment or shadow-toll based) models increased whereas user-pay models temporarily declined. This decline of user-pay models may reflect the private sector's aversion to risk, including user-demand, as well as high or volatile longer-term financing costs. Another important determinant of the compensation model is the sector, with social infrastructure projects typically based on the availability-payment model. Average project value is correlated to this, where government-pay projects are typically smaller than mixed or user-pay models. In the transport sector, which draws from the broad spectrum of models, the compensation for smaller projects is more likely to involve government payments rather than user-pay models. Alongside the renewed rise in the average value of projects, we are therefore witnessing a renaissance in PPPs based on user-pay compensation. This is particularly noteworthy for larger networks, e.g. broadband.

Institutional investors play an important role in the PPP market, especially for larger projects. Looking only at the past three years, half of the PPP market, in terms of total value, has benefited from the involvement of institutional investors. Over this period, they have remained involved across most sectors, but most notably in transport and the environment. Since 2016, institutional investors have been particularly active in the Netherlands, France, and Italy, which together account for nearly three-quarters of the PPP activity in the European Union. Institutional investors also contribute to a significant amount of activity in Ireland and Spain. It is worth noting that institutional investors tend to support larger projects: the average value of PPP projects with the involvement of institutional investors exceeded that of other projects by more than two-and-a-half times; this difference is particularly marked in the transport and environmental sectors. Institutional investors typically hold liabilities with longer-term maturities and the development of infrastructure as an asset class offers the potential to facilitate the maturity matching of their assets.

Figure 33

Compensation models (annual shares)



Source: *European PPP Expertise Centre.*
Note: *Distribution of PPP infrastructure projects according to the compensation model at financial close, by project values and number of projects.*

Box E

Challenges in evaluating the effectiveness of public-private partnerships

Despite the very large number of individual PPPs that have been carried out over more than 15 years, there have been relatively few assessments published or made publicly available. Those conducting assessments have observed that there was little data of sufficiently good quality to be able to draw reliable conclusions as to the success or failure of PPPs.

Some studies and commentaries fail to distinguish between the effectiveness of the PPP delivery tool itself and whether the tool was used correctly for the purpose for which it was designed. Another issue is distinguishing the characteristics and soundness of the underlying project itself from the PPP method that is used to deliver it. Furthermore, the perspective from which the success of a PPP project is being judged is also important. The viewpoint of a private party or lender suffering losses on a PPP project may be quite different to that of the public authority that has successfully transferred the relevant risk. From the public authority's perspective, losses by lenders or investors over time can help to demonstrate that there is an effective transfer of risk to the private party in the PPP project delivery model.

One way of assessing the performance of PPPs would be to compare the cost, time and quality parameters of PPP projects with those of similar projects that have been delivered using traditional delivery methods, over the whole life of a project. This comparative approach could seek either to (i) compare the entire cost over a project's life between PPP and traditionally delivered projects that provide a similar level and quantity of services; or (ii) identify which approach delivers a superior level and quantity of service for a similar cost. Assessments might also consider the broader context of the economic environment and industry with the original project objectives as an important dimension of the framework.

However, reports to date have generally not yet assessed the comparative performance of PPPs against traditionally delivered projects. For example, the European Court of Auditors (2018) report on PPPs reviewed a very select number (12) of EU co-financed projects (many of which were affected by the global financial crisis) across four countries on a case-by-case basis, but this did not include a direct comparative analysis of whole-life performance.[14] Where comparative analyses have been carried out, they have mainly focused on the performance of the construction phase only, and not the whole life of the project.

One of the key challenges for comparing PPP performance has been the limited availability of information on the long-term performance of traditionally delivered projects that can be used to compare PPPs (for PPPs in which regular performance measurement is already built into the PPP delivery model as a core part of the payment mechanism, this is less of an issue). In the United Kingdom, one of the most mature PPP markets in the world, the National Audit Office (2011) tellingly admits, "The systems are not in place to collect comparable data from similar projects using different procurement routes."

However, awareness of the importance of comparing whole-life performance is increasing. A recent report by the United Kingdom's National Infrastructure Commission (2019) sought to compare the life performance of comparable roads projects. This has so far been carried out on a pilot basis to help develop further approaches to assessing the performance of PPPs compared to traditionally delivered projects. The EIB is also working in this area. EIB studies focusing on the comparative performance of projects financed by the Bank over the construction phase of roads have initially found that PPP projects tend to perform better than traditionally procured projects in terms of delivering the project on time and on budget.

14 Nevertheless, the report found that "most of the nine audited projects that have been completed at the time of our audit visit showed good standards of service and maintenance" and that "this was traceable to contract incentives and penalties that could impact on the amount of annual payments."

Conclusion and policy implications

Infrastructure investment continued its downward trend in 2017. The government sector accounts for almost all of the fall in infrastructure investment over the past decade, despite a slight rebound in 2017. The public-private partnership (PPP) market has stabilised over recent years, with major shifts in sectors and sizes used. Corporate infrastructure investment activities have buttressed infrastructure investment.

The fall in infrastructure investment activities has not been due to saturation. One-third of large municipalities in Europe said that infrastructure investment was below requirements; infrastructure investment fell most in regions endowed with infrastructure of poor quality; and additional infrastructure investment continued to generate substantial spillovers in terms of firm growth (EIB, 2018a).

Digital technologies are transforming many economic components, including infrastructure. New ways of connecting people and machines, and of collecting, storing and processing data are working their way into every part of economic activity, and smart infrastructure is playing an important role in these developments. Automation and artificial intelligence along with sensors, data sharing and analytics can help to augment infrastructure, with potentially enormous economic and social benefits. Notably, benefits can occur through capacity and service quality enhancements, cost savings and environmental sustainability.

Weak government investment risks undermining the transition towards smart infrastructure. As shown in this chapter, plans to cut public infrastructure investment are associated with a lower propensity for municipalities to report smartness as a priority. The decline in infrastructure investment in recent years may therefore also slow down the much-needed modernisation of Europe's infrastructure. Conversely, other macro-economic trends such as decentralisation and ageing seem to be pushing municipalities towards making infrastructure smart.

Building up the necessary technical capacity, providing a conducive regulatory environment and addressing finance constraints is key to fully reaping the benefits of smart infrastructure. Municipalities that prioritise smart infrastructure projects tend to face a range of additional challenges, including limited access to finance, budgetary constraints, regulatory barriers and uncertainty. This is particularly true for municipalities with smart ambitions but poor quality infrastructure. The complex nature of many smart infrastructure projects and the fact that municipalities with poor infrastructure often face a number of additional socio-economic challenges, financial barriers and capacity constraints hampers new projects (EIB, 2018a).

Equal access to smart infrastructure is key to ensuring that economic growth is socially inclusive. A smart infrastructure divide (the social and economic inequalities that result from smart infrastructure, including state-of-the-art communication technology) can aggravate social inequalities. New technologies are often implemented more quickly in rich neighbourhoods, resulting in unequal access to smart mobility, communication infrastructure and high quality health and education services. This dynamic can exacerbate existing disparities in infrastructure quality, funding constraints, technical capacity, and geographical and socio-economic challenges (EIB, 2018a).

Governments may choose to solve critical bottlenecks to business activity in rural areas by investing in high-speed communication or backhaul[15] infrastructure (OECD, 2017). Another option is to provide incentives for private investment by reducing the costs and improving the deployment of networks in rural areas.

Infrastructure firms lag behind other firms in the use of digital technologies. While infrastructure investment by firms has clearly outperformed government infrastructure activities, we find little evidence that the positive investment performance was accompanied by investment in new digital technologies.

15 Backhaul facilities are the intermediate links that transport traffic to the core of a network, after which it is further distributed through a hierarchical structure on that network or to others around the world (i.e. over larger backbone networks).

On the contrary, comparing the adoption of digital technologies across sectors, we find that infrastructure firms, if anything, tend to lag behind other sectors in the adoption of such technologies.

Differences in digital adoption between infrastructure firms and non-infrastructure firms raise the question of optimal regulation in a time of new technological opportunities. While for non-infrastructure firms digital adoption is closely correlated with the business cycle, we find a negative correlation between digital adoption by infrastructure firms and sales growth. We argue that this is likely because (price) regulation provides more of a reward for the adoption of digital technologies with the aim of improving efficiency, and much less of a reward for adoption with the aim of achieving more transformational changes (this view is also consistent with the strong effects of digital adoption on firm profitability, but not on sales growth or firm investment activities).

Policymakers and regulators should pay close attention not only to the extent of digitalisation in infrastructure, but also to its purpose. Otherwise, they could miss out on substantial consumer benefits and also heighten the risk that non-infrastructure firms disrupt infrastructure sectors (with potentially negative effects for the funding of infrastructure assets).

The European Union's PPP market is witnessing a notable increase in the deployment of broadband networks, including to disparate regions and based on consumer-pay models, which support regional cohesion and convergence and require careful attention when estimating demand. The PPP market has stabilised in recent years, with significant regional and sectoral differences emerging and a notable increase in the deployment of broadband networks in a few Member States. Some of these projects involve PPPs that employ consumer-pay models and extend coverage to regions left behind. Ensuring economic viability requires careful attention be paid to future demand and the compatibility of technologies. This can be particularly challenging in high-tech sectors that continue to evolve swiftly or in regions facing demographic challenges.

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Chapter 3

Intangible investment, innovation and digitalisation

The global innovation landscape is changing rapidly due to the growing importance of digitalisation, intangible investment and the emergence of China. Together with the United States and Europe, China has become one of the three global players in research and development (R&D). While remaining at the frontier of innovation, the European Union is investing less in R&D, as a percentage of GDP, than other major economies. This low level of research and development may have negative implications for innovation and long-term growth. Business R&D expenditures are largely responsible for the R&D gap in the European Union.

European companies are among the global leaders in the automotive sector but the European Union is less present in the fast-growing technological and digital sectors. Business R&D expenditures are concentrated among a few hundred firms that account for the majority of R&D investment. Several Chinese companies are emerging as important players in the digital sector, alongside US companies. At the same time, the European Union does not appear to be generating many new innovation leaders, especially in fast-growing high-tech sectors. This may create challenges for the long-term competitiveness of Europe.

Digital adoption rates in the European Union are lower than in the United States. Firms that have implemented digital technologies tend to perform better than non-digital firms: they have better management practices, are more innovative, grow faster and create higher paying jobs. There are many old and small firms in the European Union that do not invest in digital technologies. These firms are more likely to consider the lack of availability of finance as a major obstacle to investment, which may further exacerbate the delay in adoption rates.

To catch up with its peers, the European Union will need to create better conditions for innovation and digitalisation. Public policies should not only focus on R&D support but should also consider a wide range of intangible investments – including in software and databases, training of employees or organisational and business process improvements – to promote digitalisation and improve the performance of EU companies. Measures to fast-track the adoption of better management practices and increase the financing of intangible investments and digital technologies are possible solutions.

Introduction

The global innovation landscape is changing rapidly due to the growing importance of digital technologies, intangible investment and the emergence of China. Together with the United States and Europe, China has become one of the three global players in research and development. While remaining at the frontier of innovation, the European Union is investing less in R&D, as a percentage of GDP, than other major economies. This low R&D intensity may have negative implications for innovation and long-term growth. Business R&D expenditures are largely responsible for the gap in the European Union.

This chapter provides an overview of recent trends in global R&D expenditures and the investment activities of innovative companies. It discusses the characteristics of firms that invest in intangible assets (such as R&D, software and databases, training of employees or organisational and business processes) in the European Union and the United States. It explores the rapid adoption of digital technologies, their impact on firm performance and the constraints faced by firms in the European Union and the United States. The chapter also highlights the importance of developing effective public policies to better support investment in innovation and digitalisation.

Innovation in advanced economies

Investment in innovation is recognised as the main driver of productivity, long-term prosperity and economic growth for advanced economies, such as those of the European Union and the United States. Economic activity can be supported by investment in physical and human capital. However, in the long term, income per capita rises with innovations that make physical and human capital more productive (Cirera and Maloney, 2017). New products, services and processes need to be developed to address pressing policy and social challenges – including an ageing population, climate change, and numerous environmental and health issues. This creates growth opportunities for firms as well as new skills needs and job opportunities for workers (OECD, 2018).

Innovation is the result of costly and risky processes requiring systematic investment in R&D. For instance, the Frascati Manual (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).

Innovation activities are difficult to measure. Statistics on R&D expenditures are often used to compare investment in innovation across countries and firms. Because of the capitalisation as gross fixed capital formation in national accounts, data on R&D expenditures are widely available across countries but they may only capture a small part of investment in innovation.[1] To better understand the innovation activities of firms in advanced economies, it is necessary to consider investment in intangible assets other than R&D, such as software and databases, organisational capital and training of employees, as well as intellectual property products, like patents, and digital technologies, such as advanced robotics, the internet of things, and big data and analytics (EIB, 2018).

1 For instance, from Walmart to Goldman Sachs, some large companies in the service sector report zero R&D in their corporate accounts (Jones, 2016). Accounting and fiscal regulations in many EU countries did not require companies to report R&D expenditures until recently, even for publicly listed firms. The United Kingdom is a notable exception, with an explicit recommendation of accounting practices that encourage firms to disclose R&D expenditures since 1989 (Hall, Thoma and Torrisi, 2007).

Both the public and private sectors are engaged in innovation with complementary roles. In most advanced economies, the business sector is the largest contributor to R&D investment. However, R&D investment by higher education institutions and research institutes is also essential to generate the new knowledge, human capital and skills needed by the private sector.[2] While most business R&D spending is on applied research and experimental development, governments also make major investments in basic science that are key to supporting innovation in the private sector (Mazzucato, 2013).[3] For instance, a major role played by the public sector is to procure and create demand for innovative products in various areas, including cybersecurity, military, space and health. In addition to direct involvement in R&D activities, the public sector plays a key role in providing supportive conditions for innovative firms.

Public policy for innovation should go beyond direct support for innovating firms. Understanding how firms create and adopt innovations is important for the design and implementation of effective policy. An environment that facilitates the development and use of new ideas will enhance the productivity of the economy. Due to the rising importance of intangible investment and digital technologies, policymakers should not only focus on highly innovative firms in the manufacturing sector or on tax incentives for business R&D investment. They should also aim to create an ecosystem that enables the effective diffusion, circulation, commercialisation, adoption and adaptation of new products, processes and services, including digital ones. This is especially relevant for firms that do not innovate at the technological frontier (European Commission, 2018).

2 The issues of employee training and how to better address skills shortages and skills mismatches in the European Union is discussed in Chapter 9 of this report.

3 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 both 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).

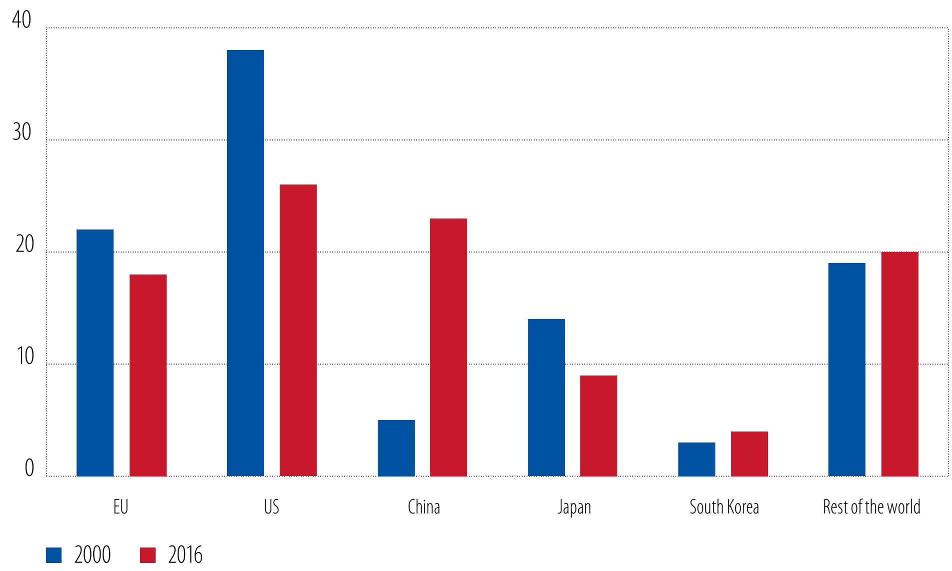
A changing global innovation landscape

Global R&D expenditures have increased rapidly over the past two decades. R&D expenditures reached an estimated USD 2.02 trillion in 2016, up from USD 739 billion in 2000 – an increase of more than two and a half times in 15 years. The largest contributor to the rise in global R&D investment was China, accounting for more than 30% of the increase during this period (National Science Board, 2018). From 2000 to 2016, R&D expenditures in China increased by a factor of ten, which corresponds to an annual growth rate adjusted for inflation of more than 15%.

The United States is the economy that invests most in R&D, followed by China and the European Union. The relative weights of the United States and the European Union in global R&D expenditures have been falling over time, mainly due to the rapid rise of China (Figure 1). Global R&D performance remains concentrated in three geographic regions: North America, Europe and East Asia. The US share of global R&D expenditures fell from 38% in 2000 to 26% in 2016, whereas the European Union represented 22% in 2000 but only 18% in 2016. Over the same period, the share of China increased from 5% to 23%.

Figure 1

Share of global R&D expenditures in 2000 and 2016 (in %)



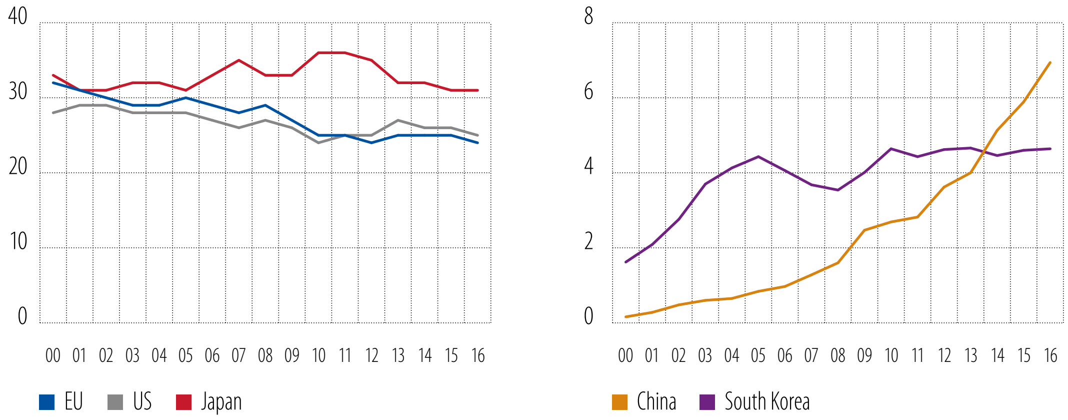
Source: EIB calculations based on data of the UNESCO Institute for Statistics Data Centre.
Note: GERD (Gross domestic expenditure on R&D) as a percentage of global GERD.

China is becoming a leader for innovation at the technological frontier. The dominance of China is also reflected in measures of innovation other than R&D, such as the stock of international patents (IMF, 2018). Patents protect novel inventions and technologies (OECD, 2017). Data on R&D and patenting activities can help in the investigation of a number of policy-relevant issues related to innovation and technological development.[4] The number of patent families filed by Chinese inventors at foreign patent offices, as a share of the total number of patent families registered, is low but increasing rapidly. China overtook South Korea in 2014, although it remains far below the level of triadic patent families filed by EU, US or Japanese inventors (Figure 2). This trend reflects the growing importance of China in the development of information and communications technologies and digital technologies, such as artificial intelligence, machine learning, robotics, synthetic biotechnology, new materials and nanotechnology. During the

4 Chapter 8 of this report discusses patenting activities and diffusion of innovation in more depth.

past decade, China also increased its production of highly-cited scientific research and its share in the world's top 10% most-cited publications. The share of China rose from less than 4% in 2005 to 14% in 2016, making China the third largest country for top-cited scientific publications behind the European Union and the United States (OECD, 2017).

Figure 2
Share of global triadic patent families 2000-2016 (in %)



Source: *EIB calculations based on OECD Patent Statistics: Patents by main technology and by International Patent Classification (IPC).*
Note: *A triadic patent family is defined as a set of patents registered in various countries (i.e. patent offices) to protect the same invention. Triadic patent families are a set of patents filed at three of these major patent offices: the European Patent Office (EPO), the Japan Patent Office (JPO), and the United States Patent and Trademark Office (USPTO). Triadic patent family counts are attributed to the country of residence of the inventor and to the date when the patent was first registered. This indicator is measured as a number.*

As a share of GDP, the European Union is investing less in R&D than the United States or China. 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 3). South Korea has the highest R&D intensity among major economies, at 4.6% of GDP in 2017, after overtaking Japan in 2009 and Finland in 2011. China overtook the European Union in 2015 and had an R&D intensity of 2.13% of GDP in 2017, compared to 2.06% in the European Union. In most advanced economies personnel costs, including researchers, account for a large part of R&D expenditures (OECD, 2017).[5] The fact that the European Union is investing less in R&D as a share of GDP than other major global players may have negative implications for 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 over firms based in other countries. Lagging EU companies may also find it difficult to catch up and adopt technologies developed elsewhere.

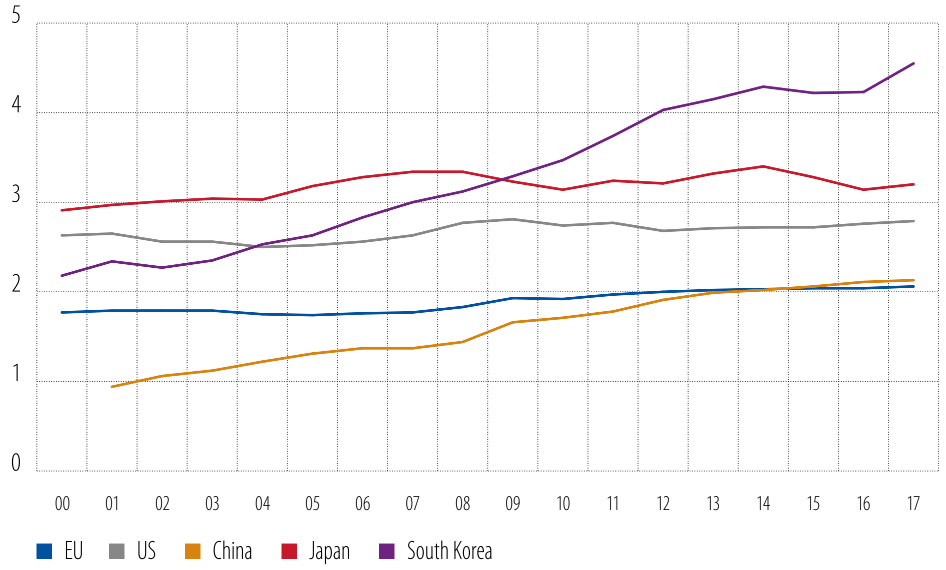
The share of total R&D investment undertaken by the business sector is lower in the European Union than in the United States or China. R&D expenditures can be disaggregated according to different sectors: the business sector, government, higher education and private non-profit institutions (including charities). The share of business R&D in total R&D expenditures is lower in the European Union (at 66%) than in the United States (72%), or China, Japan and South Korea (almost 80%). The business sector is the main driver of the rapid increase in R&D expenditures in China and South Korea (Figure 4). However, even in these countries where most R&D is funded or performed by the business sector, this does not

5 There is a close relationship between R&D as a percentage of GDP and the number of researchers as a percentage of total employment. Variations in this relationship can be related to differences in the relative prices of different R&D inputs (including researcher remuneration) and the degree of R&D specialisation in each economy (OECD, 2017).

imply that the government is not supporting business R&D. For instance, in China, many large companies are controlled by the state, directly and indirectly (Veugelers, 2013). This indicates that, to catch up with its peers, the EU will need to create better framework conditions and provide the right incentives for supporting more R&D activities by the business sector.

Figure 3

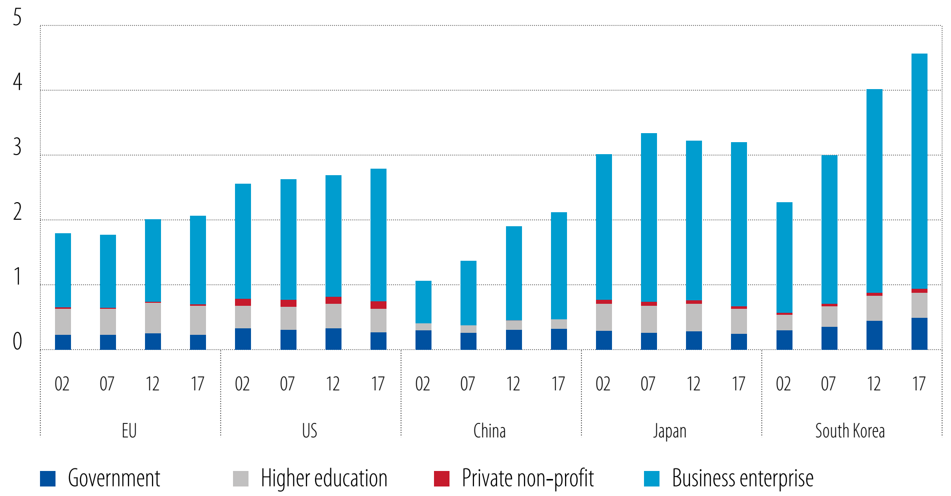
R&D investment intensity 2000-2017 (in %)



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.*

Figure 4

Composition of R&D expenditures as a share of GDP 2002-2017 (in %)



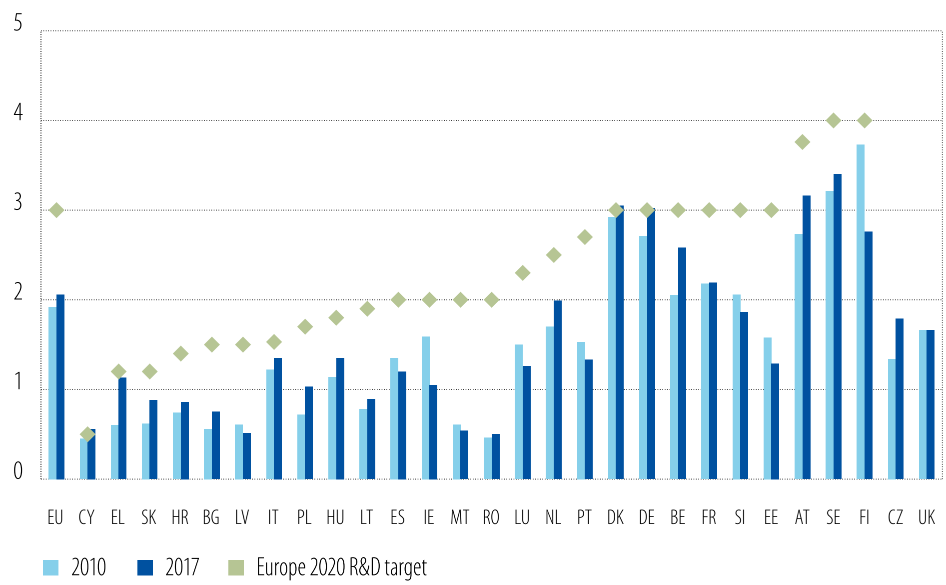
Source: *Eurostat.*
Note: *GERD (Gross domestic expenditure on R&D) as a percentage of GDP. China excluding Hong Kong. No data on the private non-profit sector in China.*

The annual R&D investment gap in the European Union is estimated at EUR 145 billion, based on the Europe 2020 target of 3% of GDP spending on R&D. 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 aims to reach an overall R&D intensity of 3% (and 2% for business R&D intensity) through different national targets. Gross domestic expenditure on R&D in the EU28 was EUR 317 billion a year in 2017, equal to 2.06% of GDP. Actual spending falls short of the target by almost one percentage point, equivalent to about EUR 145 billion invested in R&D in 2017. While R&D expenditures were resilient and continued to grow throughout the crisis period in Europe (unlike other components of gross fixed capital formation), the R&D investment gap remains significant.

Most Member States will need to increase R&D investment substantially to reach their Europe 2020 strategy national target. As of 2017, Cyprus, Denmark and Germany were the only EU countries to have reached their national Europe 2020 strategy targets (Figure 5). Greece was also very close to reaching the national target. The R&D intensity of Greece almost doubled from 2010 to 2017, with a growth rate of 90% during this period, the highest of all EU members. The strong performance of Greece could also be driven by the fact that GDP fell during the past decade. For some countries, the 2020 target is ambitious. In 2017, several countries – Finland, Estonia, Ireland, Latvia, Luxembourg, Malta, Portugal, Slovenia and Spain – were investing less in R&D (as a share of GDP) than in 2010, when the target was set.

Figure 5

R&D investment intensity in 2000 and 2017, and Europe 2020 strategy R&D target (in %)



Source: *Eurostat.*
Note: *GERD (Gross domestic expenditure on R&D) as a percentage of GDP. Countries are ordered based on their national Europe 2020 strategy target for R&D. The target for Ireland is 2.5% of GNP, which corresponds to approximately 2% of GDP. The target for Luxembourg is 2.3% to 2.6% of GDP. The target for Portugal is 2.7% to 3.3% of GDP. There are no targets for the United Kingdom or the Czech Republic. The Czech Republic has a target of 1% of GDP for public R&D investment.*

Within the European Union, the differences in R&D investment intensity across EU members are mainly driven by business R&D expenditures. However, they are only partly driven by the industry specialisation of each country (EIB, 2017). The variation in business R&D expenditures is also due to differences in the business environment, access to finance, human capital and the skills of the labour force. This indicates that there is scope for public policy to intervene on several fronts to maximise the impact of R&D investment by the private sector. In addition, public intervention can be justified due to the positive externalities that are typically associated with R&D spending and innovation.

The rise of tech 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 expenditures. The high concentration of R&D spending is reflected in the fact that the world's top 250 R&D companies account for more than 60% of business R&D expenditures – and the top 25 firms account for about a quarter of business R&D expenditures. R&D concentration is particularly pronounced in the high-tech, biopharma and digital sectors, but also in traditional industries such as automotive and aerospace.[6] Compared to sales or employment, R&D investment is more concentrated among a few incumbent firms that have grown bigger over time. However, unlike in the United States, this concentration has been stable or declining in Europe. The trend has been associated with product market reforms and stronger anti-trust regulation (Veugelers, 2018).

Over the past decade, the global R&D landscape has changed rapidly, due to the rising importance of the digital economy. This section is based on data from the EU Industrial R&D Investment Scoreboard from 2006 to 2018, which ranks the 2 500 companies investing the most in R&D worldwide (Table 1).[7] The latest edition covers approximately 90% of global business-funded R&D.[8] With more than EUR 13.4 billion spent in 2017/18, Samsung was the top global R&D spender, closely followed by Alphabet (the parent company of Google) in second place (Table 1). In contrast to previous years, Volkswagen is no longer the top global R&D spender and has fallen to third place in the list. The top ten is dominated by digital technologies, with US and Asian companies producing electronic and hardware technology equipment (Samsung, Huawei, Intel and Apple) or software and computer services (Alphabet and Microsoft).

A large number of European companies are major global players in R&D and innovation. However, the European Union and Japan are losing some ground among the top global innovators. The proportion of firms from the European Union, the United States and Japan among 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 6). At the same time, the number of Chinese companies included in the list of top R&D investors rose fast – from less than 0.5% in 2006 to 18% in 2018. Similarly, the share of total R&D expenditures of Chinese firms increased from 0.3% to 10% between 2006 and 2018. The fact that the proportion of firms from China is higher than the share of R&D expenditures indicates that Chinese companies spend less than the average firm included in the top 2 500 companies. In other words, Chinese firms are increasing their presence in the list but they are not necessarily among the biggest R&D spenders.[9] At the same time, the share of R&D expenditures of EU and US companies is higher than the proportion of firms from the European Union and United States, indicating that these are well represented among the very top global R&D companies.

The United States and China generate more new R&D leaders than the European Union. The United States and China have a higher number of recent entrants into the list of global innovators than the European Union and Japan – the new entrants are firms that were not among the top global innovators before 2014. In the case of the United States, the high rate of entry is also associated with firms exiting – otherwise, the share of US firms in the league of big R&D spenders would presumably have increased over time. The United States has generated 34% of the new firms since 2012 and these accounted for about 33% of total R&D expenditures in 2017/18. Similarly, China has generated about 26% of new entrants, whose share of R&D expenditures is 20%. The European Union has generated 13% of new entrants, with a share of R&D expenditures of 23%: this suggests that the new companies from the European Union tend to be larger R&D spenders than the average company that entered the list after 2013.

6 The OECD classifies the automotive sector as a medium-tech sector, while digital and biopharma are considered to be high-tech sectors (Veugelers, 2018).

7 The EU Industrial R&D Investment Scoreboard includes information on the name of the company, country, sector, R&D expenditures, capex, net sales, number of employees, operating profits, profitability, market capitalisation as well as the one-year growth for most variables. In addition to the top 2 500 global companies, the database also includes data on the top 1 000 R&D companies in the European Union.

8 The companies included in the 2018 EU Industrial R&D Investment Scoreboard invested EUR 736 billion in R&D in 2017/18, while total global R&D expenditures by the business sector amounted to EUR 820 billion.

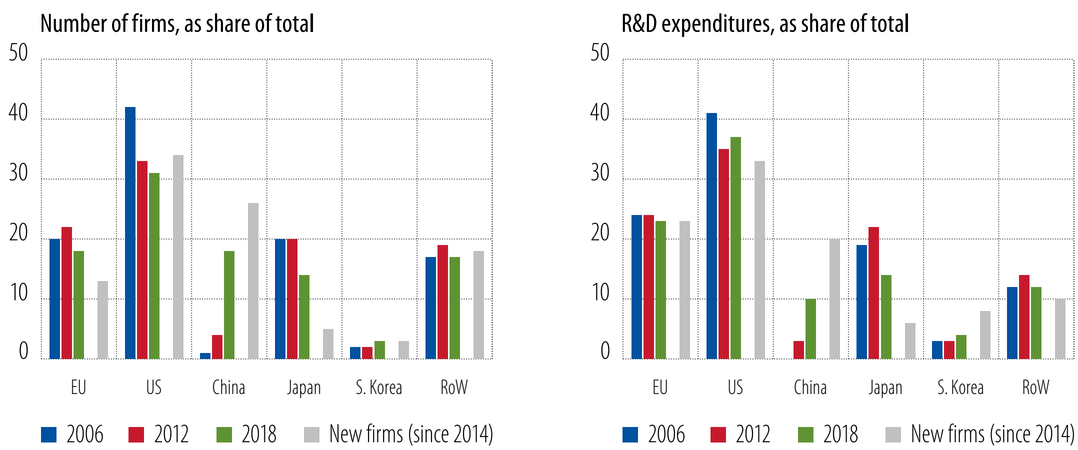
9 A similar observation can be made for companies from the "rest of the world" (i.e. not from the European Union, the United States, China, Japan or South Korea), where the proportion of firms is higher than the share of R&D expenditures.

Table 1
Top ten global R&D investors in 2017/18

Company	Country	Sector	R&D (EUR bn)	Capex (EUR bn)	Profitability (%)	Number of employees
Samsung	South Korea	Electronic & electrical equipment	13.44	34.10	22.4	320 671
Alphabet	US	Software & computer services	13.39	10.99	26.1	80 110
Volkswagen	Germany	Automobiles & parts	13.14	13.05	5.8	642 300
Microsoft	US	Software & computer services	12.28	9.70	31.7	131 000
Huawei	China	Technology hardware & equipment	11.33	2.22	N/A	180 000
Intel	US	Technology hardware & equipment	10.92	9.82	27.8	102 700
Apple	US	Technology hardware & equipment	9.66	10.38	26.8	123 000
Roche	Switzerland	Pharmaceuticals & biotechnology	8.89	3.00	23.2	93 734
Johnson & Johnson	US	Pharmaceuticals & biotechnology	8.80	2.73	24.8	134 000
Daimler	Germany	Automobiles & parts	8.66	6.74	8.9	289 321

Source: *EU Industrial R&D Investment Scoreboard.*
Note: *The companies are ordered based on their R&D expenditures in 2017/18. Profitability refers to operating profits divided by net sales.*

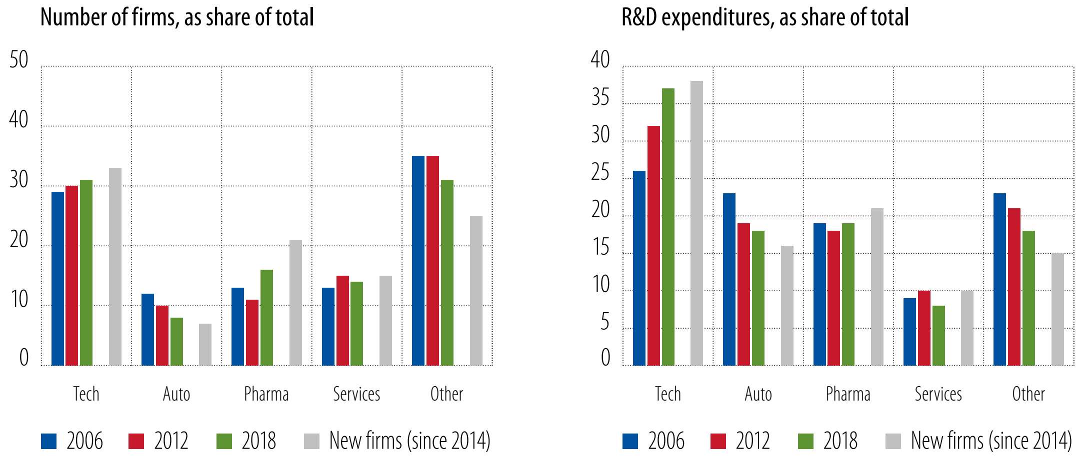
Figure 6
Proportion of top global R&D companies and share of R&D expenditures 2006-2018 (in %), **by country**



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, and share of R&D expenditures by the top R&D investors, by country. "New firms" refer to firms that entered the list of top global R&D investors after 2013. S. Korea: South Korea; RoW: Rest of the world.*

The tech sector represents more than one-third of total R&D expenditures and generates about one-third of new R&D leaders. Companies in the tech sector as well as in utilities and construction (the category "other") each represent 31% of R&D leaders (Figure 7). Only 8% of companies are from the aerospace, defence and automotive sectors but they tend to be relatively large R&D spenders, representing 18% of total R&D expenditures – which is similar to the share of R&D expenditures by companies in pharmaceuticals and biotechnology. The proportion of new entrants from the tech sector is significantly higher, at 33%, than from any other sector. The share of total R&D expenditures by the tech sector has also been increasing rapidly over time, from 26% in 2006 to more than 36% in 2018. Market concentration is rising in tech-related industries, notably the digital sector, where economies of scale and winner-takes-all dynamics can be very important (EIB, 2018).

Figure 7
Proportion of top global R&D companies and share of R&D expenditures 2006-2018 (in %)**, by sector**

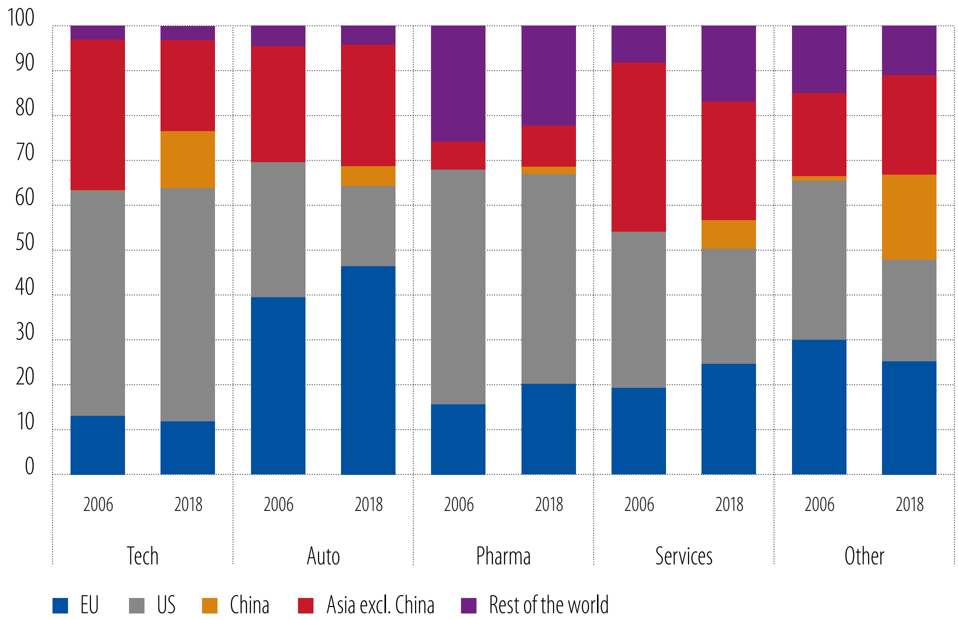


Source: *EIB calculations based on EU Industrial R&D Investment Scoreboard.*
Note: *Share of the total number of firms in the list of the top R&D investors, by sector, and share of R&D expenditures by the top R&D investors, by sector. "New firms" refer to firms that entered the list of top global R&D investors after 2013.*
Tech: electronic and electrical equipment, technology hardware and equipment, software and computer services.
Auto: aerospace and defence, automobiles and parts. Pharma: pharmaceuticals and biotechnology. Services: leisure goods, personal goods, banks, life insurance, non-life insurance, financial services, real estate investment and services, media, general retailers, food and drugs retailers, healthcare equipment and services, support services, travel and leisure.
Other: alternative energy, oil and gas producers, oil equipment, services and distribution, chemicals, general industrials, industrial engineering, household goods and home construction, construction and materials, industrial transportation, mining, industrial metals and mining, food producers, tobacco, forestry and paper, beverages, electricity, fixed line telecommunications, gas, water and multi utilities, mobile telecommunications.

The European Union specialises less in the new technology sectors, which may explain the gap between the European Union and the United States in creating new leading innovators. The European Union only represents 12% of R&D expenditures in the tech sector, compared with 52% for the United States (Figure 8). This deficit has been associated with the lower average rates of return on R&D investment for EU firms than in the United States (Cincera and Veugelers, 2014). This could be due to different business conditions, including access to finance and a regulatory environment that does not support young European firms undertaking risky and innovative investments (European Commission, 2016). 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.[10] From 2006 to 2018, the share of Chinese tech companies rose from 0.1% to 13%, taking market share mainly from other Asian countries.

10 Chapter 6 of this report discusses in more depth the importance of venture capital to finance innovative firms.

Figure 8
Share of R&D expenditures in 2006 and 2018 (in %)**, by sector and country**



Source: EIB calculations based on EU Industrial R&D Investment Scoreboard.
Note: Share of R&D expenditures by the top R&D investors, by sector and country. See note to Figure 7 for detailed list of industries.

Europe is a global leader in R&D investment in the automotive industry. Global R&D expenditures of companies in the aerospace, defence and automotive sectors are heavily concentrated in a few European countries and Japan that account for about 75% of total R&D spending. The US share has been falling over time, while the presence of China is becoming more evident. For Europe, the automotive industry is historically one of its strongest sectors. However, the sector is now experiencing a transformation, due to digitalisation and new trends – such as electrical vehicles, autonomous driving and car sharing. This development emphasises the need for continuous efforts in R&D activities as well as new investment. At the same time, the average profitability (operational profits divided by net sales) of firms operating in the auto sector is significantly lower, at 9% in 2017/2018, compared to pharmaceuticals (20%), services (18%), tech (13%), or even utilities and construction (11%).[11]

The pharmaceuticals and biotechnology sector is dominated by US companies, which account for almost half of the R&D spending in that sector. However, with 20% of global R&D investment in this sector, EU companies continue to be important players (Veugelers, 2013). Most R&D investment in pharmaceuticals and biotechnology is concentrated among a few champions: the top ten firms make up half of R&D expenditures.[12] As in the other sectors, the share of Chinese companies has been increasing over time – for example, in the construction sector and among oil and gas producers (which are included in the category "other").

Europe has strong traditional industrial sectors that were not born digital. Many indicators point towards Europe falling behind in digital transformation at a time when Industry 4.0 is gaining momentum and has started to change the business models of traditional industries substantially (see Box A). Digitalisation

11 Among the better known companies in the automobile sector, Ferrari is a notable exception, with a profit margin of 24% in 2017/2018.
12 The large share of R&D expenditures in pharmaceuticals and biotechnology attributed to the rest of the world is notably driven by two Swiss companies (Roche and Novartis).

pervades the global economy and is arguably one of the most important drivers of firms' innovation, competitiveness and growth (EIB, 2018). The digital transformation of traditional industries and the development and adoption of new emerging technologies in the European Union require substantial efforts in investing in R&D and innovation.

If a digital base is absent in Europe, future tech champions will most likely emerge from other regions, where they can develop new technologies relying on existing digital infrastructure – including hardware, software, services and platforms. European companies are essentially absent from digital B2C (business-to-consumer) platforms. However, they may still be well positioned to drive the creation of B2B (business-to-business) platforms in areas where they can leverage their market and expertise in various domains, including the manufacturing and automotive sectors (EIB, 2018). At the same time, platforms benefit from network effects that can lead to oligopolistic or monopolistic market structures, thereby reinforcing winner-takes-all dynamics and potential market failures. 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.

Box A
How digital champions invest[13]

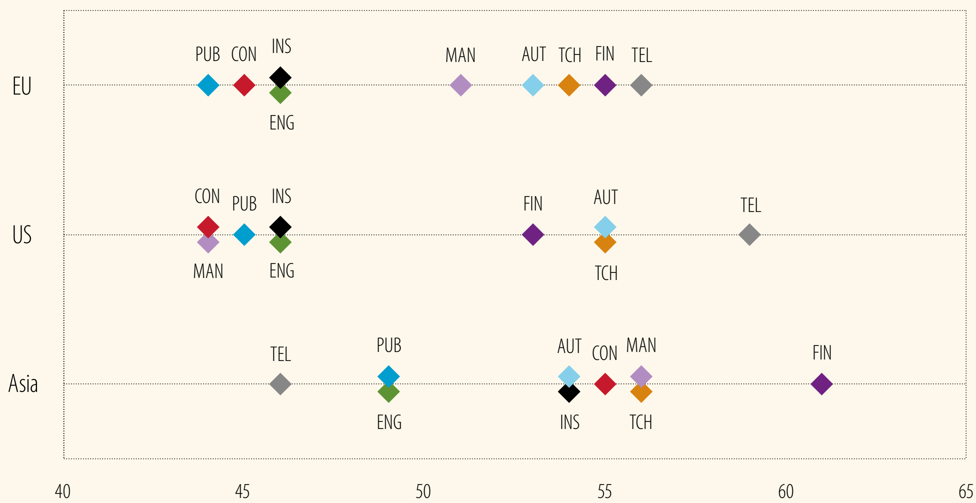
To understand what sets digital champions apart from digital laggards, it is key to look at their investment priorities. Champions invest aggressively in digital efforts, devoting a sizeable proportion of funds to building a world-class technology/IT function, such as artificial intelligence, the internet of things and cybersecurity. They dedicate a significant percentage of their workforce to digital projects, have ambitious plans to expand their digital talent base and improve the skills of their existing workforce. They also invest in pushing their digital efforts to scale up, with the focus increasingly on data and artificial intelligence.

These insights are based on the findings of the third annual survey on digital maturity of the Boston Consulting Group (BCG), which uses the Digital Acceleration Index (DAI) to understand how companies across industries and regions stack up in terms of their digital evolution. The 2019 survey asked decision-makers at more than 1 800 companies across 27 countries in Asia, Europe and the United States to assess the digital maturity of their company on a scale of one to four in 35 areas. It examined eight industries – automotive, consumer and retail, energy, financial services, insurance, manufacturing, technology, and telecommunications – as well as the public sector. The answers were used to derive an overall digital maturity score from 0 to 100 for each company. Companies with a DAI score of 67 to 100 qualify as champions, while those with a score of 43 or less are considered laggards.

The 2019 survey revealed that financial services and telecommunications are the most digitally advanced industries, with more than 25% of companies qualifying as digital champions. In contrast, energy and the public sector trail behind, with more than 40% of organisations qualifying as digital laggards. The analysis also included an assessment of industry performance across regions. In Asia, the best-performing industry is financial services, while telecommunications is the leading industry in both Europe and the United States (Figure A.1). The strength of Asian financial services companies is not surprising given that many players are digitally native and that digital banking companies such as WeChat are subject to less stringent data privacy restrictions than competitors in other parts of the world.

13 This box was prepared by Michael Grebe, Michael Ruessmann, Michael Leyh and Marc Roman Franke, Boston Consulting Group (BCG). More details on the analysis are available at: www.bcg.com/publications/2019/how-digital-champions-invest.aspx

Figure A.1
Financial institutions and telecommunications companies have the highest DAI scores



Source: *BCG global DAI study 2018.*
Note: *Scores are the average DAI score from 0 (lowest) to 100 (highest) per industry in a region. AUT: Automotive; CON: Consumer and retail; ENG: Energy; FIN: Financial services; INS: Insurance; MAN: Manufacturing; PUB: Public sector; TCH: Technology; TEL: Telecommunications.*

Some industries that are low performers in other regions have high scores in Asia (Figure A.1). For example, consumer and retail ranks second to last in terms of digital maturity in Europe and the United States, while its DAI score in Asia is roughly ten points higher. In the retail sector, online players in Asia, such as Alibaba, are shaping the shopping space more than their peers in other regions, thanks to their innovative digital offer. A similarly large spread can be observed in the insurance industry, where Asian insurers have been more technologically innovative, such as in digitising the customer experience.

In contrast, Asian telecommunications companies show comparatively low digital maturity – a surprising finding given that the telecom industry has one of the highest DAI scores worldwide. Some 38% of telecom companies in the United States and 32% in Europe qualify as digital champions, while only 13% in Asia do. The below-par performance of these firms in Asia likely stems from regulations that did not incentivise Asian telecom companies to upgrade legacy technology.

Digital champions have mastered the transition from a digital vision to digital reality. Clearly, the road to success will be different depending on a firm's industry and starting point. However, all companies with digital ambitions can learn three lessons from the champions:

- Aim for a world-class technology function. Companies should steer sizeable digital investment towards building a leading technology/IT function. This will not only position them to leverage new technologies, such as artificial intelligence, the internet of things and blockchain, to support new digital business models, but it will also create major efficiencies in the core business – generating savings that can help fund the digital journey.
- Build a digital talent engine. Companies need a talent strategy that reflects the demand for new roles and skills, including data scientists and agile coaches. They should develop a focused digital recruiting strategy and a blueprint for upskilling their current workforce to ensure that they have

the right talent – in terms of both technical skills and the capabilities needed to build and manage digital businesses.

- Transform into a data-driven company. Companies must invest in data capabilities to digitise the customer journey and develop personalised offerings, adopt new digital technologies and cultivate powerful ecosystems. Those that up their game in data stand to capture new revenue pools and drive a true digital transformation.

Success in digital demands a clear and focused investment strategy. Companies that are able to develop such a strategy can drive a successful digital transformation – and put themselves on the path to emerge as champions.

European champions meet Made in China 2025

To further strengthen the position of China in the global economy, the Chinese authorities decided in 2015 to step up investments in industrial regeneration. That year, the Chinese government announced the "Made in China 2025" (MIC25) strategic plan, which aimed to renew and restructure the industrial base as well as reduce its dependency on foreign technologies. The programme intends to raise the domestic innovation capacity and increase investments in advanced industrial technologies in ten identified key sectors or technologies (Table 2). The long-term goal of the strategic plan is to support productivity, competitiveness, position in global value chains and structural change in the economy by creating incentives for reallocation of labour across industries. In contrast to previous Chinese economic policy plans, MIC25 gives more importance to the private sector, entrepreneurship and market mechanisms, while also improving the competitiveness of state-owned enterprises that are deemed crucial for driving innovation.

Table 2

The ten sectors of the Made in China 2025 strategic plan

	Industry sector
1.	Next-generation information technology
2.	High-end numerical control machinery and robotics
3.	Aerospace and aviation equipment
4.	Maritime engineering equipment and high-tech maritime vessel manufacturing
5.	Advanced rail equipment
6.	Energy-saving and new energy vehicles
7.	Electrical equipment
8.	Agricultural machinery and equipment
9.	New materials
10.	Biopharmaceuticals and high-performance medical devices

Note: *The sector classifications are approximations of the original MIC25 industries, which have not been defined using any standardised industrial classifications.*

Chinese firms are increasingly competing with European firms in different manufacturing industries. The traditional competitive advantages of China have been the significant size and growth of the domestic market, low wages, the availability of domestic raw materials, a stable political environment and functioning infrastructure. Has the MIC25 policy programme already had a visible impact on the R&D performance of the leading Chinese companies active in the selected MIC25 industries? This section sheds some light on the competitive landscape within these MIC25 industries by comparing the performance of the leading EU firms with that of similar US and Chinese firms. It is noteworthy that the MIC25 industries include the long-term industrial strengths as well as sectors of Europe, such as information technology, in which more competition on a global scale could be beneficial.

Most studies on the competitiveness of the manufacturing sector in Europe compare the European Union with the United States, the traditional industry leaders, overlooking the rising importance of China as a global innovation player. The studies have usually been conducted by EU-level industry organisations and tend to focus on the high-tech manufacturing and information, communication and technology industries, leaving aside the traditional medium-high tech industries, which still have significant R&D investments and are affected by competition from Chinese firms. In 2019, the European Commission published a thorough analysis of the MIC25 strategic plan (European Commission, 2019). This section takes a complementary approach by relying on other data sources, such as the EU Industrial R&D Investment Scoreboard. R&D spending is used as an indicator of competitiveness, as R&D can drive technological development, innovation, productivity and renewal of the overall industrial structure. The data cover 2015 to 2018 to examine whether the impact of the MIC25 programme is already visible in aggregate statistics.[14]

The MIC25 strategic plan is expected to boost the appeal of China as an investment and export destination for European firms. The programme intends to ensure a level playing field that should be independent of the origin of the company. European industries no longer consider China to be only a low-cost production location – a destination targeted for outsourcing and exports – but increasingly also as an R&D centre. For example, many leading European car producers already have R&D facilities for electric vehicles in China. EU firms in other sectors, such as chemicals, are also starting to make significant R&D investment in China. As long as the domestic technology supply in China remains insufficient, the push towards high-tech production creates export opportunities for European suppliers.

Despite the rapid emergence of China as an innovation leader in the past decade, its specialisation profiles in innovation and science tend to be relatively narrow compared to the European Union and the United States. China has gained a prominent position in global value chains by strongly relying on the traditional engineering sectors, but the importance of high-tech sectors (especially electrical and mechanical engineering) is growing. Meanwhile, the European Union is suffering steep losses in its share of the global value chain share in the manufacturing sector (European Commission, 2019).

High R&D expenditures in relative terms are interpreted to signal proximity to the technological frontier that will create a competitive advantage for domestic enterprises over their global rivals. From the perspective of international competitiveness, it is not only the level of R&D investments in each sector that matters, but also the relative share of domestic R&D expenditures compared to the share of the same sector in the rest of the world. R&D specialisation profiles can help to detect differences in MIC25 industry competitiveness across regions over time. Changes in specialisation indicate technological change, which is a cumulative process, built on incremental changes and innovations (Pavitt, 1988). Consequently, specialisation profiles are path dependent, in other words today's specialisation profile is a result of yesterday's efforts as well as a good predictor of tomorrow's profile. The reasons for path dependency within an economy may arise from mutually beneficial knowledge linkages between adjacent fields of technological specialisation and concentration of innovators (Malerba and Montobbio, 2003).

Despite the natural path dependency in innovation, specialisation profiles may change rapidly due to targeted policy measures or disruptive innovations rapidly penetrating the markets. In some cases, the relative R&D expenditures may be high, yet the associated economic activity is far from the technological frontier. For example, this situation could arise when a new cluster is being set up or when the national innovation system is going through a political or economic transformation and is already under pressure to catch up with leading economies. The specialisation profiles in this section are based

14 The analysis is based on the NACE industry classification of companies. This information on NACE was provided by the European Commission, JRC Sevilla, and is gratefully acknowledged.

on the calculation of specialisation indices originally introduced in the context of international trade. Building on the Revealed Comparative Advantage (RCA) index introduced by Balassa (1965), this section applies the Normalised Revealed Comparative Advantage (NRCA) index introduced by Yu, Cai and Lueng (2009) and discussed in Asikainen (2016).[15]

Usually, the impact of new policy measures takes hold later in time. However, in the case of the MIC25 strategic plan, the impact could be felt faster as many large Chinese companies are partly state-owned and state-owned enterprises are expected to play a critical role in the development of strategic industries and high-tech equipment associated with MIC25. In addition, the resources allocated to the MIC25 are particularly large in terms of money and incentive structures. In "key industries", such as telecom, shipbuilding, aviation and high-speed railways, state-owned firms account for around 83% of total revenue; in "pillar industries" such as electronics, equipment manufacturing, and automotive, the share of state-owned firms is 45% (MERICS, 2019). The latest Fortune's Global 500 ranking that lists the world's largest corporations by revenue reveals that 119 out of the top 500 companies are Chinese, of which 82 are state-owned firms (Fortune, 2019).

Changes in industrial and environmental policies in China tend to be felt more rapidly than in other countries. For example, the Chinese solar power industry has expanded very rapidly from a small, rural programme in the 1990s to become the largest in the world, both in terms of solar power generation and installation of solar panels. In 2018, the installed capacity of solar panels in China exceeded one-third of the global total and half the increase in the world's solar capacity in 2018 was due to China (Yang et al., 2019). Another example is the rapid lead of China in the electric vehicle battery market. In 2017, seven of the top ten electric vehicle battery companies were Chinese, accounting for 53% of the global market share.

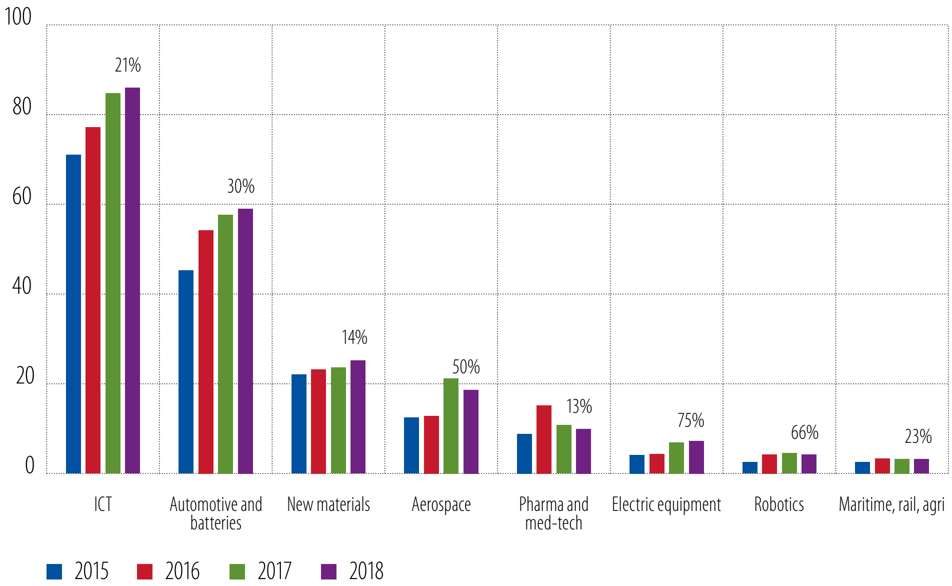
Among the various MIC25 sectors, growth in R&D spending by electric equipment companies was particularly fast. R&D spending in all MIC25 sectors increased by 26%, from EUR 169 billion in 2015 to EUR 214 billion in 2018. Chinese firms in these sectors displayed particularly high growth, almost doubling their R&D spending, from EUR 11 billion in 2015 to EUR 20 billion in 2018 (an 83% increase). The growth of R&D spending by EU firms was also strong (+41%), compared with the United States (+11%), which remains the country that spends the most in these sectors (EUR 107 billion, or about 50% of the total). Electric equipment was the sector that grew the fastest (+75%), although from a low base, from around EUR 4 billion in 2015 to over EUR 7 billion in 2018 (Figure 9). Companies in robotics (+66%) and aerospace (+50%) also reported high growth rates of R&D expenditures from 2015 to 2018.

There are large differences in industry concentration of R&D spending across the European Union, the United States and China. While US companies dominate the information and communications technology (ICT) sector, EU companies stand out in automotive and batteries (Figure 10). The importance of Chinese firms is increasing rapidly and they are already strong players in new materials and electric equipment. In 2018, US companies spent EUR 107 billion on R&D in the MIC25 sectors: 56% went to ICT, 14% to automotive and batteries, and 10% to new materials, while the share for other MIC25 sectors was lower. The European Union spent EUR 86 billion, of which 21% in ICT, 47% in automotive and batteries and 11% in new materials. The amount spent by Chinese companies was significantly lower, at EUR 20 billion, with 39% in ICT, 18% in automotive and batteries and 24% in new materials.

15 The NRCA defines a country's R&D specialisation as the deviation of a country's realised R&D expenditures in a specific sector from its specialisation neutral level (zero) and normalises this outcome by global R&D expenditures. If NRCA > 0 (< 0), then the country's actual R&D expenditures are higher (lower) than its specialisation neutral level, implying that the country is specialised (not specialised) in R&D in the sector. The higher the value of NRCA, the stronger the level of specialisation. The normalised specialisation index is not dependent on the level of sectoral aggregation in the sample. NRCA is comparable across sectors and countries as well as over time, and sums up to zero across sectors and countries. This zero-sum feature implies that if one sector in a country improves its position in the ranking, another sector's position weakens. Similarly, if a country improves its position in the ranking, then another country will lose its position.

Figure 9

R&D spending in MIC25 sectors by EU, US and Chinese companies 2015-2018 (in EUR bn)

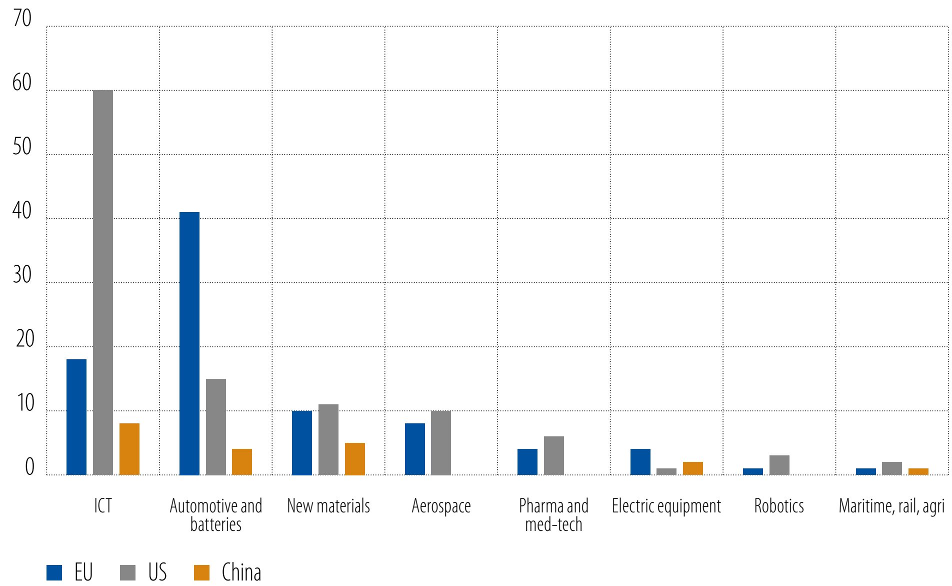


Source: *EIB calculations based on EU Industrial R&D Investment Scoreboard.*

Note: *The % displayed above the columns indicates the percentage growth in R&D spending in that sector from 2015 to 2018. The ten MIC25 sectors in Table 2 have been partly aggregated: maritime engineering equipment and high-tech maritime vessel manufacturing, advanced rail equipment, and agricultural machinery and equipment are pooled together to form a new category.*

Figure 10

R&D spending in MIC25 sectors by EU, US and Chinese companies in 2018 (in EUR bn)**, by country**



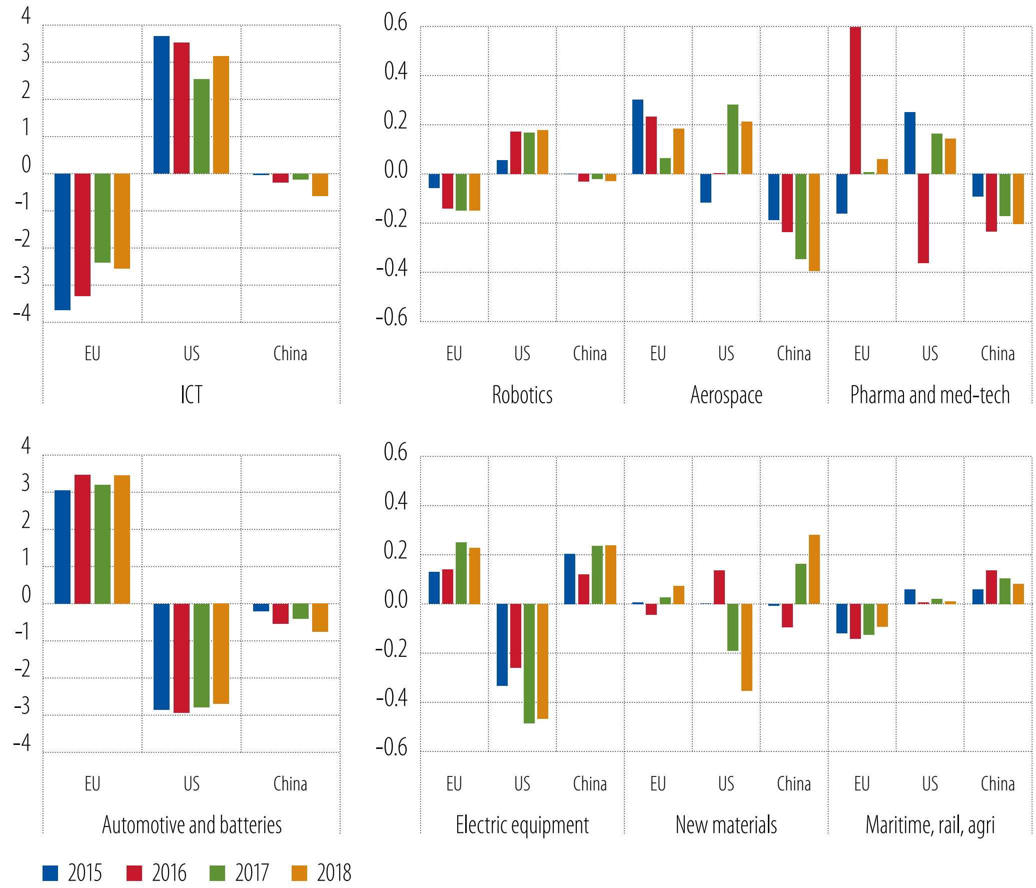
Source: *EIB calculations based on EU Industrial R&D Investment Scoreboard.*

Note: *The ten MIC25 sectors in Table 2 have been partly aggregated: maritime engineering equipment and high-tech maritime vessel manufacturing, advanced rail equipment, and agricultural machinery and equipment are pooled together to form a new category.*

The United States has a strong R&D specialisation in ICT, while the European Union is specialised in the automotive sector and China in electric equipment and new materials. The analysis based on the NRCA index confirms that US firms are strongly specialised in ICT (Figure 11). To some extent, the United States is also specialised in other high-tech industries, such as robotics, aerospace, and pharma and med-tech. The European Union has a strong specialisation in automotive and batteries, electric equipment (which are both medium high-tech sectors) and aerospace. China does not have any specialisation in high-tech sectors but is emerging as a leader for electric equipment, new materials as well as maritime, rail and agriculture. The focus of MIC25 on new materials is also supported by other initiatives, including the establishment of "smart manufacturing parks" where 17% of the 530 Chinese parks are focused on the development of new materials (MERICS, 2019). In high-tech sectors, European firms still face the strongest competition from the United States, while in medium high-tech sectors, competition is increasingly coming also from China – particularly in new materials.

Figure 11

Normalised revealed comparative advantage in MIC25 high-tech sectors and medium high-tech sectors, by country



Source: *EIB calculations based on EU Industrial R&D Investment Scoreboard.*
Note: *For illustrative purposes, the NRCA index has been multiplied by 100. ICT, robotics, aerospace, and pharma and med-tech are considered high-tech sectors, while automotive and batteries are considered medium high-tech sectors. Due to the different scale, ICT is shown in a separate graph for high-tech sectors; automotive and batteries are also shown in a separate graph for medium high-tech sectors. Pharmaceuticals and med-tech in 2016 in the European Union and the United States is an outlying observation.*

EU firms are strong players in the automotive industry but China is becoming a leader in the development of electric vehicle batteries. The analysis based on the NRCA suggests that, compared to the United States and China, the European Union is strongly specialised in automotive and batteries. However, this needs to be elaborated on further: EU firms are indeed strong in the *traditional* – combustion engine dominated – automotive industry. Nevertheless, looking into the recent development of electric vehicles, hybrids and battery technology, the frontrunners are Chinese companies, with EU peers running the risk of losing ground. China has a young, yet ambitious, automotive industry. While it remains difficult to match the quality and efficiency of established automakers at manufacturing gas-powered vehicles, electric vehicles open up opportunities for Chinese firms to compete. Among others, the MIC25 strategic plan identifies "energy-saving and new energy vehicles" as an important sector, with the goal to become the technology frontier in electronic mobility. China already has almost half the world's electric vehicles, half the global charging infrastructure and 99% of the world's electric buses (Politico, 2019).

To retain and strengthen its current position at the technology frontier, the European Union needs to develop the innovation ecosystem. This includes policies to better incentivise collaboration between companies and research institutes and ensure the availability of a highly educated labour force. The results of the EIB Investment Survey (EIBIS) indicate that the lack of availability of staff with the right skills continues to be the major obstacle to investment in Europe. The success of European industry champions relies heavily on the quality of science and effective collaboration with higher education institutions and research institutes for R&D and innovation activities. To push forward at the technology frontier, the transfer of research knowledge with commercialisation potential calls for a highly educated labour force at both ends of the transfer pipeline.

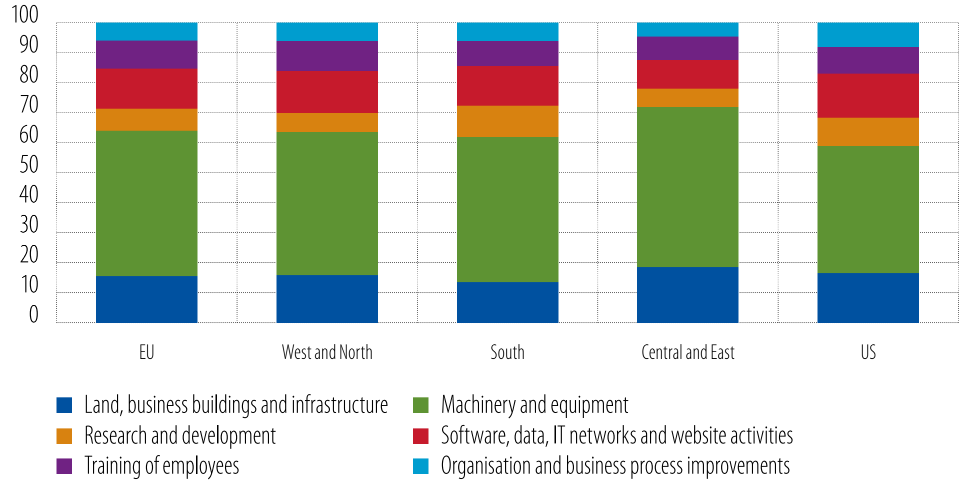
As innovation in China is increasing at a fast pace and the trend is set for further growth, this creates competition for European companies but potentially also offers opportunities for collaboration. The European innovation approach should aim at achieving global coverage, extending business models based on the technologies of the future, understanding those technologies and developing expertise based on the large pool of European skills and talent. At the same time, the European Union should leverage its long-standing and strong industrial base, while also safeguarding its core principles of democracy, reliability and security.

Intangible investment in the European Union and the United States

In addition to R&D, other types of intangible assets – including software and databases, training of employees and organisational capital – are increasingly considered important to firms' performance. Investment in intangibles represents a large part of gross fixed capital formation, which now exceeds that of tangible assets in the United States and several EU countries – including Sweden, the United Kingdom and Finland (EIB, 2016). Over the past few decades, the growing importance of intangible capital has been associated with firms' innovation activities but also with structural features of advanced economies, in particular slow productivity growth and rising inequality (Haskel and Westlake, 2017).

Investment in intangible assets is higher in the United States than in the European Union. In 2019, US firms allocated 41% of total investment to intangibles (R&D, software and databases, training of employees, and organisational and business process improvements), compared with 36% in the European Union, according to data in the EIB Investment Survey (Figure 12). The difference in the importance of intangibles between the United States and the European Union is also in line with estimates from macroeconomic statistics on intangible capital (EIB, 2016). Within the European Union, the share of investment spent on intangibles is lower in Central and Eastern Europe (28%) than in Western and Northern Europe (37%) or Southern Europe (38%).

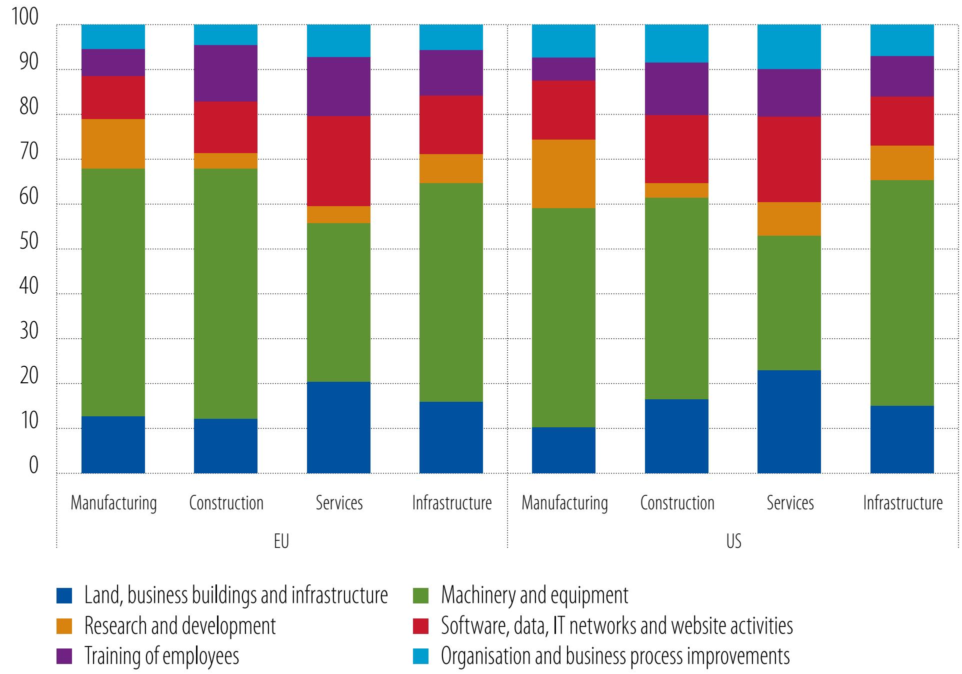
Figure 12
Composition of investment in the EU and the US (in %)



Source: EIB calculations based on the EIB Investment Survey (EIBIS wave 2019).
Note: Investment in different assets as a share of total investment. Firms are weighted with value added.

Manufacturing firms conduct more R&D than other sectors, while firms in services allocate a higher share of investment to software and data, IT networks and website activities. Machinery and equipment remains the most important investment area for all firms, even for firms in services – which tend to invest relatively more in land, business buildings and infrastructure.

Figure 13
Composition of investment in the EU and the US (in %)**, by sector**

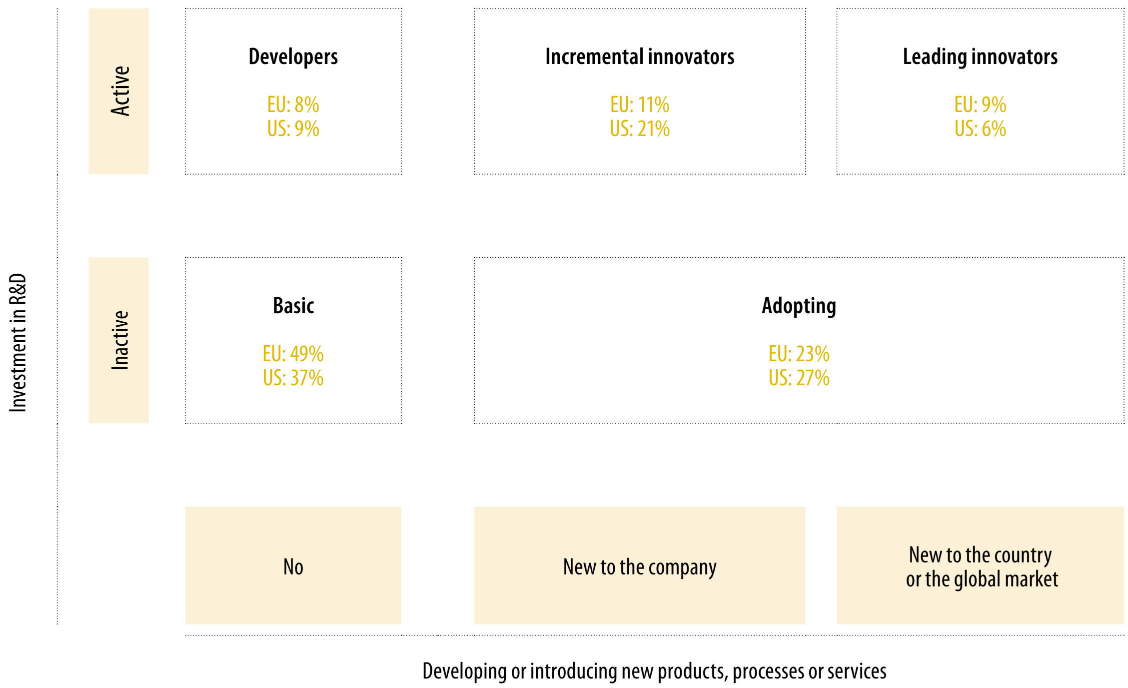


Source: EIB calculations based on the EIB Investment Survey (EIBIS wave 2019).
Note: Investment in different assets as a share of total investment. Firms are weighted with value added.

Innovation activities are correlated with investment in intangible assets. Firms that allocate a greater share of investment to intangible assets tend to be more productive and innovative: they are more likely to develop or introduce new products, processes or services (EIB, 2018). R&D investment is the main driver of this positive correlation between intangible assets and the introduction of new products, processes or services. However, investment in software and databases and in organisation and business process improvements matter as well (see Box B, which discusses the importance of investing in different intangibles for innovation and labour productivity). This emphasises the importance of complementarity across intangible assets for innovation activities, suggesting that public policies aiming to support innovation in the European Union should not only promote R&D investment.

The United States has a higher share of active innovators than the European Union. Firms can be classified by five different innovation profiles based on R&D investment and innovation activities (EIB, 2017). Firms surveyed in the EIBIS report whether they invest to develop or introduce new products, processes or services; the new products can be new to the company, new to the country or new to the global market. Firms also indicate whether they have made significant investments in R&D (including the acquisition of intellectual property). The five innovation profiles consist of basic firms, adopting firms, developers, incremental innovators and leading innovators (Figure 14). The European Union has a higher share of basic firms than the United States: basic 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 (incremental and leading innovators) than the United States. However, the difference stems from the fact that there are fewer incremental innovators in Europe, i.e. firms that invest in R&D and introduce products, processes or services that are new to the company (but not their market).

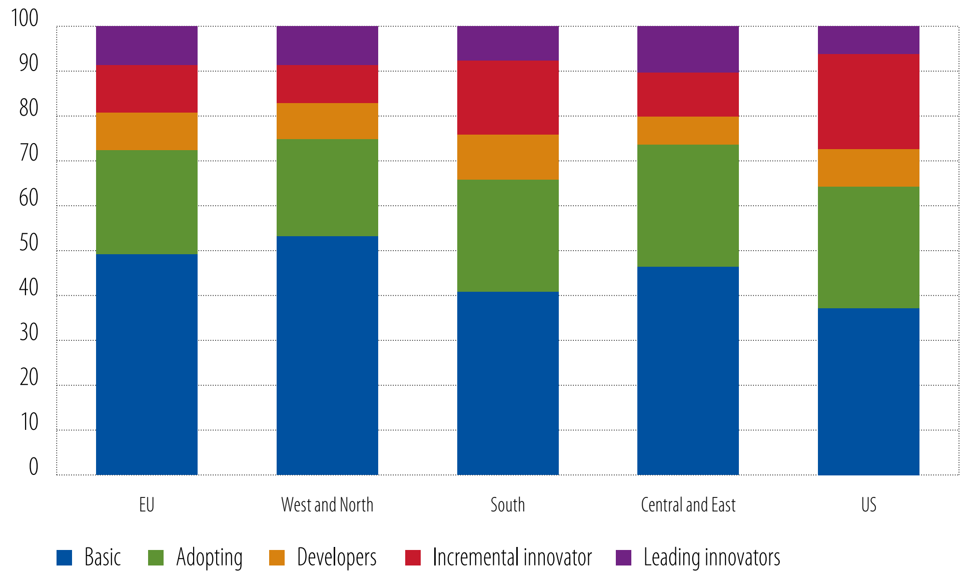
Figure 14
Innovation profiles in the EU and the US



Source: *EIB calculations based on the EIB Investment Survey (EIBIS wave 2019).*
Note: *R&D inactive: firms with an R&D investment intensity (i.e. R&D investment divided by turnover) below 0.1%. Firms are weighted with value added.*

The share of active innovators is higher in Southern Europe than in Western and Northern Europe or in Central and Eastern Europe – but this is because the share of incremental innovators is particularly high in Southern Europe. At the same time, the share of adopting firms, i.e. firms that do not invest in R&D but do introduce new products or services, is larger in Central and Eastern Europe and Southern Europe than in Western and Northern Europe – where many small firms do not engage in any form of innovation activities (EIB, 2018). Overall, all three EU regions have a lower share of active innovators than the United States (Figure 15). Innovation policy in Europe needs to better target firms with the potential to grow – as leading 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 15
Innovation profiles across the EU and the US (in %)



Source: *EIB calculations based on the EIB Investment Survey (EIBIS wave 2019).*
Note: *See Figure 14 for a definition of the innovation profiles. Firms are weighted with value added.*

Complementarities between different types of investment matter. Firms with higher investment intensity tend to perform better. Firms that invest more intensively – where intensity is defined as investment per employee – tend to have higher labour productivity (Table 3 – "direct effect"). Firms that invest simultaneously in different areas of intangible assets can benefit from spillover effects (EIB, 2018). Focusing on the interaction of tangible investments, firms that simultaneously invest in land, business buildings and infrastructure as well as in machinery and equipment tend to have higher labour productivity, which points to complementarities between the two investment areas (Table 3 – "Interaction with investment in other area", row A. and column B.).

Firms that simultaneously invest in machinery and equipment and in R&D tend to perform better. Investing in land and buildings together with software and data also tends to lead to higher labour productivity – these two asset categories are particularly important for firms in the services sector. Focusing on interactions of intangible investments, investing simultaneously in software and training of employees is associated with better firm performance. Similarly, the combination of investing in training of employees and business process improvements tends to lead to higher productivity.

Table 3

Interactions between investment intensity in different areas (tangible and intangible assets)

Outcome variable:	Direct effect	Interaction with investment in other area				
Labour productivity		B. Machinery	C. R&D	D. Data	E. Training	F. Org.
Total investment intensity	+					
A. Land and business buildings		+	0	+	0	0
B. Machinery and equipment			+	0	0	0
C. R&D				0	0	0
D. Software and databases					+	0
E. Training of employees						+
F. Organisation improvements						

Source: EIB calculations based on the EIB Investment Survey (EIBIS waves 2016, 2017, 2018 and 2019).

Note: Ordinary Least Squares (OLS) regression, with labour productivity (turnover per number of employees, in logarithm) as the dependent variable.

The explanatory variables are the investment intensity (total investment divided by the number of employees, in logarithm) and the interactions between investment intensity in different asset categories. Other explanatory variables: country, sector, year and firm size. The second column refers to the estimated coefficient on total investment intensity. Columns 3 to 7 report estimated coefficients on the interaction terms between different asset categories. "+": the estimated coefficient is positive and statistically significant at the 10% confidence level; "–": the estimated coefficient is negative and statistically significant at the 10% confidence level; "0": the estimated coefficient is not statistically significant at the 10% confidence level. Data on all firms are pooled from EIBIS (waves 2016, 2017, 2018 and 2019). The sample size is 43 271. Firms in EIBIS are weighted with value added.

Box B

Intangible investments and productivity performance[16]

Investment in intangible assets has increased rapidly over the past few decades, mainly driven by changes in industrial market structure, with several important implications for how firms operate (Haskel and Westlake, 2017). The manufacturing sector is becoming more oriented towards services and customers, while an increasing number of tasks in the services sector are automated, due to artificial intelligence and robotisation. In this context, information and communications technologies affect the organisational structure and commercial strategies of firms by providing them with new ways of selling products and services (e.g. e-commerce) or giving fast and easy access to data (e.g. information about customers). Technological change is also affecting the structure of the labour market, creating needs for new jobs in the ICT sector and changes in the demand for worker skills.

EU firms are facing new challenges: due to digitalisation and globalisation, they have greater difficulty maintaining their market position and keeping up with competition. Investment in intangible assets – such as R&D, intellectual property rights (patents, trademarks and design), software and data, and training of employees – has gained relevance in overcoming these market pressures (Crépon, Duguet and Mairesse, 1998; Hall, Lotti and Mairesse, 2013).

Many studies have found intangible assets or investments to have a positive effect on firm performance, measured by sales growth, total factor productivity, labour productivity or innovativeness (Dal Borgo et al., 2013; Cincera and Veugelers, 2014; Ugur et al., 2016). However, comparing the effect of different types of intangible investments is less well documented in the literature.

Cincera et al. (2019) use an augmented version of the model of Crépon, Duguet and Mairesse (1998) to analyse the effects on innovation and productivity of four different types of intangibles together:

16 This box was prepared by Michele Cincera (ULB), Pierre Mohnen (University of Maastricht), Julie Delanote, Anabela Santos (ULB) and Christoph Weiss.

namely R&D, software and data, the acquisition of new skills through training of employees, and investment in organisation and business process improvements. They show that R&D and ICT investments have a positive and significant effect on the probability of developing or introducing new products, processes or services (Table B.1). The acquisition of new skills seems to have no significant effect while organisational and business process improvements appear to have a negative effect on firm innovation activities. This could be related to the fact that organisational and business process improvements (and possibly also new skills) are more associated with the replacement of fixed assets and capacity expansion for existing products and services than with the development of new products or services.

Table B.1

Impact of different intangible investments on innovation

Dependent variable: probability of introducing new products, processes or services				
Intangible investment:	**R&D (1)**	**ICT (2)**	**Skills (3)**	**Organisation (4)**
Predicted intangible investment	0.353***	0.336***	-0.082	-0.260***
per employee (in logarithm)	(0.025)	(0.057)	(0.094)	(0.096)
Marginal effect	0.119***	0.114***	-0.028	-0.088
Investment in tangibles	Yes	Yes	Yes	Yes
Investment in other intangibles	Yes	Yes	Yes	Yes
Firm characteristics	Yes	Yes	Yes	Yes
Country, sector and year	Yes	Yes	Yes	Yes
Sample size	24 126	24 126	24 126	24 126
Pseudo R^2	0.083	0.080	0.081	0.078

Source: *Authors' calculations based on the EIB Investment Survey (EIBIS waves 2016 to 2018).*
Note: *Probit regressions. Firm characteristics include: firm size (number of employees), age, belonging to a group (yes/no), being an exporter (yes/no). The log of intangible investment per employee was estimated using an OLS regression, controlling for selection bias (decision to invest), obstacles to investment activities, competition index in the sector, firm production capacity utilisation and firm characteristics. Intangible investments refer to: (1) R&D expenditures (including the acquisition of intellectual property); (2) software, data, IT networks and website activities; (3) acquisition of new skills through the training of employees; (4) organisation and business process improvements (such as restructuring and streamlining). Robust standard errors in parentheses. Significance level: *** p<0.01, ** p<0.05, * p<0.1.*

Cincera et al. (2019) also find that both (predicted) innovation activities and the intensity of all four types of intangible investments positively impact labour productivity. This suggests that intangible investment can enhance productivity directly – and not only indirectly through innovation. Nevertheless, R&D investment appears to be associated more with innovation than with productivity and its effect on productivity is less important in comparison with ICT and new skills (Table B.2). In turn, ICT investment has a decisive effect on both the propensity to innovate and productivity gains.

The higher impact of ICT investment on both innovation and productivity is in line with the results of Hall et al. (2013) who argue that ICT could be a better predictor of productivity performance than innovation. The importance of ICT in achieving higher firm productivity could be symptomatic of changes in the economy, marked by a focus on the digital era. At the same time, the importance of skills to enhance productivity also confirms the findings of Díaz-Chao et al. (2015).

These findings support the need to design broader and more effective policy instruments that do not only focus on R&D. Even if R&D investments are important to enhance innovation, a combination of other factors is needed to achieve higher productivity. This is in line with recent evidence suggesting the need for structural reform needs in the areas of R&D, ICT and training of the workforce to meet the challenges for the next decade (European Commission, 2018; EIB, 2018).

Table B.2

Impact of innovation and different intangible investments on labour productivity

Dependent variable: labour productivity				
Intangible investment:	**R&D (1)**	**ICT (2)**	**Skills (3)**	**Organisation (4)**
Predicted probability of innovating	0.137***	0.128***	0.116***	0.107**
	(0.044)	(0.045)	(0.045)	(0.046)
Predicted intangible investment	0.046*	0.505***	0.592***	0.252***
per employee (in logarithm)	(0.025)	(0.047)	(0.078)	(0.081)
Capital stock per employee	Yes	Yes	Yes	Yes
Investment in other intangibles	Yes	Yes	Yes	Yes
Firm characteristics	Yes	Yes	Yes	Yes
Country, sector and year	Yes	Yes	Yes	Yes
Sample size	24 126	24 126	24 126	24 126
R^2	0.360	0.363	0.362	0.361

Source: Authors' calculations based on the EIB Investment Survey (EIBIS waves 2016 to 2018).

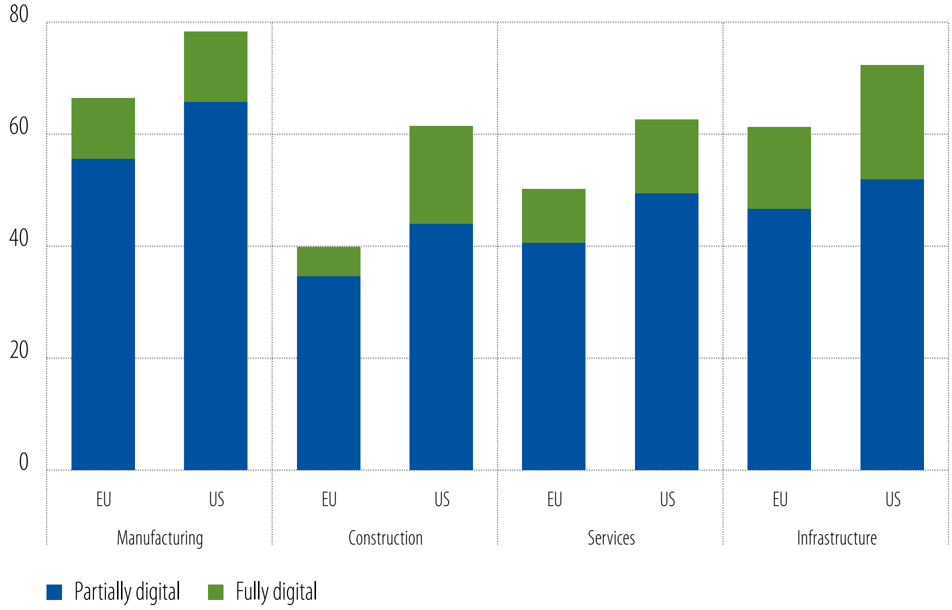
*Note: OLS regressions. Firm characteristics include: firm size (number of employees), age, belonging to a group (yes/no), being an exporter (yes/no). The log of intangible investment per employee was estimated using an OLS regression, controlling for selection bias (decision to invest), obstacles to investment activities, competition index in the sector, firm production capacity utilisation and firm characteristics. Intangible investments refer to: (1) R&D expenditures (including the acquisition of intellectual property); (2) software, data, IT networks and website activities; (3) acquisition of new skills through the training of employees; (4) organisation and business process improvements (such as restructuring and streamlining). The predicted probability to innovate is estimated based on the results of Table B.1. Labour productivity is measured by the logarithm of turnover per employee. Robust standard errors in parentheses. Significance level: *** p<0.01, ** p<0.05, * p<0.1.*

Adoption of digital technologies in the European Union and the United States

Digital adoption rates in the European Union are lower than in the United States. The adoption of digital technologies in the business sector in the European Union and the United States is spreading rapidly. In the European Union, 66% of manufacturing firms report having adopted at least one digital technology compared with 78% in the United States (Figure 16). The difference is particularly large in construction, where the share of digital firms is 40% in the European Union and 61% in the United States. The difference in adoption rates between EU and US firms is 13 percentage points in the services sector and 11 percentage points in the infrastructure sector.

Figure 16

Digital adoption in the EU and the US (in %)

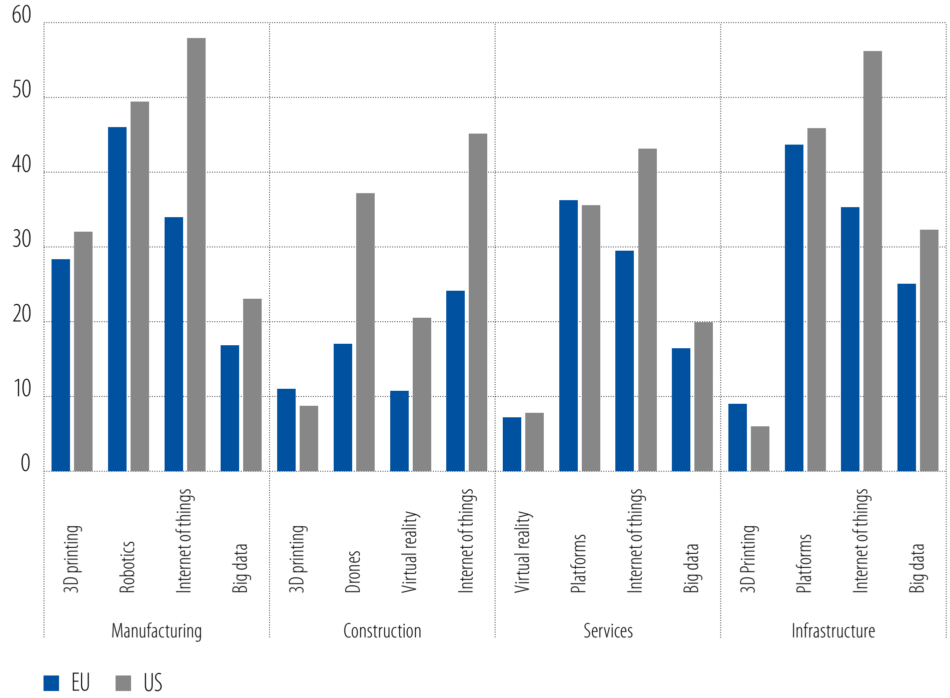


Source: EIB Investment Survey (EIBIS wave 2019).

Note: The figure is based on a question asking firms to report, for four different digital technologies, whether they have heard about them, not heard about them, implemented them in parts of their business, or whether their entire business is organised around them. A firm is identified as partially digital if at least one digital technology was implemented in parts of the business, and fully digital if the entire business is organised around at least one digital technology. Firms are weighted using value added.

EU firms have lower adoption rates of the internet of things than in the United States. Using data on specific digital technologies within the four sectors suggests that the differences between the European Union and the United States in adoption rates are driven by the lower adoption rates of the internet of things, i.e. electronic devices that communicate with each other without assistance (Figure 17). In addition, firms in the US construction sector employ drones more often than in the European Union.

Figure 17
Adoption of different digital technologies in the EU and the US (in %)

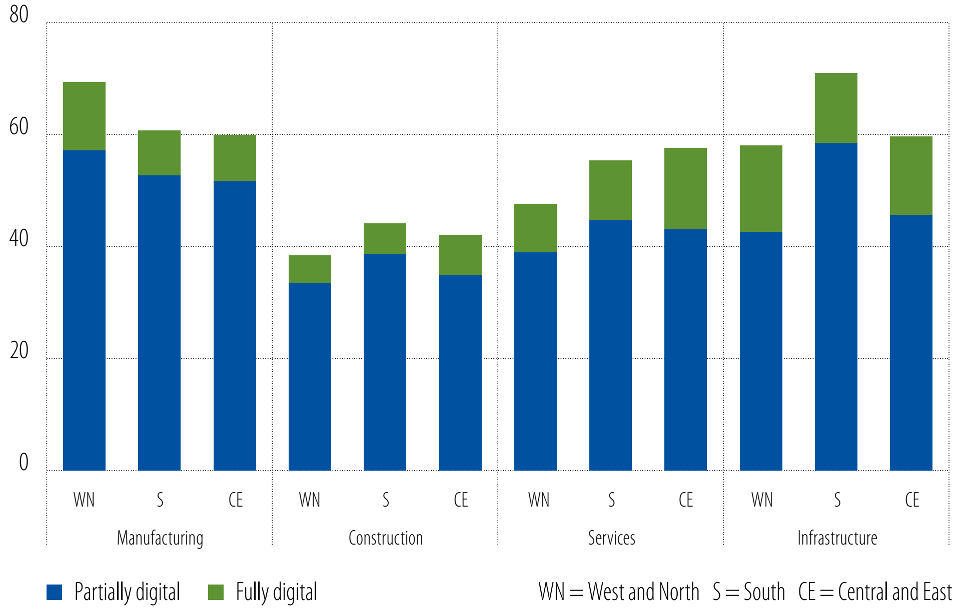


Source: *EIB Investment Survey (EIBIS wave 2019).*
Note: *The figure is based on a question asking firms to report, for each technology, whether they have heard about them, not heard about them, implemented them in parts of their business, or whether their entire business is organised around them. It shows the share of firms that have implemented (or organised their entire business around) each technology. Firms are weighted using value added.*

Manufacturing firms in Western and Northern Europe have higher rates of digital adoption than in Southern or Central and Eastern Europe. At the same time, construction firms in Western and Northern Europe tend to be less digital than in other regions of the European Union (Figure 18). Firms in services and infrastructure in Southern Europe also appear to be more digital than in Western and Northern Europe or Central and Eastern Europe.

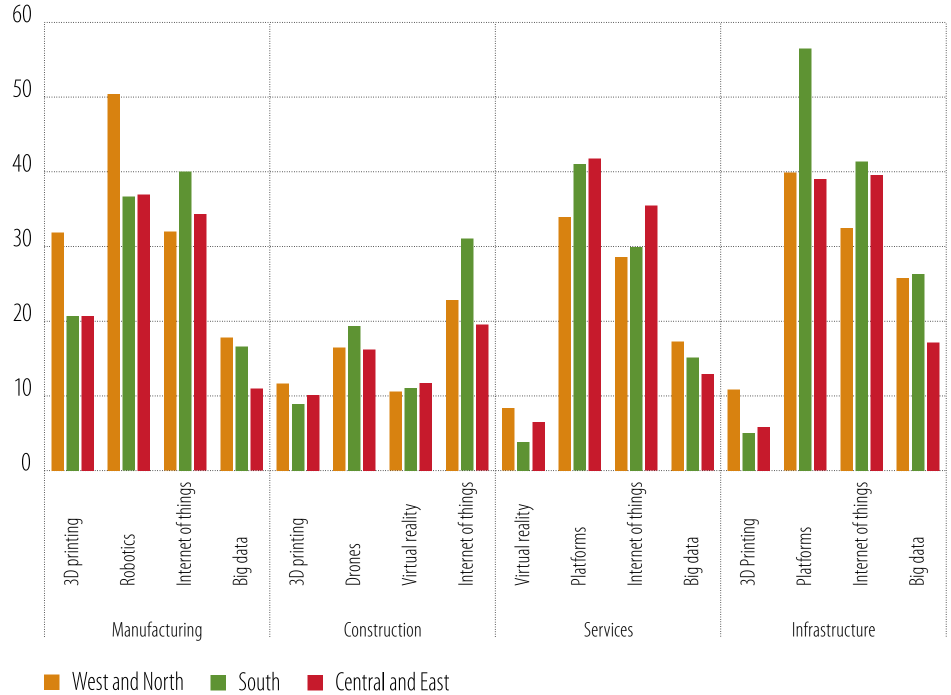
Manufacturing firms in Western and Northern Europe are more likely to have implemented 3D printing and advanced robotics than in Southern or Central and Eastern Europe. This explains the higher rate of digital adoption for manufacturing in Western and Northern Europe. The evidence on automation via advanced robotics is also in line with data of the International Federation of Robotics (IFR) that suggests that the density of industrial robots (number of industrial robots per thousand manufacturing workers) is higher in Western and Northern Europe than Southern or Central and Eastern Europe, as discussed in Chapter 1 of this report. At the same time, infrastructure firms in Southern Europe are more likely to have implemented digital platform technologies that connect customers to businesses (or customers to customers). Construction companies in Southern Europe also have a higher adoption rate of the internet of things than in other regions of Europe.

Figure 18
Digital adoption across the EU (in %)



Source: *EIB Investment Survey (EIBIS wave 2019).*
Note: *See note to Figure 16 for the definition of digital adoption. Firms are weighted using value added.*

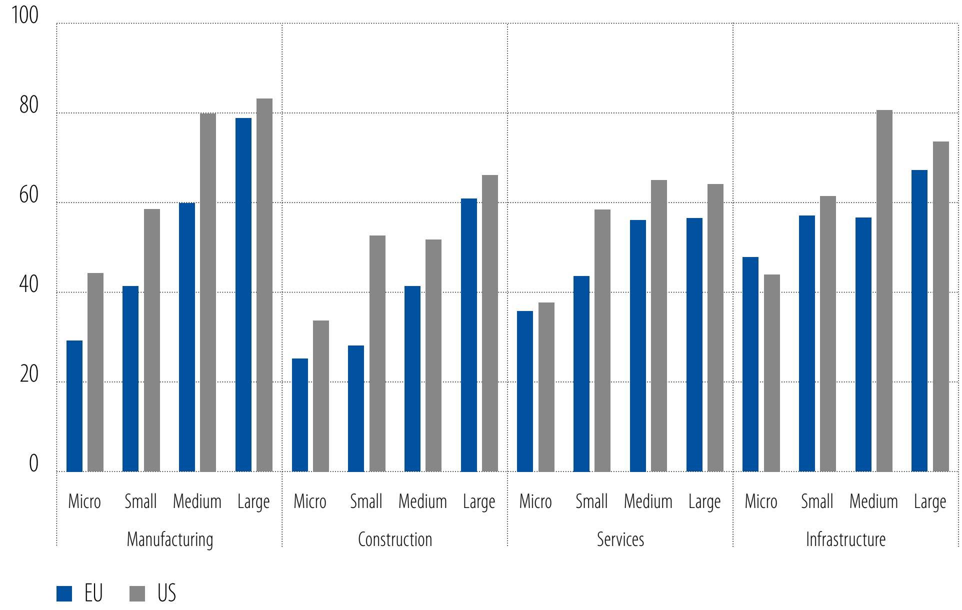
Figure 19
Adoption of different digital technologies across the EU (in %)



Source: *EIB Investment Survey (EIBIS wave 2019).*
Note: *See note to Figure 16 for the definition of digital adoption. Firms are weighted using value added.*

Larger firms have higher rates of digital adoption than smaller firms. Both in the United States and in the European Union and across all four sectors, the adoption of digital technologies increases with firm size (Figure 20). This size effect is particularly pronounced among manufacturing firms: for example, only 30% of EU firms with fewer than ten employees adopted digital technologies, whereas this share increases to 79% for firms with more than 250 employees. In addition, the difference in digital adoption between the European Union and the United States seems to be mainly driven by smaller firms.

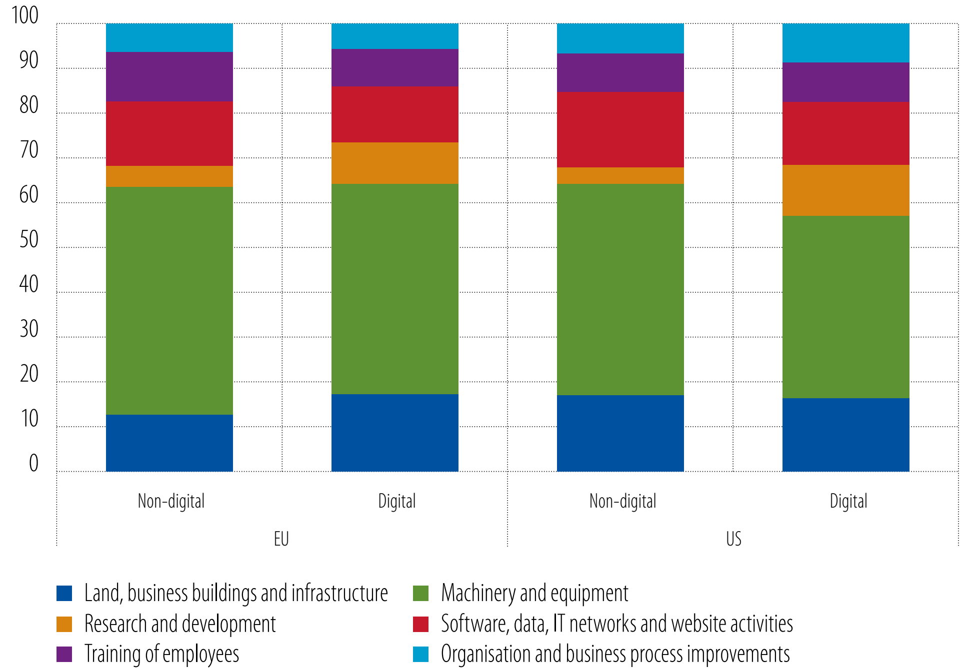
Figure 20
Digital adoption in the EU and the US (in %)**, by firm size**



Source: *EIB Investment Survey (EIBIS wave 2019).*
Note: *See note to Figure 16 for the definition of digital adoption. Firms are weighted using value added.*

Digital firms tend to invest more in R&D. Firms that have implemented digital technologies tend to allocate a larger share of their investment activities towards R&D and a smaller share towards machinery and equipment, both in the European Union and the United States (Figure 21). The stronger focus on R&D is particularly pronounced in the manufacturing and infrastructure sectors. Perhaps surprisingly, digital firms (i.e. firms that have implemented at least one digital technology) do not allocate a higher share of investment towards software, data, IT networks and website activities.

Figure 21
Composition of investment in the EU and the US (in %)**, by digital intensity**

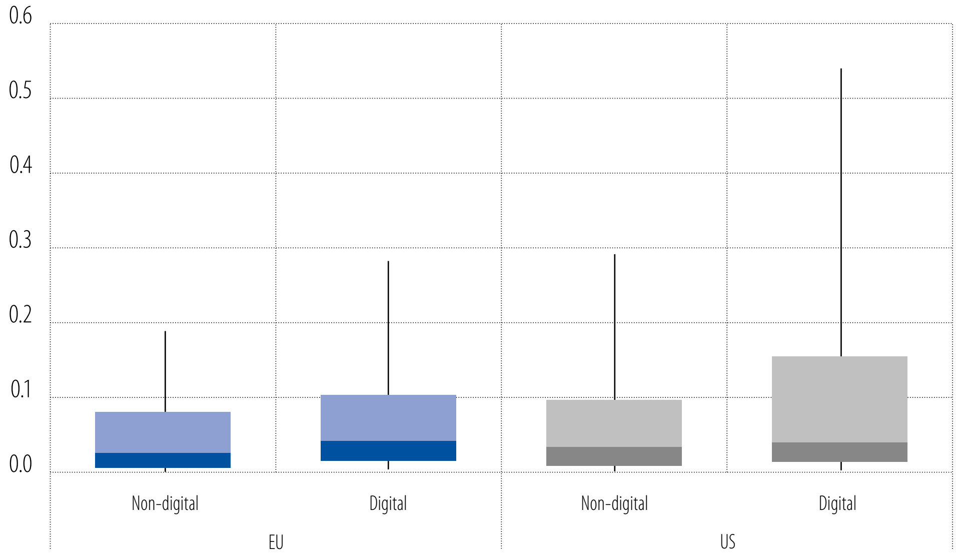


Source: *EIB calculations based on the EIB Investment Survey (EIBIS wave 2019).*
Note: *Investment in different assets as a share of total investment. See note to Figure 16 for the definition of digital adoption. Firms are weighted with value added.*

Digital firms have a higher investment intensity. Firms that have adopted at least one digital technology have a higher investment rate (investment over turnover), both in the European Union and the United States (Figure 22). This holds in particular for firms with high investment intensity (75th or 90th percentile of the distribution). This result may be explained by the fact that intangible assets, such as R&D or software, have higher depreciation rates than tangible assets: the higher the depreciation rate, the higher the investment needed to keep the capital stock at a given level.

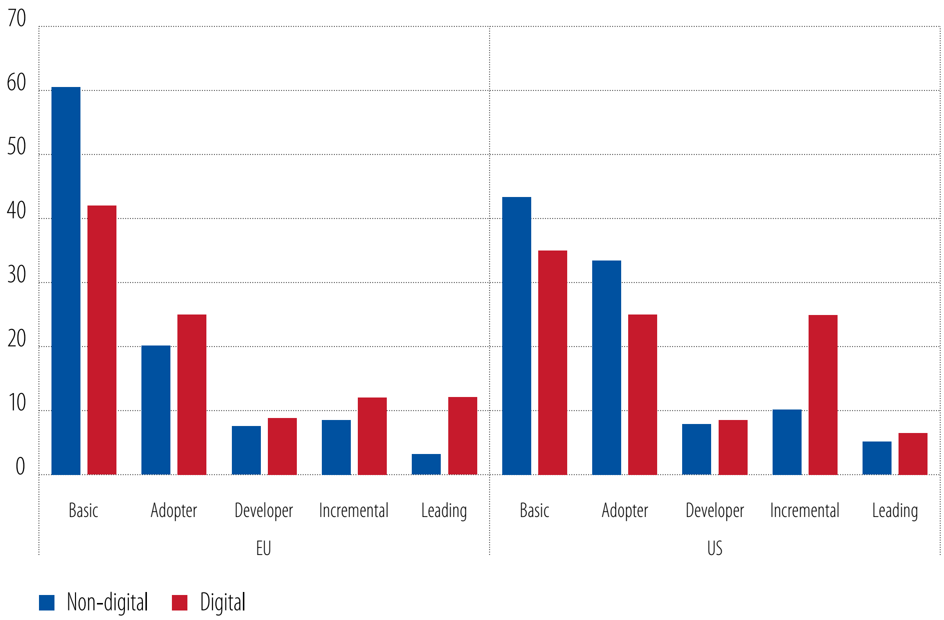
Firms that have implemented digital technologies are more likely to engage in innovation activities. The share of active innovators (i.e. firms that invest in R&D and introduce new products, processes and services) is higher among digital firms (Figure 23). At the same time, non-digital firms are more likely to be basic firms that do not innovate – as they do not conduct any R&D and do not develop new products, processes or services.

Figure 22
Distribution of investment intensity, by digital intensity



Source: EIB calculations based on the EIB Investment Survey (EIBIS wave 2019).
Note: The figure shows the 10th, 25th, 50th, 75th and 90th percentiles of the distribution of investment intensity. Investment intensity is defined as investment divided by turnover. See note to Figure 16 for the definition of digital adoption. Firms are weighted with value added.

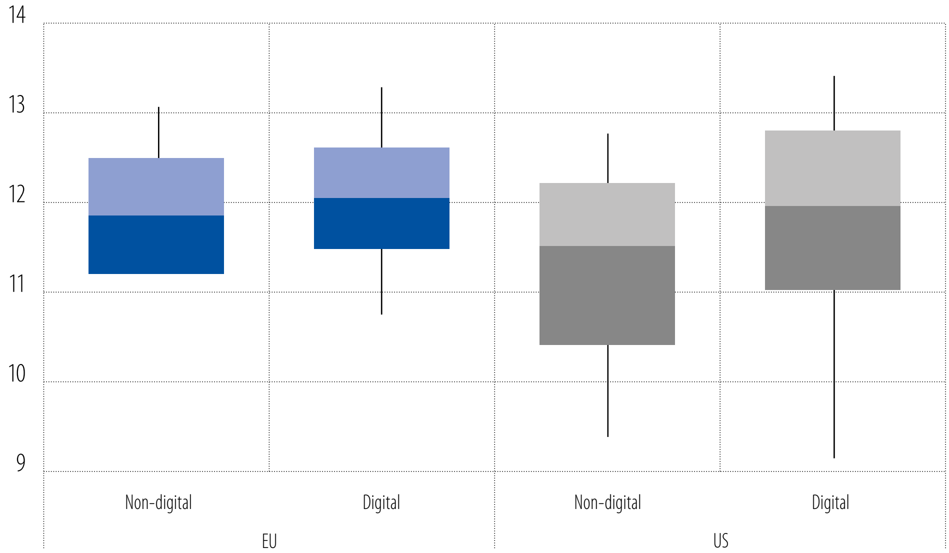
Figure 23
Innovation profiles (in %)**, by digital intensity**



Source: EIB calculations based on the EIB Investment Survey (EIBIS wave 2019).
Note: See Figure 14 (page 127) for a definition of the innovation profiles. See note to Figure 16 (page 132) for the definition of digital adoption. Firms are weighted with value added.

Firms that have implemented at least one digital technology tend to be more productive. Digital firms have higher median labour productivity (turnover divided by the number of employees) than non-digital firms (Figure 24). This difference is particularly large in the United States where the distribution of labour productivity appears to be wider. The 25th percentile of the distribution of labour productivity among digital firms is higher in the European Union than in the United States: this suggests that there are many digital firms in the United States that are less productive than in the European Union. At the same time, the 75th percentile of the distribution of labour productivity is lower in the European Union than in the United States. In other words, the United States also has a large share of top performing digital firms that are more productive than in the European Union. It is important to bear in mind that the share of firms that have implemented digital technologies is higher in the United States than in the European Union (Figure 16). This suggests that the European Union needs to take measures to better support digital champions so that they can compete against the most productive US firms.

Figure 24
Distribution of labour productivity, by digital intensity

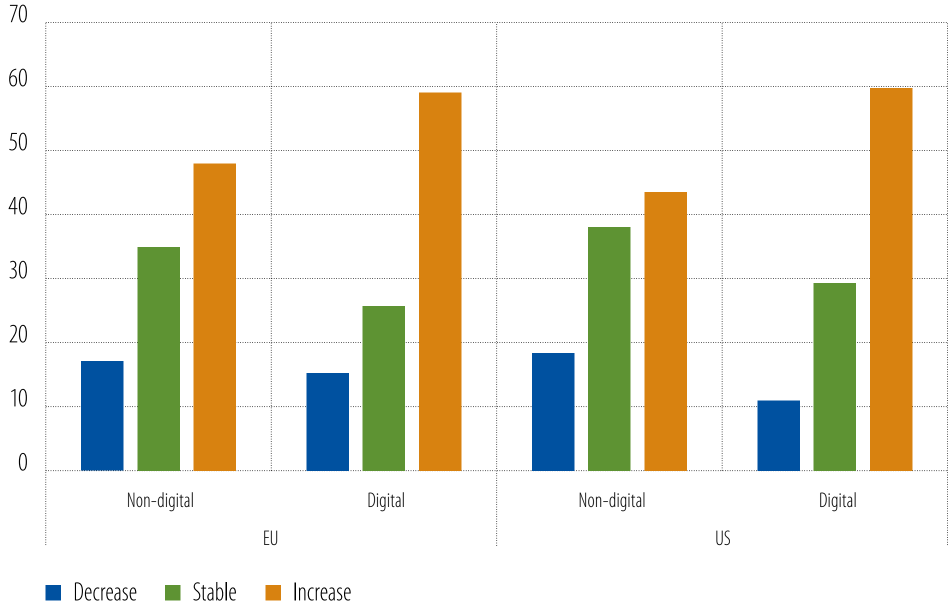


Source: *EIB calculations based on the EIB Investment Survey (EIBIS wave 2019).*
Note: *The figure shows the 10th, 25th, 50th, 75th and 90th percentiles of the distribution of labour productivity. Labour productivity is defined as turnover divided by the number of employees. See note to Figure 16 for the definition of digital adoption. Firms are weighted with value added.*

Digital firms are more likely to grow. Digital firms are more likely to have hired new employees over the past three years, suggesting that they are more dynamic, both in the European Union and the United States, while a higher share of non-digital firms have reduced employment or remained stable (Figure 25).

Figure 25

Share of firms with negative, stable and positive employment growth over the past three years (in %)**, by digital intensity**

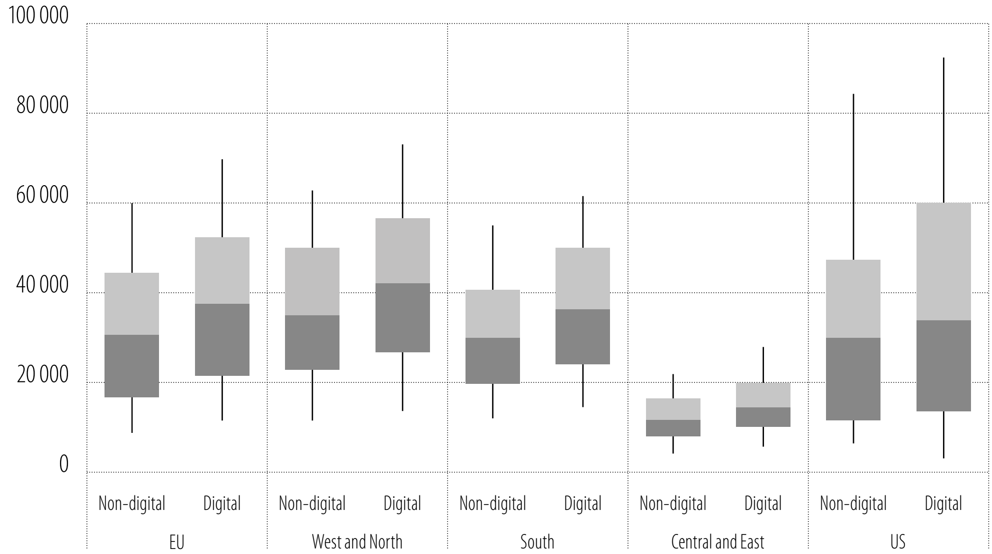


Source: *EIB calculations based on the EIB Investment Survey (EIBIS wave 2019).*
Note: *See note to Figure 16 for the definition of digital adoption. Firms are weighted with value added.*

The higher demand for skilled staff is reflected in higher wages among digital firms. Many economists argue that digital technologies – such as artificial intelligence, machine learning and industrial robots – have an impact on employment, wages, skills demand, and job polarisation because of automation and skills-biased technological change (Acemoglu and Autor, 2011; Autor and Dorn, 2013; Goos, Manning and Salomons, 2014; Autor, 2015; Autor and Salomons, 2017; Brynjolfsson and Mitchell, 2017; Acemoglu and Restrepo, 2019; Frank et al., 2019). Firms that have adopted at least one technology tend to pay higher wages (Figure 26). While digitalisation may lead to the disappearance of entire professions, the jobs created by digital firms often appear to be relatively well paid. Clearly, average wages are lower in Central and Eastern Europe, compared to other regions in Europe or the United States. 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.

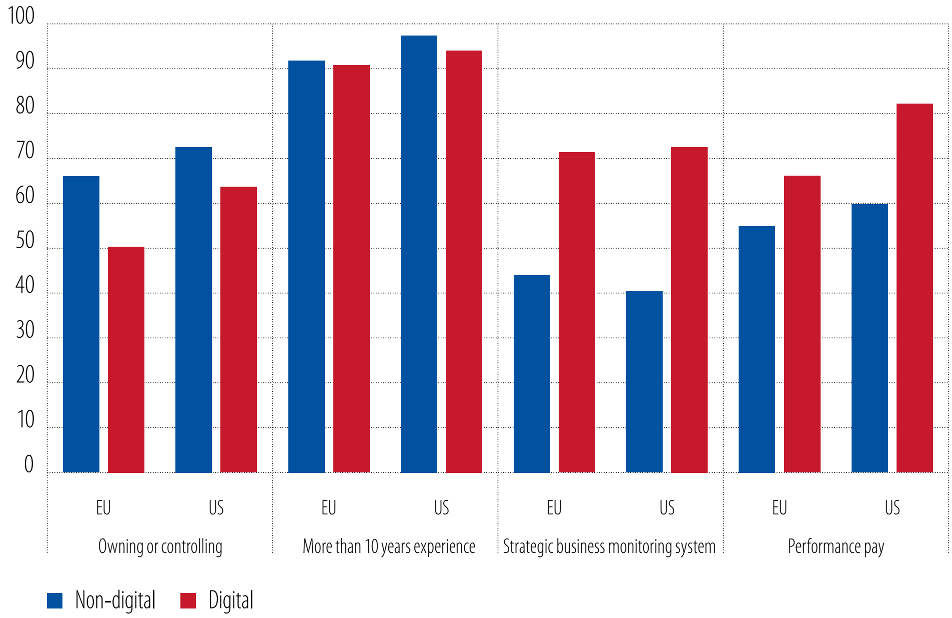
Digital firms tend to have better management practices. Firm culture matters for the adoption of digital technologies. Digital firms more often report that they use a formal strategic business monitoring system than non-digital companies, both in the European Union and the United States (Figure 27). Digital companies also tend to reward individual performance more often with higher pay – this difference is larger in the United States than in the European Union. By contrast, digital firms are less often owned or controlled by their chief executive (or family members of the chief executive) than non-digital firms.

Figure 26
Distribution of average wage per employee (in EUR)**, by digital intensity**



Source: *EIB calculations based on the EIB Investment Survey (EIBIS wave 2019).*
Note: *The figure shows the 10th, 25th, 50th, 75th and 90th percentiles of the distribution of average wage per employee. Average wage per employee is defined as the wage bill divided by the number of employees. See note to Figure 16 for the definition of digital adoption. Firms are weighted with value added.*

Figure 27
Management practices (in %)**, by digital intensity**

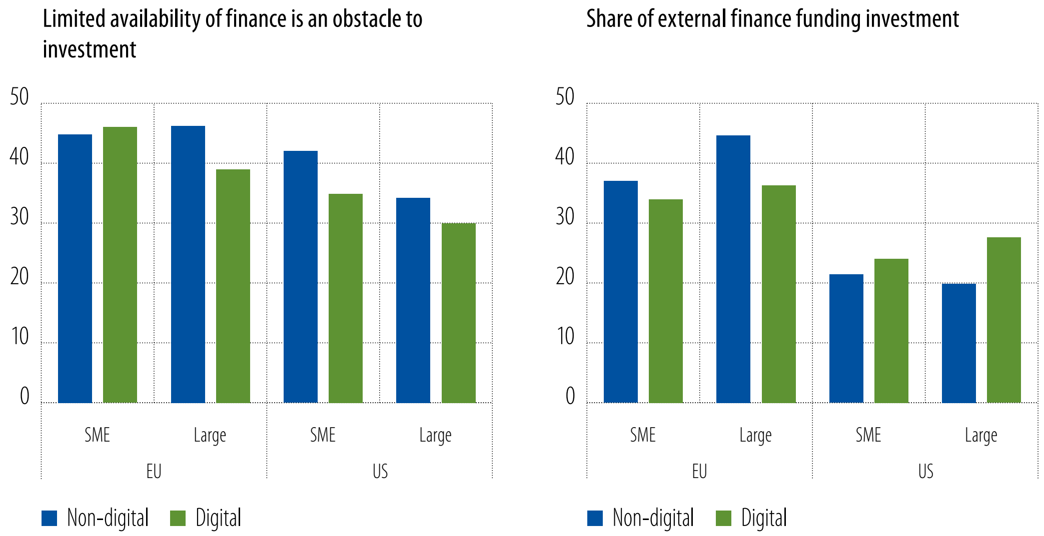


Source: *EIB Investment Survey (EIBIS wave 2019).*
Note: *Firms are weighted with value added.*

A lack of access to finance can be a barrier to the adoption of digital technologies in the European Union, especially for small businesses. While most digital firms are less likely to report the limited availability of finance as an obstacle to investment activities, lack of access to finance tends to be a stronger barrier for small digital firms in the European Union (Figure 28). This is also reflected in the share of external finance used to fund investment in the previous financial year, as EU digital firms tend to rely more on internal funds (e.g. cash or profits). That does not appear to be the case in the United States, where the share of digital firms is higher than in the European Union (Figure 16). Overall, US firms tend to rely less on external finance than EU firms. However, US digital firms rely more on external finance and are less likely to complain about the limited availability of finance than other US firms.

Figure 28

Share of firms that report the limited availability of finance as an obstacle to investment (in %) **and share of external finance funding investment** (in %)**, by digital intensity**



Source: EIB calculations based on the EIB Investment Survey (EIBIS wave 2019).
Note: Firms are weighted with value added.

Access to growth capital may be one reason why small digital firms in the European Union tend to rely less on external finance than non-digital firms. While leasing is an important source of external finance for EU firms, US digital firms make use of newly issued equity to a much larger extent than in the European Union. US digital firms in the manufacturing and services sectors report the highest shares of external equity.[17]

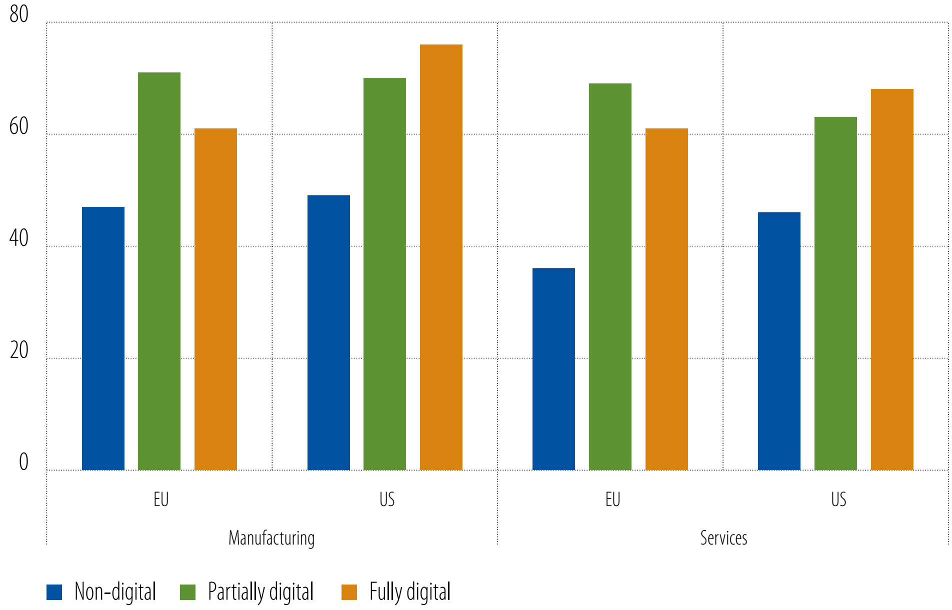
17 Chapter 7 of this report discusses in depth the differences in the sources of funding for start-ups and scale-ups in the European Union and the United States.

The growing digital divide

Digital technologies can be a source of disruption, leading to a more polarised economic structure, with the benefits concentrated in a few "superstar firms" and many other firms and workers on the losing side. Evidence exists of rising concentration and increasing firm mark-ups in advanced economies (Autor et al., 2017; De Loecker and Eeckhout, 2017). In particular, mark-ups are rising for firms in the top decile of distribution of mark-ups within their industry, which is consistent with "winner-takes-all" dynamics (Diez et al., 2018). These trends tend to be more pronounced in the sectors where digital technologies – especially digital services – are developed or intensely adopted (Calligaris, Criscuolo and Marcolin, 2018). The European Union may be falling behind in the digital technology race, trapped on the wrong side of the digital technology divide.

There is a growing digital divide between digital firms that increase their investment in digital technologies and non-digital firms that do not plan to invest in digital technologies. This section relies on data of the EIB Digital and Skills Survey that asks firms about their adoption of digital technologies and their plans for future investments.[18] Digital firms are significantly more likely to have plans to increase their investment in digital technologies over the next three years (Figure 29). This trend is likely to exacerbate the digital divide across firms in the European Union and the United States.

Figure 29
Share of firms that plan to increase their investment in digital technologies (in %)**, by digital intensity**

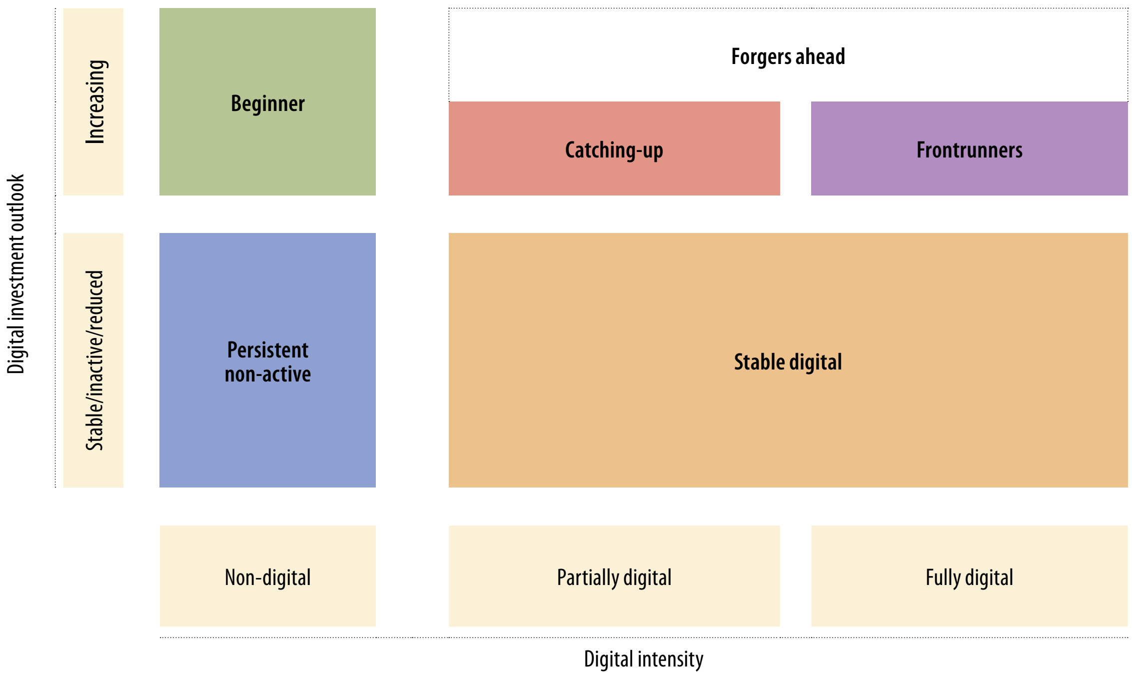


Source: *EIB Digital and Skills Survey 2018.*
Note: *The figure is based on a question asking firms to report, for four different digital technologies, whether they have heard about them, not heard about them, implemented them in parts of their business, or whether their entire business is organised around them. A firm is identified as partially digital if at least one digital technology was implemented in parts of the business, and fully digital if the entire business is organised around at least one digital technology. Firms are weighted using employment.*

18 The EIB Digital and Skills Survey interviewed 1 700 firms in manufacturing and services in the European Union and the United States in 2018. The previous section relies on EIBIS (wave 2019) instead. EIBIS 2019 asks firms about digital technologies that have already been implemented but does not ask whether they plan to increase their investment spend on digital technologies. See EIB (2018) for more details on the EIB Digital and Skills Survey.

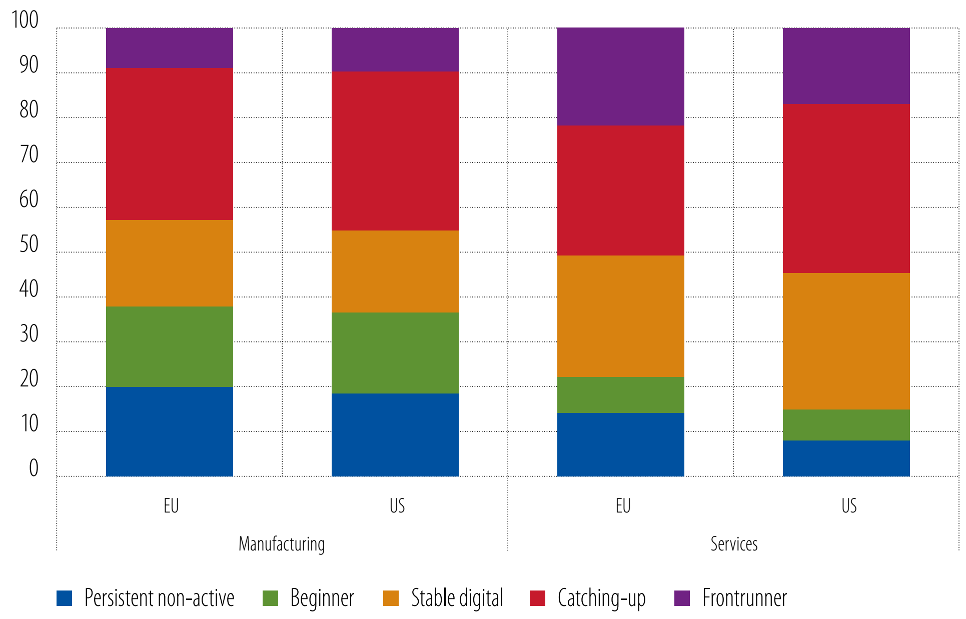
Veugelers, Rückert and Weiss (2019) identified five different digital profiles using two sets of questions about whether firms implemented digital technologies and whether they planned to increase their investment spend on digital technologies. The first group consists of firms that have not implemented any digital technology and do not plan to invest in digital technologies in the next three years: these companies are falling behind on the digital divide grid and are labelled as "persistent non-active" (Figure 30). Companies that are currently non-digital but have plans to invest in digital technologies are labelled "beginners". Within the group of firms that have implemented digital technologies, there are firms that are already digital but do not intend to increase investment in digital technologies in the next three years: they are labelled as "stable digital". Digital firms that are planning to further invest in digital technologies are labelled "forgers ahead". "Forgers ahead" can be further divided depending on whether they have implemented a digital technology in parts of their business or whether their entire business is organised around digital technologies. "Catching-up" firms are partially digital and plan to increase further their digital investments, while "frontrunners" are already fully digital and are continuing to increase their investment spend on digital technologies.

Figure 30
The five corporate digital divide profiles



The share of services firms left behind because of their (lack of) digitalisation activities is higher in the European Union than in the United States. There are more "persistent non-active" firms in services in the European Union than in the United States: "persistent non-active" firms are those that have not implemented any digital technology and do not plan to invest in them over the next three years. In the manufacturing sector, EU firms are not significantly more likely to be "persistent non-active" than in the United States (Figure 31). On the other side of the corporate digital divide, no large differences exist between the European Union and the United States in manufacturing for "forgers ahead" (or "catching-up" firms and "frontrunners"). Even though the difference on "forgers ahead" is not significant in services either, the European Union has somewhat more "frontrunners" than the United States. Together with the higher share of "persistent non-active" firms, this suggests that the European Union seems to have a deeper and more polarised digital divide in services compared to the United States.

Figure 31
Digital divide profiles (in %), **by sector and country**

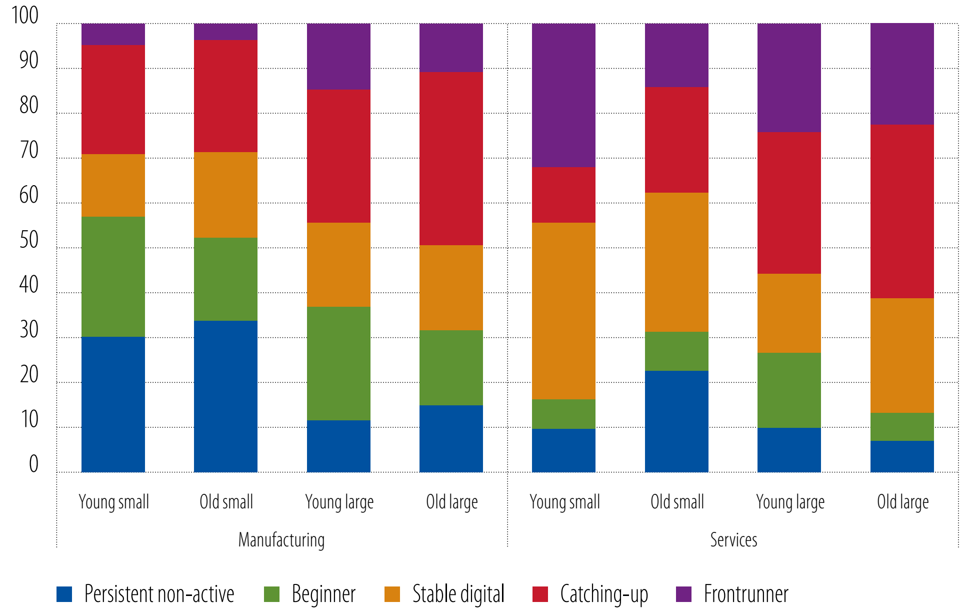


Source: EIB Digital and Skills Survey 2018.
Note: See Figure 30 for a definition of the digital divide profiles. Firms are weighted using employment.

Old small firms, such as firms with fewer than 50 employees and more than ten years old, are significantly more likely to be on the wrong side of the digital divide. Old small firms, which represent a significant share of the corporate landscape in the European Union, are more likely to be "persistent non-active" and less likely to be "forging ahead", both in services and manufacturing (Figure 32). This evidence is also in line with the evidence that the adoption of digital technologies increases with firm size (Figure 20). The results of regression analysis show that, among non-digital firms, old small firms are significantly less likely to "begin" investing in digital technologies. In addition, even when they have already implemented digital technologies, old small firms are significantly less likely to increase their digital investments. Box C discusses four different profiles of digital maturity among US and Canadian small businesses based on innovation culture and digital intensity. The results suggest that there are no large differences between the United States and Canada but confirm the findings that firms in services and large firms tend to be more digital (in line with the evidence of Figure 31 and Figure 32).

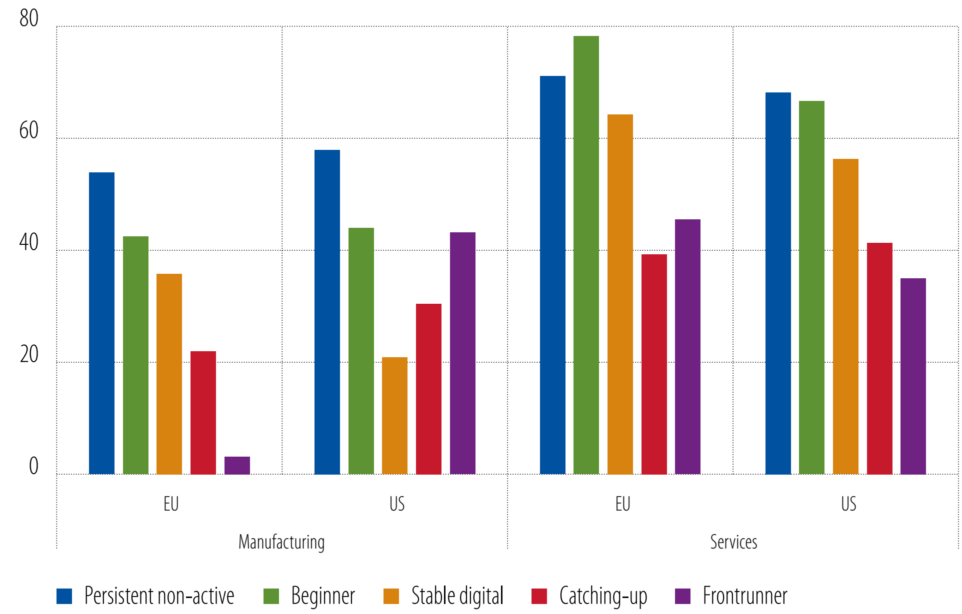
Digital firms that plan to further increase their investment in digital technologies tend to be more innovative. Digital technologies are likely to be empowering innovation. Firms that are in the digital divide categories "stable digital", "catching-up" and "frontrunner" are less likely to be basic innovators, and are less likely to invest in R&D or to develop new products or services (Figure 33), which is also in line with the evidence of Figure 23. Digital investment polarisation thus appears to be associated with an innovation divide gap.

Figure 32
Digital divide profiles (in %)**, by sector, country, firm size and age**



Source: *EIB Digital and Skills Survey 2018.*
Note: *See Figure 30 for a definition of the digital divide profiles. Young: less than 10 years old. Small: fewer than 50 employees. Firms are weighted using employment.*

Figure 33
Share of basic innovators (in %)**, by digital divide profile**

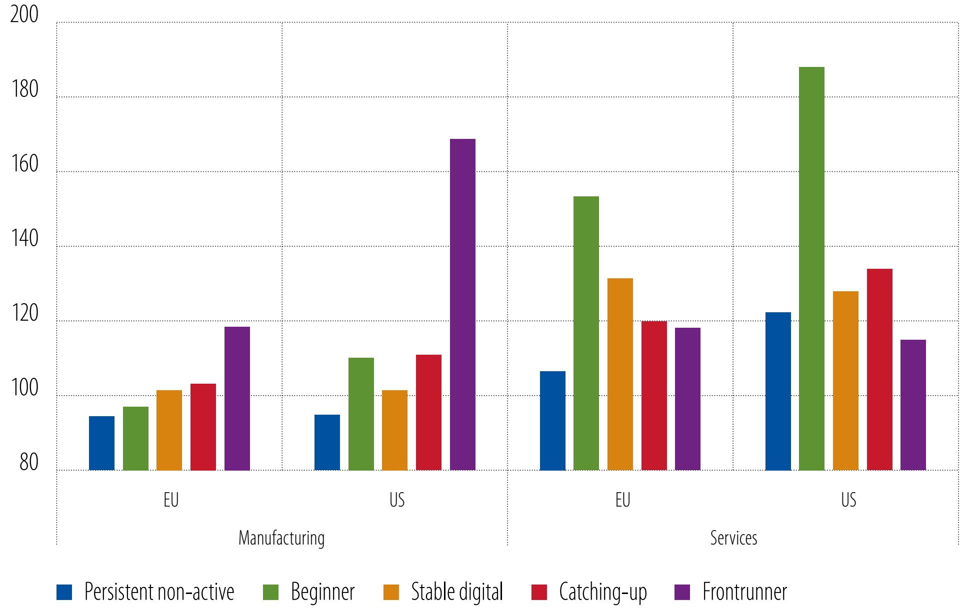


Source: *EIB Digital and Skills Survey 2018.*
Note: *See Figure 14 for a definition of the "basic" innovation profile: a firm that does not invest in R&D and does not invest to develop new products or services. See Figure 30 for a definition of the digital divide profiles. Firms are weighted using employment.*

Non-active digital firms tend to have lower mark-ups. Digitalisation is often linked to concerns of excessive market power and a concentration of big technology companies. Digital technologies often come with features such as scalability, sunk fixed costs and synergies, which tend to advantage large, incumbent firms and foster market concentration (Haskel and Westlake, 2017). Frontrunner firms in manufacturing appear to be able to command higher mark-ups, compared to less digital manufacturing firms (Figure 34). On average, services firms and US firms appear to be more profitable – as proxied by their higher mark-ups.[19] In services, beginners, i.e. firms that have not implemented any digital technologies but plan to invest in them, tend to have higher mark-ups. The results of regression analysis also confirm that non-active firms are associated with significantly lower mark-ups.

Figure 34

Mark-up index, by digital divide profile



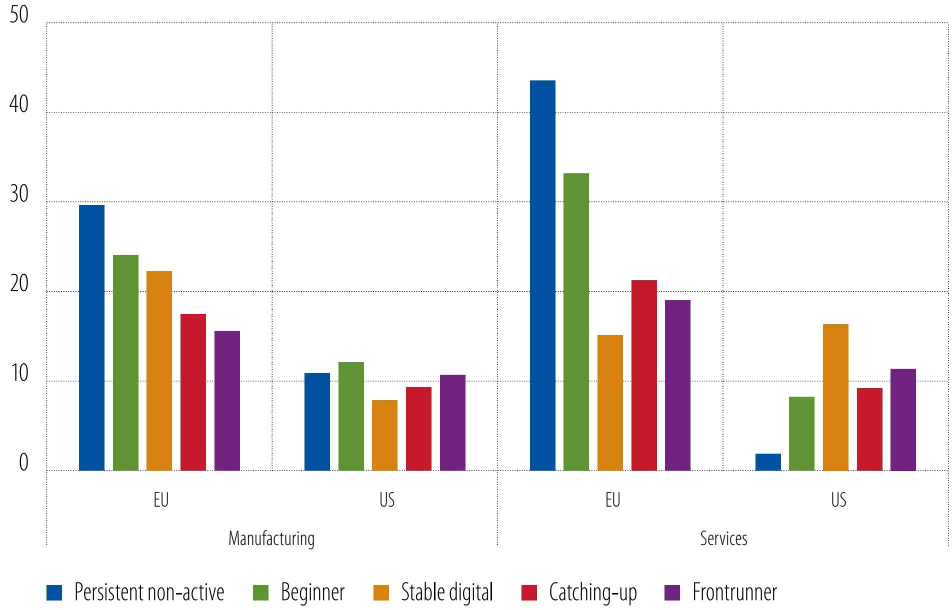
Source: *EIB Digital and Skills Survey 2018.*
Note: *For each digital divide profile, the mark-up index is standardised with the average mark-up of all firms in the sample (e.g. average mark-up of EU manufacturing firms with the profile "frontrunner"/average mark-up of all firms*100). See Figure 30 for a definition of the digital divide profiles. Firms are weighted using employment.*

Lack of access to finance is perceived as a major obstacle to investment by many non-digital firms in the European Union. Out of a list of nine obstacles to investment, the barrier that is most often reported by firms (44% of all firms) as major is the limited availability of staff with the right skills. Uncertainty about the future and business regulations are other factors mentioned by many firms as major obstacles. However, compared to other firms, non-digital firms are not more likely to report that they are major obstacles. The limited availability of finance is a barrier where the share of "persistent non-active" firms is significantly higher than for other digital divide profiles: 25% of persistent non-active firms report it as a major obstacle to investment, compared with 16% of all other firms, which either have already implemented digital technologies or plan to invest in them. The limited availability of finance is more likely to hold as a major obstacle in the European Union than in the United States (Figure 35). This difference between the European Union and the United States is most pronounced in the services sector. In services, "persistent non-active" firms from the European Union are significantly more likely to report lack of access to finance as a major barrier compared to all EU firms, while this is not the case in the United States. Using public policy to improve access to finance could encourage EU firms to invest more in digital technologies.

19 The estimation of mark-ups is based on the approach of De Loecker and Eeckhout (2017).

Figure 35

Share of firms that report lack of access to finance as a major obstacle to investment (in %), **by digital divide profile**



Source: EIB Digital and Skills Survey 2018.
Note: See Figure 30 for a definition of the digital divide profiles. Firms are weighted using employment.

Box C

Digital maturity in Canada and the United States[20]

BDC, the business development bank of Canada, in 2018 surveyed 2 000 Canadian and 600 US small and mid-sized businesses to assess their level of digital maturity and investigate the relationship between digital maturity and financial performance. The survey found that small and mid-sized businesses that invest in digital technologies were better at growing revenue, but their capacity to manage change drove profitability.

Following an approach developed by the MIT Centre for Digital Business, BDC defined digital maturity as a combination of two separate but related dimensions: digital intensity and innovation culture. Digital intensity measures the use of digital technologies such as software, data and e-commerce in a company's operation. Innovation culture measures the ability to implement change in a company, such as having a strong vision, appropriate planning and an environment that rewards risk-taking. These two dimensions make it possible to classify each company under one of the four digital profiles: conservative, techno-shy, techno-centred and advanced (Figure C.1).

20 This box was prepared by Pierre-Olivier Bédard-Maltais, Business Development Bank of Canada.

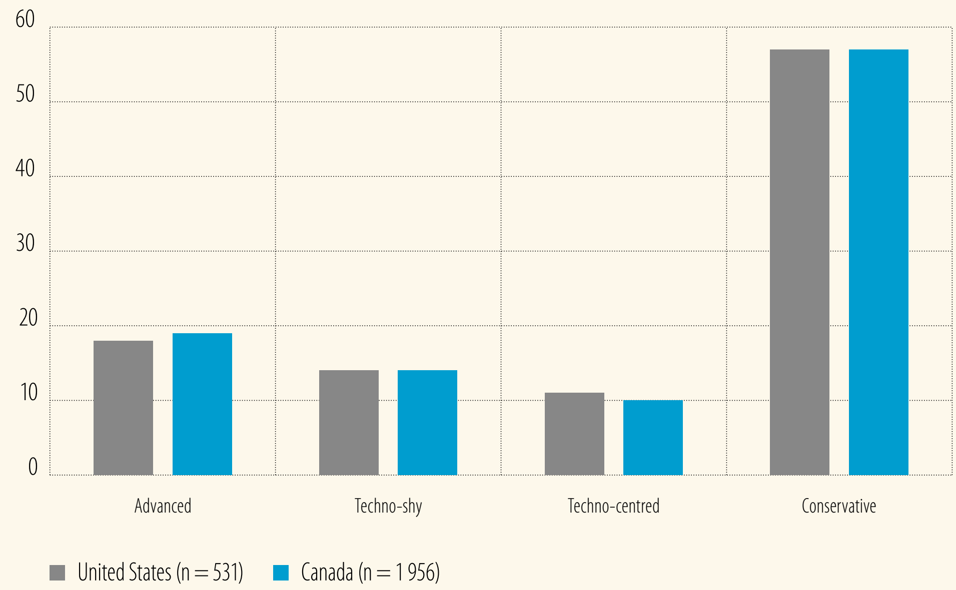
Figure C.1
BDC's digital maturity model

Innovation culture		Digital intensity: Low	Digital intensity: High
	High	**Techno-shy companies** These companies have the right culture in place to implement digital technologies, but they have not invested enough to take full advantage of these technologies.	**Advanced companies** These companies scored high on both innovation culture and digital intensity. They use digital technologies effectively to run their business and have the right culture to drive changes across the organisation.
	Low	**Conservative companies** These companies scored low on both innovation culture and digital intensity. They make limited use of digital technologies and have trouble managing and driving culture.	**Techno-centred companies** These companies have invested a lot of resources into digital technologies, but their company culture has made it difficult to fully benefit from the investment.

Note: *Adapted from George Westerman et al. (2012).*

Using this approach, the survey showed that one in five (19%) Canadian businesses had an advanced digital profile, while more than half (57%) had a conservative profile. These proportions were the same for US businesses, suggesting there was no digital gap between the United States and Canada among small and mid-sized businesses (Figure C.2). Larger businesses and service providers also tended to be more digitally mature (Figure C.3 and C.4).

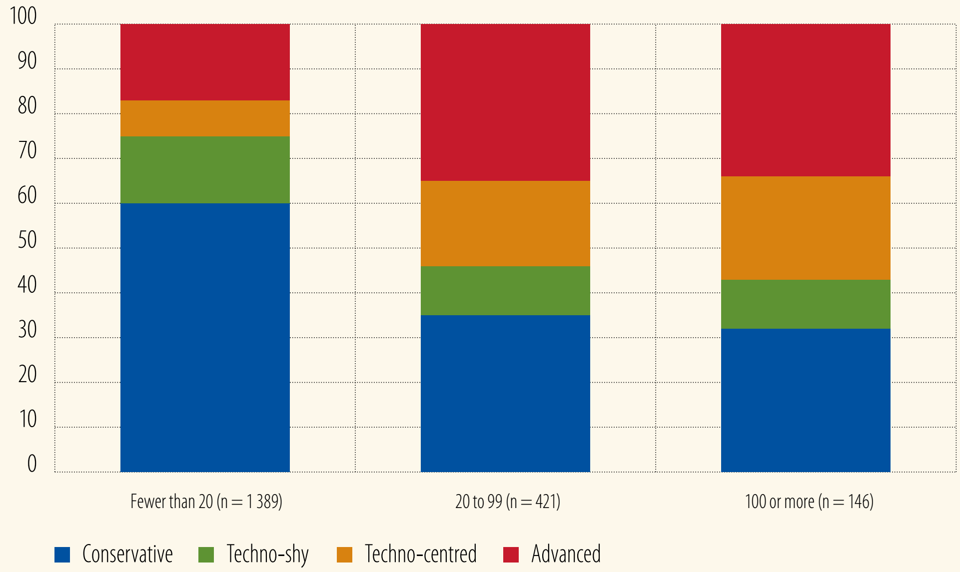
Figure C.2
The distribution of digital maturity profiles is the same in Canada and the US (in %)



Source: *BDC Digital Assessment Survey 2018.*

Figure C.3

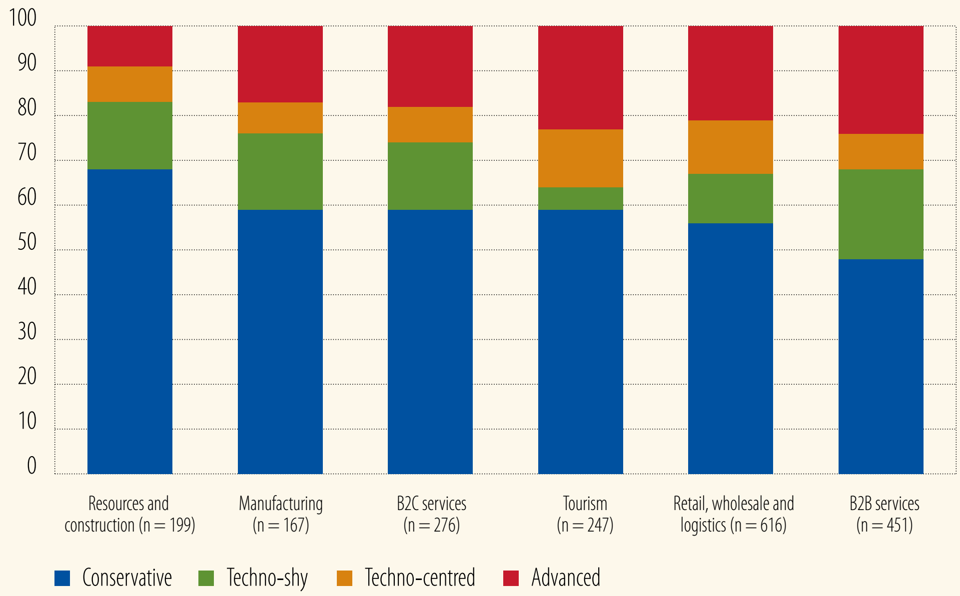
Larger companies tend to be more digitally mature (in %)



Source: *BDC Digital Assessment Survey 2018.*

Figure C.4

Companies in the natural resources and construction industries are the least digitally mature (in %)



Source: *BDC Digital Assessment Survey 2018.*

The study found that Canadian businesses with higher digital maturity were more likely than their peers to have enjoyed higher sales and profit growth over the last three years. They were also more likely to have exported and innovated. In particular, firms with high digital intensity enjoyed faster growth, while companies with a strong innovation culture were better at growing profits.

Using survey results, BDC developed a free digital maturity assessment tool to help entrepreneurs who want to make the digital shift in their business. The tool allowed them to evaluate their digital maturity, discover their digital profile and get personalised advice and information on best practices.

Policy implications and conclusion

Digital adoption rates in the European Union are lower than in the United States. Because of path dependency in innovation, this may create challenges for the long-term competitiveness of Europe. Firms that have implemented digital technologies tend to perform better than non-digital firms: they have better management practices, are more innovative, grow faster and create higher paid jobs. There are many old and small firms in the European Union that are not investing in digital technologies. These firms are more likely to consider the limited availability of finance as a major obstacle to investment, which may further exacerbate the delay in adoption rates.

Public policies should not only focus on R&D support and but should also consider a wide range of intangible investments – including in software and databases, training of employees or organisational and business processes improvements – because of the important complementarities of investing in various assets at the same time. For example, firms that invest in machinery and equipment and in R&D simultaneously tend to perform better. Similarly, firms that invest in software and in employee training at the same time tend to be more productive. Policy action should develop measures to fast-track the adoption of better management practices, improve the skills of workers through training and make it easier to finance intangible investments and digital technologies. Financial diversification, e.g. raising equity instead of bank debt, can be an effective way of supporting innovation and the digitalisation of EU companies, especially small businesses. This can be as important as direct public R&D support.

Innovation financing policy should be embedded in an environment that addresses barriers to innovation and digitalisation and provides the right incentives to support investment. However, the issue of access to finance for firms investing in intangible assets or digital technologies cannot be tackled in isolation. Difficulties in finding finance do not always make a case for government intervention in support of innovative and digital firms. Even if there is a case to be made for intervention, for example financial market failure, governments need to be careful to redress this failure without distorting the business environment. Innovation policy intervention needs to be regularly evaluated to assess whether the policy instrument is the most appropriate to best alleviate market failures at the local level.

To catch up with peers, the European Union will need to create better framework conditions to support innovation and digitalisation. This includes reforms that make it easier for firms that are not performing to exit the market so that capital and labour can be reallocated to more productive firms. Strong barriers to investment for new innovative market entrants in the European Union (such as limited access to finance or the inability to find workers with the right skills) and less dynamism as a result of lower rates of failure could cause a systemic innovation deficit for Europe, especially in the fast-growing technological and digital sectors. The European Union needs to generate more new leaders in these sectors and put pressure on leading companies to continuously reinvent themselves so that they help push the technological and digital frontiers. It is also critical to support fast-growing small and young innovative firms, to balance network effects and winner-takes-all dynamics. This calls for improvements to competition policies, the functioning of product and labour markets and the implementation of the digital single market in the European Union.

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Chapter 4

Energy transition: investment challenges, options and policy priorities

The EU transition to a net zero carbon economy by 2050 could be a boon for economic growth and employment. The transition is starting to look economically and technically feasible, although more research and development is required to continue reducing the cost of low carbon technologies. This requires a supportive regulatory framework that rethinks the taxation of both energy and non-energy products and makes climate finance easier to come by. It is also necessary to re-evaluate production and consumption patterns, balancing economic growth, well-being and equality. This is particularly important in the context of a just transition, making sure that the people most vulnerable to the effects of climate change are protected, and the burden of transitioning to a low carbon economy is fairly shared between developed and developing countries.

Today the European Union spends almost as much as the United States on climate change mitigation (CCM) technologies as a share of GDP, and three times less than China, which is the world's biggest emitter of greenhouse gases. The United States continues to invest considerably in fossil fuels and the European Union's investment in climate mitigation technologies is falling, particularly for research and innovation. In all three regions, the renewable energy, energy efficiency and transport sectors attract the bulk of CCM investment. However, the transport sector is still largely dependent on fossil fuels, and more investment is needed in low carbon infrastructure, electric vehicles, batteries and biofuels. Several EU members are not on track to meet the 2020 targets for renewable energy. The European Union's energy transition is challenging, especially for members from Eastern or Southern Europe, given that more investment will be required for them to reach mid and long-term decarbonisation goals.

Attracting private finance is a critical enabler of the energy transition. The renewable energy sector is entering a new phase, as governments move away from a regulated to a more competitive environment, partly in response to the increasing costs of support schemes and the falling capital cost of renewable energy technologies. Attracting new financiers and strategic investors requires new business models and strategies to meet the current financing challenges. The good news is that investors, consumers and firms are more concerned than ever about the risks and negative consequences of climate change and are seeking ways to reduce their climate impact. This new attitude could radically change the CCM investment landscape over the coming years and decades.

Introduction

On 28 November 2018, the European Commission adopted a strategic, long-term vision for climate change set out in the report *"A Clean Planet for all"*. The strategy confirms Europe's commitment to be a leader in global climate action and presents cost-effective pathways to achieve a zero net contribution to greenhouse gas (GHG) emissions by 2050 through a socially fair transition. Specifically, the proposed strategy outlines a European enabling framework for the long-term transition and addresses investment and finance, research, innovation and deployment, economic and social impacts, the European Union's global role and the role of citizens and local authorities.

This chapter is divided into three sections: discussing how the EU can transition to a net zero carbon economy by 2050, current clean energy investment flows in the world's three leading regions, and the main developments and determinants in renewable and energy efficiency investments. The objective is to focus on the critical questions currently surrounding climate investment, with a view to providing useful insights for designing successful climate policies.

Energy transition in the European Union

This section explains why the "energy transition" is more than a catchphrase. It starts by briefly discussing the importance of the transition to an inclusive green economy (climate risks, growth opportunities, the modernisation of economies) and the main challenges to implementing the EU's zero carbon emissions goal by 2050. The section then outlines the macroeconomic and social benefits of reducing greenhouse gas emissions (output, employment and sectoral competitiveness) by drawing on the existing literature. Finally, the section suggests ways to make the energy transition socially fair, by supporting workers, entrepreneurs, consumers and residents.

The need for an EU climate change strategy

Reaching net zero emissions by 2050 is a precondition for having a reasonable chance of keeping global temperature increases well below 2°C. The increased intensity and frequency of extreme weather events due to global warming is negatively influencing individuals and the economy as a whole. If global warming surpasses 2°C, the world will face unacceptable ecological, economic and societal consequences. In response to the 28 March 2019 publication of the World Meteorological Organization (WMO)'s alarming report on the State of the Climate, UN Secretary-General António Guterres said: "*Climate change is moving faster than our efforts to address it.*"

Addressing the potential fallout of climate change requires a comprehensive EU climate change strategy. Achieving the goals of the Paris Agreement necessitates far-reaching changes to the global energy system and economy. As energy consumption, greenhouse gas emissions, economic growth and societal well-being are deeply interlinked, an emissions strategy is required to make sure this transition[1] happens in a timely manner, effectively and fairly. This strategy, supported by an investment plan, should be one of the European Union's top priorities for the next decade. There is no room for complacency, given that delayed actions will result in higher costs and emissions and overall lower economic growth or even a contraction.

Climate change policy should be put in an international context. Climate change transcends national borders. While local circumstances influence the degree to which populations feel the effects of climate change, the impact of the emissions themselves is the same throughout the world. A tonne of carbon emitted into the atmosphere fuels global climate change regardless of where it

1 The energy transition will transform the energy sector from fossil-based fuels to zero carbon energy by the second half of this century.

is released. In most estimates, Europe's dependency on energy imports is expected to decline from 55% to 20% by 2050 (European Commission, 2018a), but that drop in fossil fuel imports will not be enough to offset greenhouse gas emissions globally. If the European Union imports goods from countries with a very high share of fossil fuels in their energy mix, it is indirectly responsible for the greenhouse gas emissions resulting from the production of those goods. This is why EU climate policy should include initiatives to help other countries with their energy transition, for example through knowledge sharing, development grants and other measures to level the playing field, such as access to climate finance.

The decisions taken today will have lasting consequences for future generations, particularly when considering the lifetime of assets such as power plants, energy distribution networks and transport infrastructure, which can easily reach up to 50 years. Usually these types of investments represent irreversible economic decisions that will be locked in for the project's life. Combined with the fact that greenhouse gases can linger in the atmosphere for decades, addressing climate change and implementing the energy transition requires a comprehensive strategy looking ahead at least 30 years.

The European Union should ensure that its economy and society can resist the impacts of climate change. In addition to mitigating climate change as much as possible, the European Union should prepare for climate change impacts that cannot be avoided. This should be an integral element of a wider EU climate change strategy, as climate effects will be felt throughout society. To prepare, financing for adaptation projects such as dykes, water storage or wildfire warning systems should be a top priority. In addition, there is a need to ensure future access to critical infrastructure in areas such as water, power and food and health care.

The energy transition impacts the whole economy

Although the energy sector is the cornerstone of the transition, the sectors where energy is more intensively used (e.g. industry, transport and the built environment) also have a role to play. In the European Union, by far the largest share of greenhouse gas emissions comes from the production of energy (78%). About 10% comes from agriculture, which is closely followed by industrial processes and product use (9%) and finally waste management (European Parliament, 2018a). Taking into account where this energy is consumed, roughly 30% of greenhouse gas emissions originate from energy production, 20% from industry, 20% from transport and 15% from the residential and commercial sector (EEA, 2018). Each of these four sectors plays an important role in the energy transition.

The decarbonisation of the energy sector will take place largely through the shift from fossil fuel-based electricity generation to low carbon technologies, such as renewables, nuclear energy and power plants, combined with carbon capture and storage (CCS). Electricity use will increase and the energy supply will become more decentralised. This will require a smarter and more flexible electricity network with improved interconnectivity, energy storage and demand management. Electricity can be used to create e-fuels (synthetic, carbon neutral fuels), which can facilitate the decarbonisation of industry and transport. As an added benefit, a reduced reliance on imported fossil fuels will increase the security of the European Union's energy supply (European Commission, 2018a).

For the transport sector, the transition to low carbon solutions will follow an "avoid, shift and improve" approach. A wide range of measures can be used to avoid transport, such as digitalisation, providing communication alternatives (like videoconferencing) and making existing public transport as efficient as possible in load management. In addition, car use can be curtailed through measures like parking restrictions and fuel taxes. Transport can be shifted from roads to low energy/carbon solutions such as rail or water by providing additional infrastructure, subsidising alternative modes of transport, improving awareness and improving travel planning (EEA, 2018). In addition, improving transport requires switching to very efficient low and zero-emission vehicles, whether they be electric or based on hydrogen or liquefied natural gas in combination with biofuels.

Industry will need to become more energy efficient. From 2005 to 2017 the energy intensity, namely the energy used to produce one unit of economic output, of EU industry declined by 20% (European Commission, 2019). Continued energy efficiency improvements are required in a wide range of industries, such as steel, cement, chemicals, glass and plastics. A combination of measures such as digitalisation and automatisation, process improvements and increased recycling and re-use of materials can improve energy efficiency and increase the competitiveness of EU industry (European Commission, 2017a). For some energy-intensive industries, alternative sources like electrification, the increased use of hydrogen, biomass and renewable synthetic gas, if produced sustainably, can decarbonise the remaining energy used. Lower resource and energy consumption would reduce the European Union's dependence on imported materials (European Commission, 2018a).

In addition to becoming more energy efficient, industry needs to cut emissions. It has the potential to sequester greenhouse gases from the atmosphere through carbon capture and storage (CCS). Like power plants, industrial installations are large stationary sources of greenhouse gas emissions. This makes them excellent sites for CCS, which plays an important role in keeping temperature increases below 2°C.[2] In combination with biofuels, carbon capture could even lead to the removal of CO_2 from the atmosphere. Generally, process improvements and alternative, largely bio-based, feedstocks can lead to lower emissions and replace carbon-intensive products with carbon alternatives.

Transitioning to bio-based feedstocks, process optimisation and the use of innovative materials can make EU industry more climate friendly and increase its competitiveness. Today, industry largely uses fossil fuels such as natural gas to power industrial processes, for example in the production of plastics, fertilisers and fabrics. Alternative fuels or alternative production processes can reduce fossil fuel consumption and therefore lower greenhouse gas emissions. In addition, low carbon alternatives such as carbon fibres or materials with improved performance, such as stronger cements, can reduce the amount of materials used and emissions produced. Increased resource efficiency and the adoption of circular economy practices could make European industry one of the most efficient in the world.

Improving energy efficiency in the built environment is crucial as buildings account for 40% of energy consumption in the European Union. It is important to increase the renovation rates of buildings and to ensure that all new construction focuses on near zero energy buildings. Moreover, the efficiency of appliances should be improved and digitalisation and automation should be put in place to create smart buildings. According to the note of the Council of the European Union (2014) on energy efficiency: "More efficient appliances are expected to save consumers EUR 100 billion annually – about EUR 465 per household – on their energy bills by 2020." Labelling and standard-setting can play an important part in this process. As is the case with industry, switching heating from fossil fuels to renewable sources or other low carbon alternatives such as hydrogen or bio-methane will also play an important role in the decarbonisation of buildings.

Agriculture and forestry will need to become more efficient to provide food, livestock feed and fibres for a growing global population while at the same time limiting its ever-larger environmental impact. Agricultural and forestry projects produce biomass that can be used directly as a fuel or converted to biofuels and biogas, which in turn can play a role in decarbonising the remaining energy use in mobility and industry. Combined with carbon capture storage, agriculture and forestry can play a role in sequestering carbon emissions. Innovation in agriculture can increase energy efficiency by optimising fertiliser and water usage and increasing crop yields. Moving away from animal-based nutrition (meat, dairy and eggs) to plant-based nutrition would result in the better use of land and resources and lower methane emissions (European Commission, 2018a and 2019e).

2 The below 2°C and the 2°C scenarios presented by the International Energy Agency (IEA) in its Energy Technology Perspectives (ETP) calls for limiting global warming to 2°C or 1.75°C by 2100.

Supporting the energy transition

The energy transition is becoming technically and economically feasible. However, the costs of some low carbon technologies remain high compared to conventional alternatives (International Energy Agency – IEA, 2018; European Commission, 2018a). Research and innovation is required to make low carbon technologies economically viable and to bring technologies to the market that are not yet mature. In its Horizon Europe proposal, the European Union recommends that 35% of its budget be invested in the development of low carbon solutions.

To facilitate the energy transition, research should focus on low carbon solutions. Particular support should be given to fields such as electrification (renewables, smart networks and batteries) as well as hydrogen and fuel cells, energy storage, energy efficiency in intensive industries, the circular economy and the bio-economy. The European Union has agreed that, by 2020, EU members should increase research spending to 3% of GDP, but current figures show the countries are lagging behind. Moreover, spending on climate-related R&D in the European Union is very low – just below 0.04% of GDP. Ultimately, increased spending on research will result in lower costs for meeting energy and climate targets.

A strategic approach to investment, enabling innovations to reach the market, is necessary for the economy to benefit from energy research. The adoption of new technologies also requires a supportive regulatory framework that allows for the quick uptake of new technologies and strong links between researchers and business. These links are particularly important for small businesses, which might not have the same capacity for research and innovation as large companies.

To mobilise more climate finance from the private sector, a mix of incentives should be put in place. Increased investments in climate-resilient infrastructure and innovative low carbon technologies, such as smart meters, e-mobility or solar and wind energy, are essential for a successful energy transition. Incentives such as a carbon tax or carbon dividend model in addition to regulatory interventions at the EU and national government level should be put in place to provide certainty to the private sector and make sustainable investments financially attractive (Welsch, 2017). Innovative solutions often have high upfront costs and high risks. The Innovation Fund, funded by the EU Emissions Trading System, will support the commercialisation of technologies.

Incentive schemes should not inadvertently support activities that are not aligned with the Paris Agreement. A successful climate policy is not only about allocating more money to mitigation and adaptation, it is also about allocating less funds to activities that are clearly not aligned with the Paris Agreement, such as fossil fuels, internal combustion engines and inefficient industries. All financial flows should be aligned with the Paris Agreement. Many Multilateral Development Banks are already working together in that direction.[3]

3 https://www.eib.org/attachments/press/20181203-joint-declaration-mdbs-alignment-approach-to-paris-agreement_cop24.pdf

Box A[4]
Major challenges in the energy transition

Decarbonisation is a huge endeavour. Replacing fossil fuels will require investments in renewable plants, grids and pipelines, storage facilities, carbon-free fuel alternatives, as well as the rehabilitation of buildings, efficient industrial processes and appliances, new transportation technologies and smart systems. The envisioned transition is a tremendous opportunity for technology-driven, new economic growth, as long as Europe is in a position to produce this equipment domestically and implement investment in a cost-effective manner. Financing conditions, stable conditions for future markets and policy coordination, including effective regulation, are all necessary to implement new technologies and move along their steep learning curves.

Market coordination failure is a common problem when restructuring markets and technological innovations depend on many actors. The role of policymaking is to enable the coordination of investment decisions by infrastructure developers, technology developers, manufacturers, financing institutions and, most importantly, final consumers in the uptake of new technologies. In this way, market coordination will bring positive benefits such as cost reductions and improved performance.

The quantitative assessment of the European Commission's decarbonisation strategy, performed using the PRIMES energy system model, among others, illustrates that irrespective of the technologies used all scenarios achieving decarbonisation imply a significant increase in investment in energy. The largest portion of that investment, 60-65%, would need to go to energy consumers for building rehabilitation, improved industrial processes, efficient equipment and new transportation technologies. About 35-40% would need to go to energy suppliers to develop and reinforce energy infrastructure, to build plants using renewable sources and new facilities for storing energy, and to factories for producing carbon-free hydrogen and synthetic fuels.

The majority of energy sector projects have long lead times and operation lifetimes. The projects are typically irreversible economic decisions and present high risks of locking in particular technologies or approaches if not well planned. The learning process behind technology development and the achievement of economies of scale in industry are also long-term processes. Therefore, investment plans, cautiously designed with clear priorities in mind, should be moved to the top of the European Union's agenda as early as possible. Besides, economic analysis has shown that failure to invest in technology and infrastructure in 2020-2030 will result in higher costs and emissions in the future, rendering the next decade as a "lost decade".

The emergence of carbon neutral gaseous fuels, whose carbon footprint is very low or even zero, would make it possible to continue using the extensive European gas transmission and distribution network. However, gas infrastructure should be adapted to accommodate a paradigm shift in which the majority of gas is no longer imported into Europe Union via pipeline or liquefied natural gas (LNG) terminals, but is rather produced domestically. The new gas infrastructure will have to accommodate multiple energy generation points at its core rather than its periphery, and be able to transport gases towards regions that cannot produce this type of energy.

Furthermore, the grid infrastructure for electricity transmission will have to be extended considerably to access renewable energy produced in remote areas, supply electricity to centralised facilities producing hydrogen and carbon neutral fuels, and fully integrate the markets to balance resources effectively. At the same time, the electricity distribution system will have to expand significantly to integrate battery-recharging networks, be able to respond to demand and highly dispersed generation and reap the full benefits of digitalisation.

4 The text in this box was provided by Pantelis CAPROS, Professor of Energy Economics, Head of E3MLab/National Technical University of Athens.

It is worth noting that the final consumers, households and firms, will have to take on the biggest part of the investment needed. However, most individuals are highly risk-averse, and their investment decisions depend on their disposable income. Uncertainty about the future of certain technologies and imperfect information dampen consumers' willingness to invest in new energy infrastructure. Moreover, lower-income households are unlikely to have the cash available to invest in building rehabilitation and the purchasing of more efficient appliances or vehicles. The result is a new type of "technology poverty" that can further exacerbate the conditions of people already living in energy poverty.

The common approach of financial institutions to energy investment must be revisited. Certain issues that need to be tackled are methods for assessing infrastructure projects, the funding conditions required for the rapid industrialisation of proven but not yet fully mature alternative fuels and technologies, the promotion of platform business models to help integrate renewable production and, most importantly, effective ways to facilitate fundraising by individuals. A model-based macroeconomic assessment of the European Commission's long-term strategy, based on the GEM-E3 general equilibrium model, has shown that the financing conditions available determine the impact the energy transition has on the European Union's GDP. Under certain conditions, adequate financing could support new growth and jobs created by the replacement of imported fossil fuels.

The consumer's role in the energy transition

The energy transition is more than a gradual switch to low carbon power generation. It requires a step change in how people live, work and spend time together. Consumers determine energy consumption when they buy a house, a vehicle, electronics or groceries. A successful energy transition will require consumers to be aware of their impact on energy consumption and to play their role in moving towards a low carbon economy.

Consumption levels in the developed world will need to account for the economic growth of developing countries. Mitigating the impacts of climate change requires the combined efforts of developed as well as developing countries. However, it is particularly important for a globally just transition that consumption in the developed world factors in the growing demand for energy from developing countries. These countries have rapidly expanding economies and corresponding living standards, and they need to meet the basic needs of their population for food, water and electricity. Technological progress can reduce the developed world's climate impact, but the transition will also require more conscientious consumer choices. Balancing these more conscious consumption patterns with social well-being and sustainable economic growth will be key to a successful energy transition.

Consumers will play an active role in the energy transition by adjusting their electricity demand and supplying energy to the grid. In addition to changing consumption patterns, the energy transition will gradually turn consumers into "prosumers", where they are able to sell electricity back to the grid. Most EU countries already have the regulatory framework in place for this to happen. This will be increasingly important as our society further electrifies, which will require a better matching of energy supply and demand due to greater volatility. Consumers will be able to participate in this process not only by providing electricity, but also by adjusting their electricity demand (e.g. appliances, vehicles, heating) to the available supply.

Impact of the energy transition – economic growth, employment and equality

The energy transition can lead to increased economic growth and additional jobs, particularly if Europe can leverage the domestic production of low carbon technologies. The model-based macroeconomic assessment of the European Commission's long-term strategy (European Commission, 2018a), based on the GEM-E3 general equilibrium model, shows that the decarbonisation of the EU economy is expected to have a moderate to positive impact on GDP and lead to the creation of additional green jobs (current green jobs are estimated at 4 million in the European Union). To take advantage of this opportunity for sustainable growth, Europe has to strengthen its efforts to reduce imports of raw materials and move up aggressively in the value chain, by developing the clean technologies necessary for the energy transition.

The overall impact of the energy transition on employment is expected to be positive, adding around 0.3% compared to the baseline scenario by 2050.[5] This figure can be translated into an additional 492 000 to 616 000 jobs under a global commitment to reduce greenhouse gas emissions, or if the European Union acts alone, and could increase to 0.9% in more ambitious climate scenarios.[6] Most of these additional jobs will be in the construction and services sectors, driven by renewable, energy efficiency and circular economy policies. More ambiguous are the results of the energy transition on the transport and agriculture sectors. Transport's impact will depend on the type of vehicle produced (e.g. combustion engines production) and the production location (some firms may decide to move part of their production abroad), and agriculture's impact will depend on its ability to adapt sustainable production.

Energy-intensive economic sectors will see a shift to new production processes, which will need to be accompanied by workers with new skills. These developments will lead to a transformation of the labour market, in combination with an ageing population and increases in digitalisation and automation. Most new jobs would be created outside the auto industry, in sectors such as services and construction, which will benefit from the shift in spending away from production based on fossil fuels and towards domestically produced goods and services.

The impact of the energy transition is not uniform across regions in the European Union and can lead to increased inequality. Regions that depend heavily on the coal industry will be most affected by the energy transformation. Today, the coal sector employs around 237 000 people in the European Union, of which 185 000 work in coal mining and the remainder in coal-fired power plants. These jobs are concentrated mainly in Central and Eastern European countries (JRC, 2018), such as Poland (54%), Germany (13%), the Czech Republic (10%), Romania (8%) and Bulgaria (6%). In Poland, coal mining is a major employer, representing 5% jobs, while in other countries coal accounts for less than 1% of jobs and largely concerns employees that will be close to retirement by 2030. Similarly, refineries will have to adapt their business model and shift production towards synthetic fuels.

A just energy transition: how to ensure a fair distribution of the burden

A fair and just transition is increasingly important to the climate agenda. During the last Conference of Parties in 2019, the largest annual gathering of climate experts and policymakers, the host country Poland called for a just transition. Poland highlighted its own coal dependency and how a rapid decarbonisation of the energy supply could have severe consequences for its economy (Climatetracker, 2019). This dependency also applies to countries in Southern Europe. Developing countries are more vulnerable to the impact of climate change (Ghosh, 2009) because their energy and carbon intensity is higher than in developed countries and therefore more efforts are required to decarbonise their economy. A just transition means that developed countries take responsibility

5 The baseline scenario projects the achievement of energy and climate 2030 targets as agreed by June 2018, as well as a continuation of policies influencing non-CO_2 emissions. It assumes that after 2030 there will not be any new energy and climate policies.

6 Table 12 and 13 of the in-depth analysis "A Clean Planet for all". The estimated impacts are greater when the macro-models assume that there is a global commitment to achieve GHG emissions reductions close to 94% and a 1.5°C temperature increase.

for their share of greenhouse gas emitted in the last century and help more vulnerable countries to align with the Paris Agreement.

A just transition is crucial for the public acceptance of the energy transition. This is not only valid for regions and countries, but also holds for different parts of the population. A change in lifestyle is required, but the costs of increasing the energy performance of homes or retraining for jobs in the automotive sector can hit low and middle-income households harder. For lower-income households, energy consumption makes up an increasingly large share of disposable income and rising prices can lead to energy poverty. The dynamics fuel popular movements against the energy transition.[7] However, facilitating renovations of social housing or increasing public transport in poorer areas could reduce the vulnerability of low-income households to rising or fluctuating energy prices.

Investments in green skills and public infrastructure can facilitate a just transition. These kinds of investments represent a major win-win situation that would bring widespread well-being and support solidarity and trust in institutions. Retraining workers affected by changes in the labour market could soften the negative impacts and increase support for the energy transition. It would also foster EU competitiveness by addressing the skills gap facing European businesses (both through more adapted skills and through greater social mobility, matching people to the jobs they are best at).

Clean energy investment flows and challenges

This section aims to improve the current understanding of European clean energy investment flows and the corresponding investment needed to mitigate climate change. It quantifies investment in climate change mitigation (CCM) technologies to assess the current trends in CCM investment in terms of amounts spent per sector and with respect to GDP growth. This section compares the European Union with its most important international partners (the United States and China) and also shows the investment levels needed to reach the European Union's mid and long-term objectives (2030-2050).

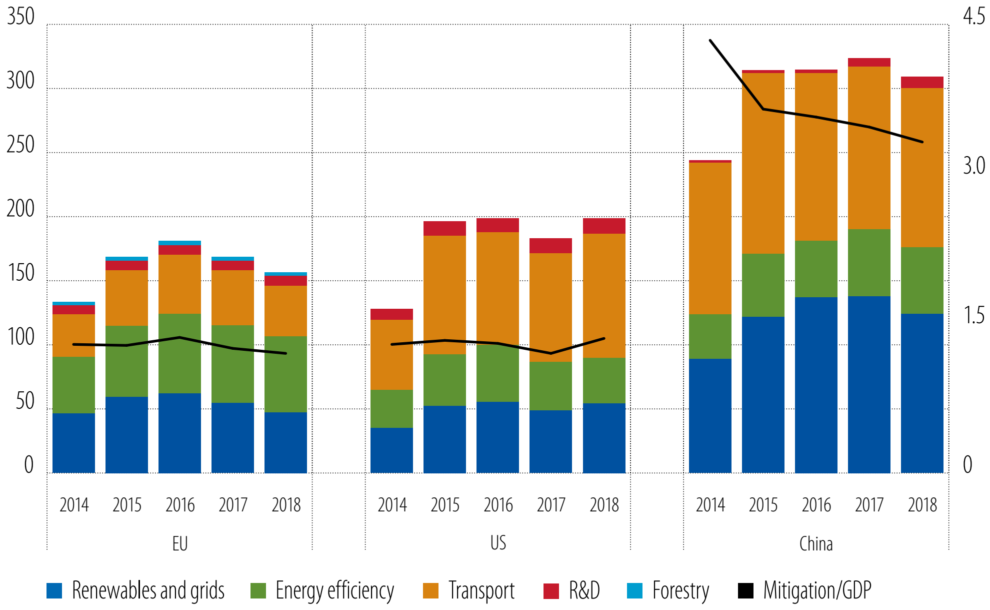
Total climate investment in the world's three leading regions

A backlog of investment in climate change mitigation challenges Europe's forerunner position in climate investment. The bloc invested EUR 158 billion in 2018, 7% less than the year before (Figure 1). The share of CCM investment as a percentage of EU GDP declined to 1.2%. The United States invested EUR 190 billion, recording a 9% year-on-year increase despite the current administration scaling down climate efforts and tilting regulation in favour of coal. In the United States, after three consecutive years of decreases, the share of CCM investment as a percentage of GDP increased for the first time to almost 1.3%. China, the world's largest consumer of energy and emitter of greenhouse gases, outperformed both other regions, as CCM investments made up 3.3% of the country's GDP.

Climate investment in the European Union grew more slowly than overall average investment. Climate investment grew 3% a year from 2014 to 2018, compared to almost 6% for the economy as a whole, despite strong policy support. The European Union set targets for energy efficiency, renewables and emission abatement for the first time in 2009. The "20-20-20" targets laid out goals until 2020 for the decarbonisation of the EU economy. In 2014, a successive climate and energy framework followed, setting the policy agenda until 2030. In 2018, the European Union's CCM investment accounted for 5.8% of total investment, whereas in the United States it stood at 6.2% and in China at 7.8%.

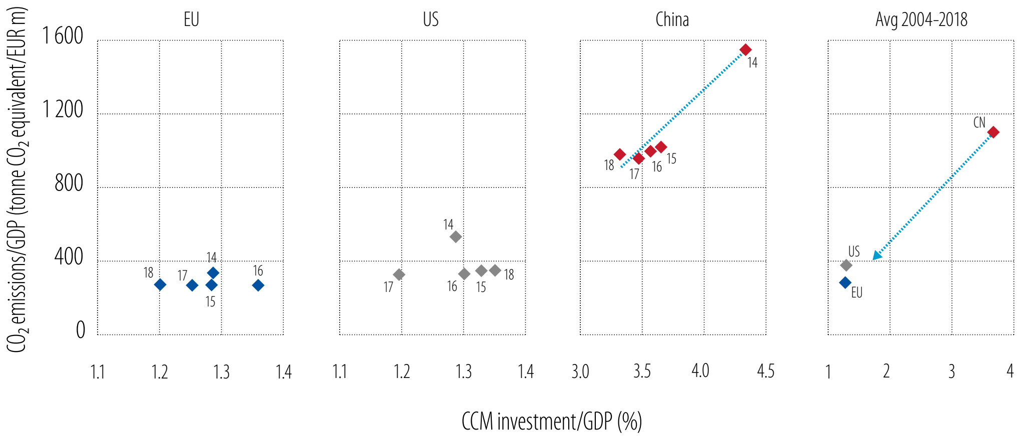
7 For example the Gilets Jaunes movement in France. The movement started in November 2018 partly as a reaction to rising fuel prices, which greatly affects households in rural France.

Figure 1
Climate change mitigation investment per sector (EUR billion, % of GDP)



Source: IEA, BNEF (Bloomberg New Energy Finance), Eurostat, and authors' estimations.
Note: Data for investment in forestry in the United States and China were unavailable.

Figure 2
CCM investment and carbon intensity



Source: IEA, BNEF, Eurostat, and authors' estimations.

Overall, China dominates the shifting landscape of global climate investment. With CCM investments amounting to EUR 322 billion in 2018, China was the world's largest climate investor. It invested as much in clean energy as the European Union and the United States combined. The main support instrument for Chinese renewable energy development is the 13th Five Year Plan, which set policy targets for 2016-2020. The plan also introduced a novelty for energy efficiency: a consumption cap decoupled from the country's GDP growth (Euractiv, 2017). In the transport sector, China's high-speed railway expansion continued in 2018, adding 25 000 km over the last decade – more than the rest of the world combined (Lawrence et al., 2019).

However, the European Union outperforms the United States and China when historic decarbonisation efforts are taken into account. The European Union has been continuously decoupling its economic output from its CO_2 emissions since the turn of the millennium. Today, the EU economy is 20% less carbon-intensive than it was in 2000 and its CO_2 intensity is also notably lower than that of the Chinese and American economies. In absolute terms, the bloc's CO_2 emissions also decreased by 2.5% from 2017 to 2018. At the same time, Chinese emissions increased for the second year in a row (Figure 2). Despite China's remarkable achievements in decarbonising its economy over the last decade, its CO_2 intensity remains well above the global average. The high share of CCM investment in China can partly be attributed to a "catching-up effect". As the CO_2 intensity of China's economy falls to the levels of the European Union and the United States, this effect is expected to diminish, resulting in the Chinese CCM investment falling closer to levels in the European Union and the United States.

Box B

The diverging investment paths in fossil fuels between the European Union, the United States and China

In the United States, fossil fuels still attracted 66% of all energy sector investment in 2018. The decarbonisation of the power sector is also progressing more slowly in the United States than in the European Union and China, as fossil fuel-fired power generation accounted for 27% of all power sector investment. This is despite a strong performance of renewables in 2018. In the United States, investment in all major renewable power technologies (bioenergy, wind, solar, concentrated solar power, hydro, geothermal) increased, while investment in gas and oil power generation decreased. By contrast, investment in coal-fired power generation increased by 17% in 2018. Further growth is expected, as the United States Environmental Protection Agency finalised its coal-friendly climate plan in June 2019 (EPA, 2019).

The United States alone invested more in fossil fuels than the European Union and China combined: EUR 160 billion, against EUR 40 billion in the European Union and EUR 100 billion in China. The majority (90%) of the US sum was invested in oil and gas, in line with the country's expanding natural gas production. The United States recorded its largest ever annual growth of natural gas production in 2018, which increased by 10 billion cubic feet per day (Energy Information Administration, 2019). In April 2019, 2 708 billion cubic feet of dry natural gas was produced in the United States, the highest number in any month since the Energy Information Administration started tracking gas production in 1973.

The future of natural gas looks vastly different in the European Union. While US spending on fossil fuels has been increasing for the last three years, the European Union and China invested less in fossil fuels – including natural gas – in each of the last five years. Today, natural gas makes up almost one-quarter of the European Union's energy mix. Current low investment levels, however, indicate that this share is likely to decrease. The European Union's long-term decarbonisation strategy predicts that in a carbon neutral scenario for 2050, natural gas will account for less than 2% (European Commission, 2018a) of the European Union's energy consumption. Over the mid-term, natural gas will continue to complement variable renewable generation, until it is replaced by synthetic gases in the European Union's pipelines.

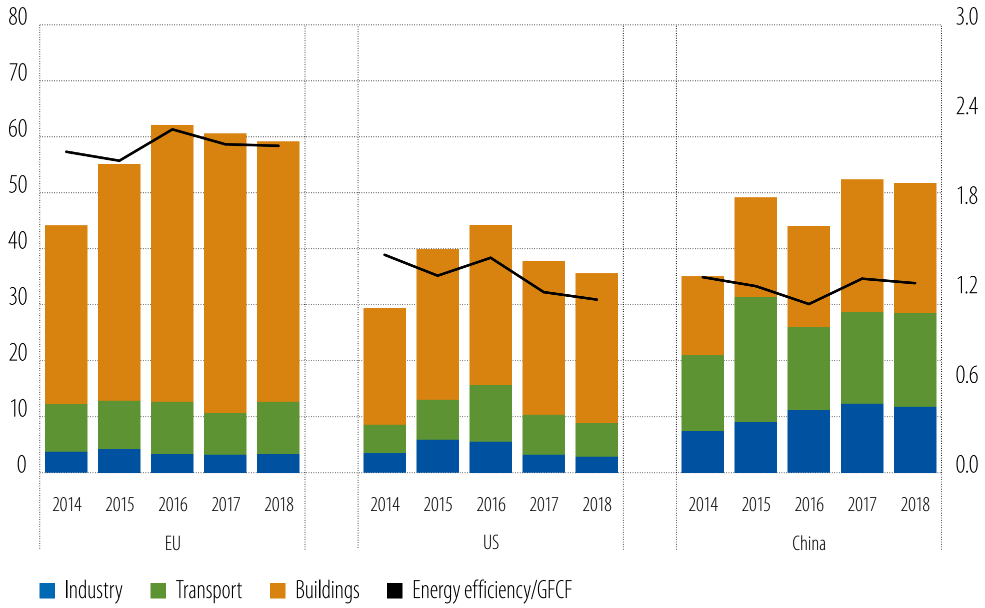
Energy efficiency

The European Union's "energy efficiency first" principle sustained high levels of investment. Energy efficiency (EE) attracted almost EUR 60 billion in investment in 2018, making it one of the few EU sectors to surpass both the United States and China (Figure 3). EU support schemes and funding programmes, specifically aiming to help businesses, regions and countries to implement energy efficiency projects, played an important role in channelling high levels of energy efficiency investment. The framework programmes, European Structural and Investment Funds (ESIF) and European Fund for Strategic Investments

(EFSI) declared energy efficiency as one of their strategic priorities. Smart Finance for Smart Buildings serves as an initiative dedicated entirely to efficiency measures. In the European Union and in China, energy efficiency investments as a share of overall investments in the economy remained relatively stable over the last five years. In the United States on the other hand, energy efficiency experienced a steeper decrease, falling from 1.5% to 1.2% over the same period.

Figure 3

Energy efficiency investments by sector (EUR billion, % of gross fixed capital formation – GFCF)



Source: IEA and authors' estimations.

Buildings attracted the lion's share of energy efficiency investment in the European Union and the United States. Buildings accounted for three-quarters of all energy efficiency spending in both regions, even after such spending declined by 7% in the United States and 3% in the European Union year-on-year. In absolute terms, the European Union spent more on energy efficiency in buildings (EUR 47 billion) than the United States (EUR 27 billion) or China (EUR 24 billion). Investment in buildings includes the building envelope (walls, windows, etc.), heating and cooling systems, control systems, appliances and lighting. The building envelope accounts for the majority of efficiency investment in this category, mostly involving improvements in insulation and windows.

Energy efficiency investments in China have a stronger emphasis on transport. Transport makes up one-third of all energy efficiency investment in China – a much higher share than in the European Union or the United States. China's "double control system" sets efficiency targets relative to the aforementioned cap (15% energy intensity improvement and total energy consumption capped at 5 giga tonnes equivalent). To achieve these targets, China monitored the energy consumption of enterprises, pioneered natural gas-fuelled vehicles, implemented fuel consumption standards (Sino-Italian Cooperation Program for Environmental Protection, 2016) and established the world's largest electric vehicle market (Financial Times, 2019). Despite all this progress, China has a long way to go, as its energy intensity remains well above the global average (Voita, 2018).

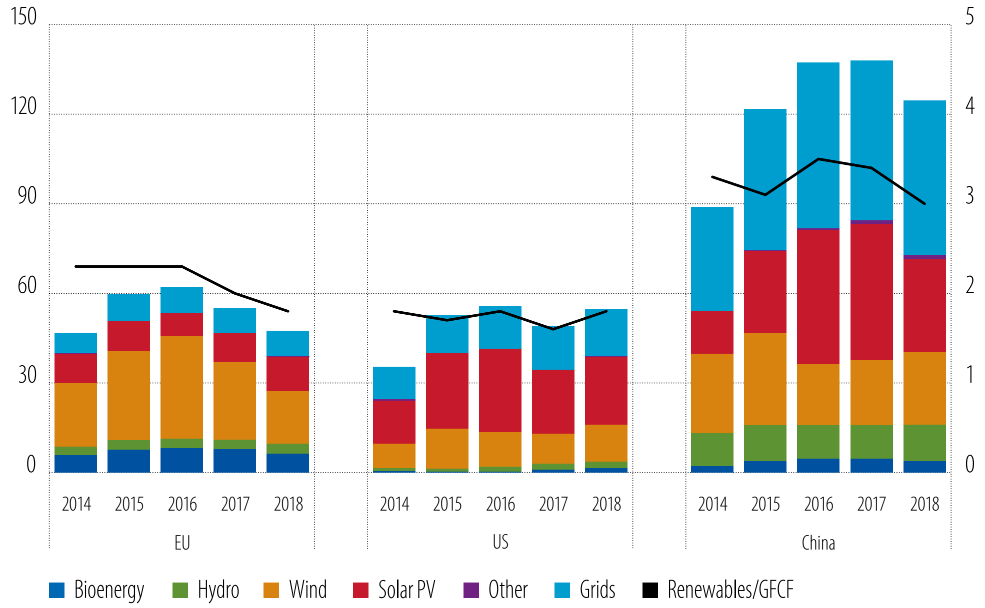
Energy efficiency investment in the industrial sector remained flat in all three regions. Such investment aims at increasing the efficiency of mass production as well as of specific processes. Public support in China helped to sustain high levels of efficiency investments for industry: the country declared energy efficiency its "first fuel" (IEA, 2016b) in the late 1990s and has continued to put in place government incentives ever since. The prioritisation of energy efficiency in Chinese government policy unlocked significant gains, particularly in the energy-intensive industry sector, where a mandatory, target-based energy savings programme has been in place since 2006. The programme was expanded to over 16 000 enterprises in 2011 (IEA, 2016a). In absolute terms, China invested significantly more (EUR 12 billion) in industrial energy efficiency than the European Union (EUR 3 billion) or the United States (EUR 3 billion).

Renewables and grids

In China and in the European Union, renewables attracted over 80% of power generation investment. In the European Union, less than 12% of power generation investment went to fossil fuels (Figures 5 and 6). This was the lowest share across the three regions in 2018, yet two percentage points higher than in the previous two years. China was not far behind, as fossil fuel-fired generation accounted for 17% of all power generation investment. These figures indicate that the decarbonisation of the power sector is continuing, albeit at a slower pace than before as absolute levels of investment in renewable power generation edged down in both the European Union and China. From 2014 to 2018, the European Union recorded its peak investment in renewables in 2016 and China one year later. In relative terms, the share of renewable investment in overall economic investment has dropped sharply in the European Union since 2014, as well as in the United States and in China, albeit at a slower pace (Figure 4).

Figure 4

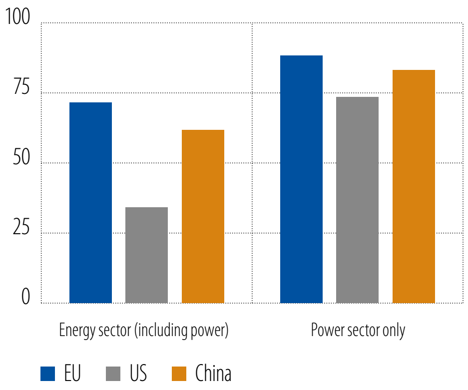
Renewable and grids investment by sector (EUR billion, % of GFCF)



Source: IEA and authors' estimations.

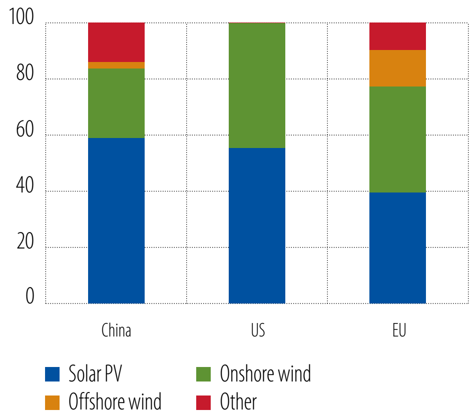
EU investment in renewable power generation decreased for the third consecutive year. The decline was driven by the falling capital cost of solar photovoltaic technologies and fewer new installations. The overall decrease conceals divergent trends for different renewable technologies. Investment in wind power halved in the last two years, from EUR 34 billion in 2016 to EUR 17 billion in 2018. Over the same period, solar photovoltaic recorded a 52% increase. Despite these developments, wind attracted 40% of all renewable power investment, followed by solar photovoltaic (30%) and bioenergy (16%).

Figure 5
Share of CCM investment (%)



Source: *IEA.*

Figure 6
Capacity additions in 2018 (%)



Source: *IRENA.*

Solar PV and the related grid investment dominated the power sector in China. Solar photovoltaic comfortably retained its dominant position on the Chinese market, attracting 35% of all power generation investment. Despite a 32% year-on-year decrease, investment in solar remained well above the average of the last eight years. A major factor in the investment drop was the policy shift introduced by the 13th Five Year Plan (Colle, 2019). Feed-in-tariffs were cut and will be replaced by utility-scale projects (Merchant, 2018) based on competitive price setting auctions, as the Chinese government seeks ways to make subsidies more efficient (DiChristopher, 2018). Higher efficiency is also a guiding principle for investment in power grids. Such investments enable the system to integrate rising shares of more variable renewable energy. China's EUR 51 billion investment in grids goes hand in hand with the expansion of solar and wind generation.

Investment in solar PV boomed in the United States as well. The expansion of solar photovoltaic installed capacity continued to accelerate in the United States as investment increased 6% compared to 2017. Despite the stronger prevalence of fossil fuels, the share of solar investment remained higher in the United States than in the European Union or China, accounting for 43% of all power generation investments. Voluntary procurement of renewable energy both by corporations and households and the soon to be phased out tax support for renewable energy production were major factors contributing to the US solar boom (Deloitte, 2019).[8]

The upward trend in investment in solar PV is expected to continue in the United States, but will end in China. The dominant role of solar PV is a relatively new development in both markets. In 2014, China invested almost twice as much in wind as in solar PV. In the United States, the solar PV boom started in 2012 when photovoltaic and wind attracted EUR 14 and EUR 10 billion in investment respectively. In previous years, US investments in solar PV were lower than in wind. Unlike in China, where the new policies are expected to slow down or even reverse the growth of solar PV, in the United States its expansion is projected to continue in the coming years (Egan, 2019).

8 Box C provides further information on tax policies in the three regions, including the US tax cut programme that will be phased out by 2021, ending its three-decade-long pivotal role in American renewables.

Box C

The impact of energy taxation on clean energy investment

Energy taxation influences investment in clean energy technologies on both sides of the Atlantic – albeit in different directions. Taxes make up a notable share of the prices of energy products: they account for 60% of the average EU gasoline price and for around 10% (shares range from 8% to 11% depending on consumption volume) of average electricity and natural gas prices. Consequently, the preferential tax treatment of low carbon energy products – in other words, the mitigation of the price premium over competing fossil fuels – is a powerful tool to reduce emissions, increase energy efficiency and enhance security of supply.

In China, energy use is largely untaxed. All fuels and electricity used in the industrial, residential, commercial, agriculture and fisheries sectors are untaxed (OECD, 2019). In the United States, fossil fuels used in all but the road sector are untaxed at the federal level. The European Union's energy taxation is governed by the Energy Taxation Directive (ETD) of 2003.

Unlike the European Union, the United States has kept updating its energy tax regime [9]. The United States originally enacted its Renewable Electricity Production Tax Credit (PTC) in 1992. The programme has since been renewed and expanded numerous times. The European Union's directive has remained unchanged since its adoption one and a half decades ago, while the bloc's climate and energy policies underwent major developments. Consequently, the European Union's energy taxation is unfit to deliver on the bloc's climate and energy objectives (European Commission, 2019b).

The ETD possibly hinders the European Union's clean energy transition. The directive was adopted long before the emergence of technologies that are important building blocks of the European Union's decarbonised future. As a result, the current directive cannot ensure the preferential tax treatment of these technologies. In the worst cases, uncertainties resulting from taxation hamper investment in climate technologies.

Investment in emerging fuels, including hydrogen is hindered by the dated directive. Alternative resources, such as e-fuels (power-to-gas, power-to-liquid), bio-methane, and fuels of non-biological origin including synthetic ammonia are gaining traction. The directive does not contain clear legal provisions regarding the taxation of these new products and uses. Consequently, their preferential tax treatment is not ensured, despite their potential for reducing greenhouse gas emissions .

The lack of tax provisions makes electricity storage less interesting to investors in the European Union. Storage technologies make an important contribution to balancing power systems and enabling the integration of variable energy sources, such as wind and solar. The directive's definition of the taxable event opens the possibility of double taxation of electricity that is stored and re-sold. As of 2018, at least six Member States double-taxed stored electricity. Thus, the lack of EU-wide harmonisation might hinder investment in storage technologies.

Volume-based taxation disadvantages biofuels in both the European Union and the United States. In both regions, the taxation of biofuels is based on volume. The rate applicable to the volume of biofuels is the rate applicable to the equivalent fossil fuel. This fails to take into account the lower energy content of renewable fuels, leading to a higher tax burden on biofuel compared to the competing fossil fuel. The practice goes against the Group of 20 commitments of both the European Union and the United States to end insufficient fossil fuels subsidies (European Commission, 2009).

9 The box considers the impact of taxation that is harmonised at the EU level and at the US federal level, i.e. consumption taxation in the European Union and production taxation in the United States.

Investment in advanced biofuels faces further challenges due to taxation. At the time of the adoption of the ETD, biofuels were immature technologies, limited in variety and significance. Consequently, the directive does not differentiate between types of biofuels. Since 2003 however, biofuels with significantly improved environmental performance have emerged. In the absence of EU-wide harmonisation, each Member State applies its own technical classifications as a basis for preferential tax treatment. As these classifications are highly divergent, biofuel producers have no certainty that their product will qualify for preferential tax treatment on other markets. Due to the high share of taxes in the final price of transport fuels, tax reductions and exemptions have an impact on investment decisions.

The United States' renewable electricity production tax credit (PTC) – more specifically its looming phase-out – contributed to a 13% increase in renewable power investment in 2018. Developers rushed to commence the construction of projects in 2018 to benefit from the tax credit before it was abolished. Solar energy experienced the second largest expansion ever, as 8.4 GW of new capacity was installed in 2018. This figure was surpassed only in 2016, the last year when the full tax credit applied. Since 2017, the rates have been successively decreased. For wind facilities commencing construction that year, the tax credit was reduced by 20%. The reduction reached 60% by 2019. The three-decade-old programme will be entirely phased out by 2021.

Energy taxation is entering a period of change both in the European Union and in the United States. In the European Union, the discussion intensifies as Ursula von der Leyen, President-elect of the European Commission, declared that taxation must play a central role in the European Green Deal (European Commission, 2019c). Accordingly, she intends to revise the dated ETD (European Commission, 2019d). In the meantime, due to the absence of a European Union-wide agreement, Member States pursue national solutions, thereby possibly fragmenting the bloc's internal market. The United States will also phase out its Residential Renewable Energy Tax Credit by 2022, thus posing further insecurity to investment in the sector. It is, however, certain that taxation continues to hold the potential for fighting climate change in all three regions.

Transport

The transport sector remains almost entirely fossil fuel-based in all three regions. Consequently, it holds great potential for energy efficiency and emissions abatement. Yet, in the European Union, as well as in the United States and China, transport is expected to remain the largest source of greenhouse emissions beyond 2030 (EEA, 2018). In 2018, the EU members agreed to increase the share of renewable energy in the transport sector to 14% (Directive 2018/2001) after the interim target of 10% for 2020. This sectoral target has a novel aspect: it is set uniformly for all Member States[10]. In 2017, the EU average share of renewables in the transport sector stood at 7%, below the 2020 target.[11] Only four EU members exceeded or were close to the target (Sweden 38.6%, Finland 18.8%, Austria 9.7%, France 9.1%) and eight did not even reach 5%.

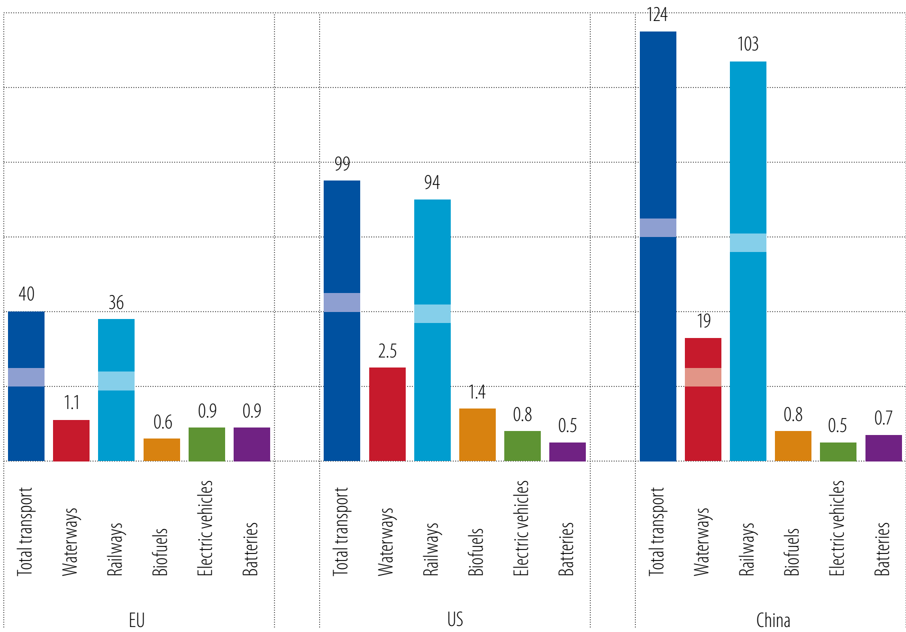
The decarbonisation of transport drives clean energy investment in the United States and China. Combined spending on railway networks, inland waterways, biofuels, electric vehicles and batteries accounted for 38% of all climate change mitigation investment in the United States (Figure 7). In China, the share of investment in these activities accounted for half of all CCM investment. US investment in this sector continued to accelerate and reached its highest level yet at EUR 94 billion in 2018. After two years of decline, Chinese investment in railways also edged up to EUR 103 billion, remaining 13% below

10 This is not like the economy-wide renewable energy targets, which differ for all Member States. The EU-wide target of 20% is calculated based on non-uniform national targets.

11 The 2020 and 2030 targets are not entirely comparable as the post-2020 framework introduces new multipliers. They continue, however, to be indicative of the below target level decarbonisation.

its peak level of 2015. Generally, the United States and China invested two to three times more in their railway networks than the European Union did (EUR 36 billion).

Figure 7
Climate investments in the transport sector in 2018 (EUR billion)



Source: IEA and authors' estimations.

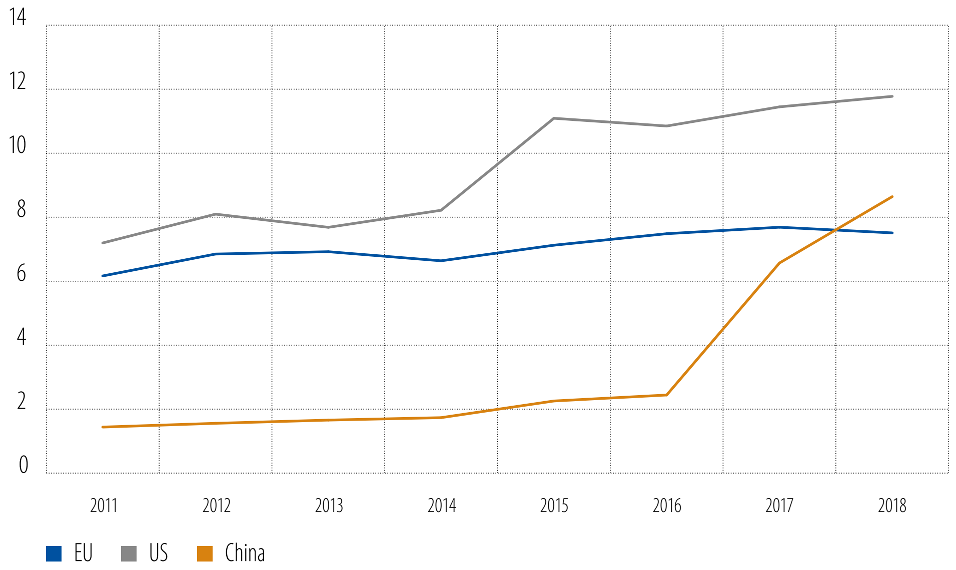
EU investment in batteries and electric vehicles is broadly in line with that of the United States and China. The European Union's strategic approach to decarbonising road[12] transport spurred investment in electric vehicles and batteries. The European Union released a Strategic Action Plan for Batteries, which includes a joint undertaking that combines public and private sector resources (European Commission, 2018c). Boosted by continued policy support, investment in both technologies has been on an uninterrupted upward trajectory since 2011. Electric vehicles and batteries were among the few CCM technologies that saw investment increase from 2017 to 2018 and retained their positions among the leaders.

Research and development (R&D)

The United States remained world leader in climate-related R&D investment. In 2018, it invested almost EUR 12 billion in clean energy R&D, while China spent about EUR 8.6 billion and the European Union EUR 7.5 billion. Climate-related spending on R&D in the European Union declined in the same period, despite overall R&D spending being one of the five headline targets of the European Union's 2020 strategy (Figure 8). This sets a target for R&D intensity at 3% of GDP by 2020. To achieve this target, the European Union's R&D spending will have to increase significantly in the coming years. In 2017, the European Union's total R&D intensity stood at 2.1% with no prospects of a significant uptick in the next few years (compound annual growth rate of 0.6% according to Eurostat), whereas the climate-related R&D intensity was very low at 0.04%.

12 Regulation drives up the cost of clean micro-mobility solutions in some EU countries. Regulation favours polluting cars over clean micro-mobility. Electric-powered scooters and uni-cycles are rapidly becoming part of the urban landscape. These micro-mobility solutions provide alternatives to commuting to work by car.

Figure 8
Investment in climate-related R&D, 2011-2018 (EUR billion)



Source: *BNEF.*

The EU research budget for clean energy technologies reflects the strategic role attributed to electric vehicles and batteries. In 2011, hydrogen and fuel cells accounted for 10% of all climate-related R&D in both the European Union and the United States. While this share remained stable in the European Union, it had halved in the United States by 2018. Smart energy technologies, including hydrogen, fuel cells, energy efficiency and digitalisation, attracted 63% of all climate-related R&D, both in the European Union and in the United States. In China, the share was lower at 29%. The difference is due to the large presence of low carbon services and support, including China's highly developed and diversified Energy Service Company (ESCO) market, which accounts for a larger share (48%) of all clean energy R&D than in the European Union (10%) and the United States (17%).

Mid and long-term investment needs

Investment in climate change mitigation must increase to reach the European Union's mid and long-term decarbonisation targets. From 2011 to 2015 the European Union invested, on average, EUR 190 billion per year in energy-related technologies, including both CCM and conventional (coal, natural gas, etc.) technologies. This level is far below the estimated requirement of EUR 400-500 billion a year over the coming decade (European Commission, 2018a). At current levels, climate investment, excluding transport vehicles, would need to double in the coming years, to set the European Union on the path to meeting its own 2030 targets. Today around 2% of the European Union's GDP is invested in the bloc's energy system and related infrastructure. This would have to increase by close to 3% to achieve a net zero carbon economy by 2050 (Figure 9). The investment gap further widens when all investments necessary to decarbonise the transport sector are considered.

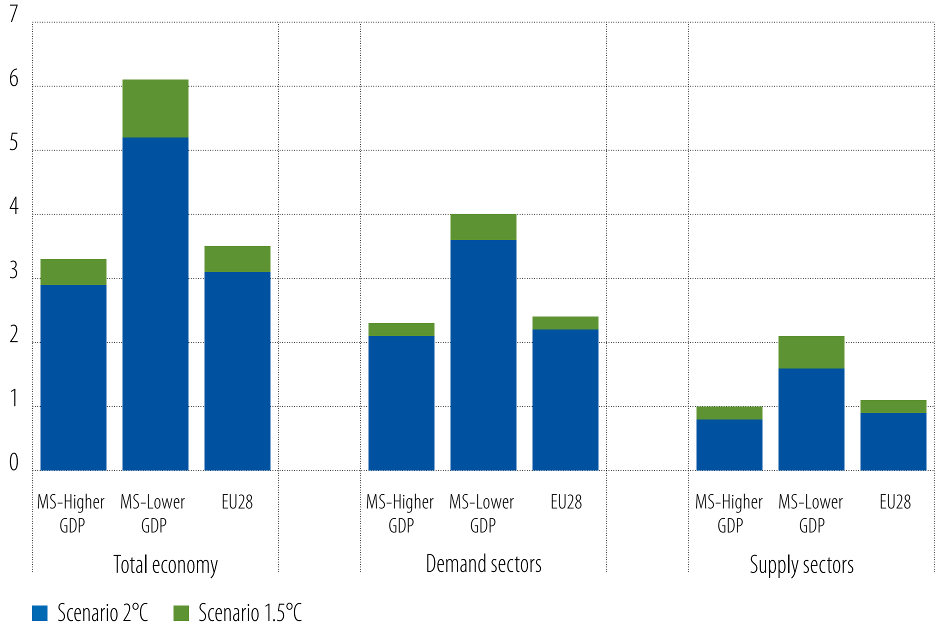
All scenarios achieving decarbonisation imply increasing investments in both the energy demand and supply sectors.[13] During the transition, investment in the different energy sectors would represent

13 The quantitative assessment of the European Commission's decarbonisation strategy, performed using, among others, the PRIMES energy system model, has shown that, irrespective of their specific technology orientation, all scenarios achieving decarbonisation imply a significant increase in investment in the energy demand and supply sectors.

2.5% to 3% of GDP a year until 2050, or roughly 1.5% of GDP above business-as-usual (Figure 9). The largest portion, namely 60-65%, would need to be spent in the end-use sectors (around 2.5%), including households and firms, for building rehabilitation, improvement of industrial processes, efficient equipment and new transportation technologies. The energy supply sectors would need to spend around 1%, primarily for developing and reinforcing energy infrastructure, building renewable energy power plants and facilities for storing energy, and producing carbon-free hydrogen and synthetic fuels.

Figure 9

Annual investment expenditure – energy-related, 2021-2050 (% GDP)

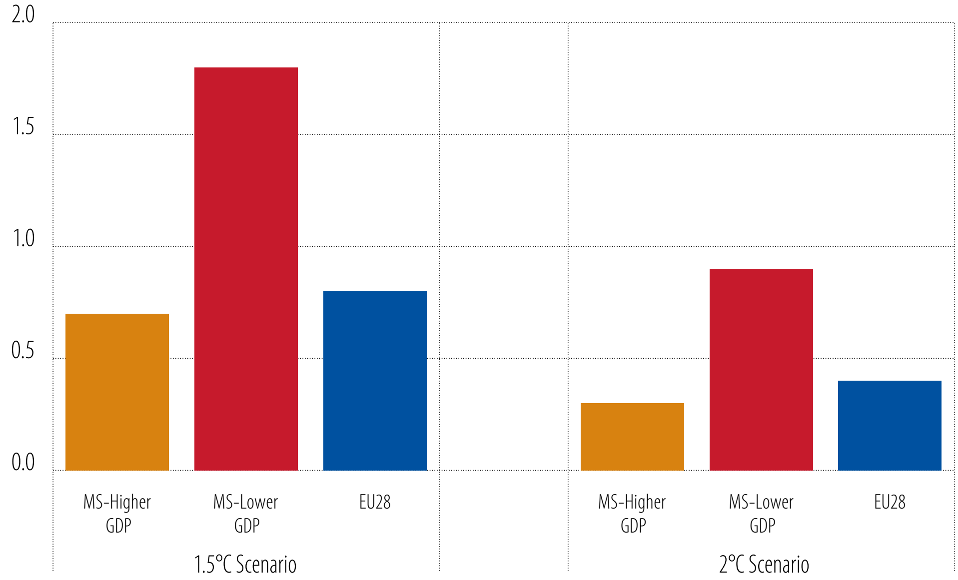


Source: *Authors' estimation based on the in-depth analysis of A Clean Planet for all (COM(2018) 773 final).*

Note: *The group of Member States (MS) with GDP per capita 60% below the EU average in 2013 includes Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania and Slovakia. Disaggregation by country was based on indicators such as carbon and energy intensity, as projected in the reference scenario 2016 and the EUCO scenario by country and published in the Clean Energy for all Europeans study of the European Commission.*

The negative consequences of the climate investment shortfall are already visible today. Insufficient investment in CCM technologies not only puts the European Union's mid and long-term targets in jeopardy, but also might lead to the European Union failing to meet its renewable target set for 2020. A report published by the European Court of Auditors in August 2019 finds that the progress made so far might not be enough to achieve a 20% share of renewables in the European Union's energy consumption (Gross Final Energy Consumption) by 2020. The report also finds that by 2017, 11 (Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, Hungary, Italy, Lithuania, Romania and Sweden) of the 28 Member States had already reached their 2020 target and three more (Austria, Greece, Latvia) were likely to meet theirs if they continued to implement renewable support measures at the current pace. In eight other Member States (Belgium, Cyprus, Germany, Malta, Portugal, Slovakia, Slovenia and Spain), the share of renewables would need to increase by 2 to 4 percentage points to meet the 2020 target. This would require faster growth and consequently higher investment levels than in the past. The report concludes that six Member States (France, Ireland, Luxembourg, Netherlands, Poland and United Kingdom) are unlikely to meet their 2020 target.

Figure 10
Additional annual investment expenditure – energy-related, 2021-2050 (% GDP)



Source: *Authors' estimation based on the in-depth analysis of A Clean Planet for all (COM(2018) 773 final).*
Note: *The additional investment expenditure has been estimated as the difference between the scenarios maintaining the temperature increase at 1.5°C and 2°C and the EUCO scenario that reflects the current EU decarbonisation trajectory, i.e. the 2030 energy and climate targets. Low-income Member States are those where the per capita GDP does not reach 60% of the EU 2013 average based on the Modernisation Fund.*

Financing the energy transformation will be more challenging in Eastern and South-Eastern EU members. In lower-income states, both the energy and carbon intensity are significantly above those in higher-income states and hence higher investments are needed to decarbonise their economies. These investment needs are once again higher in the demand than the supply sectors. In the next 30 years (2021-2050), the additional annual investment needs as a percentage of GDP across lower-income countries are estimated to be between two and three times higher than those of higher-income states, in the 1.5°C and 2°C scenarios respectively (Figure 10). Overall, however, the estimated additional investment needs are considered relatively small in both groups, especially in the 2°C scenario.

Determinants of climate investments

Meeting the European Union's long-term climate objectives requires both a disinvestment from fossil fuels and a significant scale-up of investment in low carbon, sustainable infrastructure and technologies. This section focuses on the determinants of investments in renewable energy and energy efficiency improvements, which are the cornerstones of EU long-term energy policy and closely linked to the policy's three main pillars: security, sustainability and competitiveness. First, this section discusses the main developments in renewable energy and the role of financing sources, policy instruments and the institutional environment for attracting investment in renewable energy. It then explores the factors that influence firms' decisions to invest in energy efficiency improvements and why firms should not focus only on direct energy impacts when assessing such projects. The aim is to understand investment decisions and provide recommendations for investments in both sectors.

Determinants of investments in the renewable energy sector

Investment in renewables has grown substantially over the last two decades and was less affected by the recent economic crisis than any other type of investment. A number of studies (Trinomics, 2017; Polzin et al., 2019) have attempted to pinpoint the main factors in investors' decisions on renewable technologies, from a theoretical or empirical perspective. The majority of them have found that multiple factors are significantly associated with the renewables' investment flows and that in some cases they interact with each other. The empirical literature broadly classifies these factors into five categories: policy design, business environment, governance and accountability, macroeconomic factors, and technological developments. However, the determinants identified as being significant vary, depending on the countries, renewable technologies and period studied and the econometric methodology applied. To this end, it is worth understanding what drives investment decisions in the EU renewables sector.

Table 1

Impact of policy instruments on the effectiveness of renewable energy support schemes

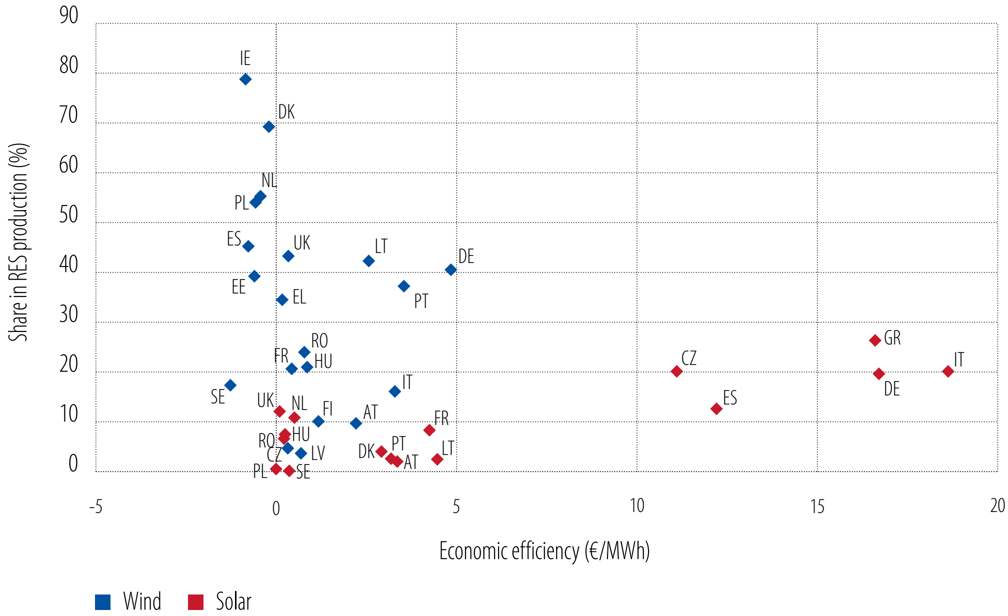
	Model 1			Model 2		
	Coeff.	Std. weight	Rank	Coeff.	Std. weight	Rank
Stand. codes	-0.114	0.04	7			
Info education	0.036	0.03	9			
Direct investment	0.416***	0.17	3	0.458***	0.24	3
Grants/subsidies	0.172*	0.08	5	0.148*	0.09	4
Loans	0.051	0.08	4			
FiTs	0.150***	0.22	2	0.140***	0.26	2
Tax relief	-0.039	0.00	10			
Policy support	0.230***	0.29	1	0.214***	0.36	1
R&D support	-0.193**	0.04	8	-0.164*	0.04	5
Voluntary appr.	0.058	0.05	6			
Observations	252			252		
R^2 (LSDV)	85%			84%		
R^2 (FE)	25%			25%		

Source: EIB estimations.
*Note: The definition of policy instruments can be found in the IEA renewable energy policies and measures database; ranking of estimated coefficients, after removing the fixed effects, based on standardised weights, which are the general dominance weight from McFadden R[233] normed or standardised to be out of 100%. The dependent variable, the support schemes' effectiveness, is measured as the yearly additional electricity generation in comparison to the remaining additional available potential for each of the EU Member States, based on the 2020 national renewable energy action plans; *, **, *** indicate significance at 10%, 5% and 1%.*

Among the policy instruments established to promote investment in renewables, feed-in tariffs (FiTs)[14] and premiums appear to be the most successful. Governments, in their attempt to attract investments in the renewables sector, have provided public incentives to reduce the risks (higher relative upfront capital spending) associated with renewable investments. Table 1, confirms that long-term policies, such as institutional creation and strategic planning and feed-in tariffs proved to be more effective in the deployment of renewables than short-run policies, such as grants, loan subsidies and tax incentives. The implementation of feed-in tariffs and the institutional creation and strategic planning explain more than half of the variation in the effectiveness of support schemes across the European Union and over 2010-2017 (Kalantzis and Niakaros, 2019). Policies aimed at the direct acquisition of renewable power capacity by public authorities appeared to be an additional important driver of the deployment of renewable technologies.

14 Feed-in tariff is a policy mechanism designed to accelerate investment in renewable energy technologies. It achieves this by offering long-term contracts to renewable energy producers, typically based on the cost of generation of each technology.

Figure 11
Economic efficiency indicator for solar PV and wind generation in 2016

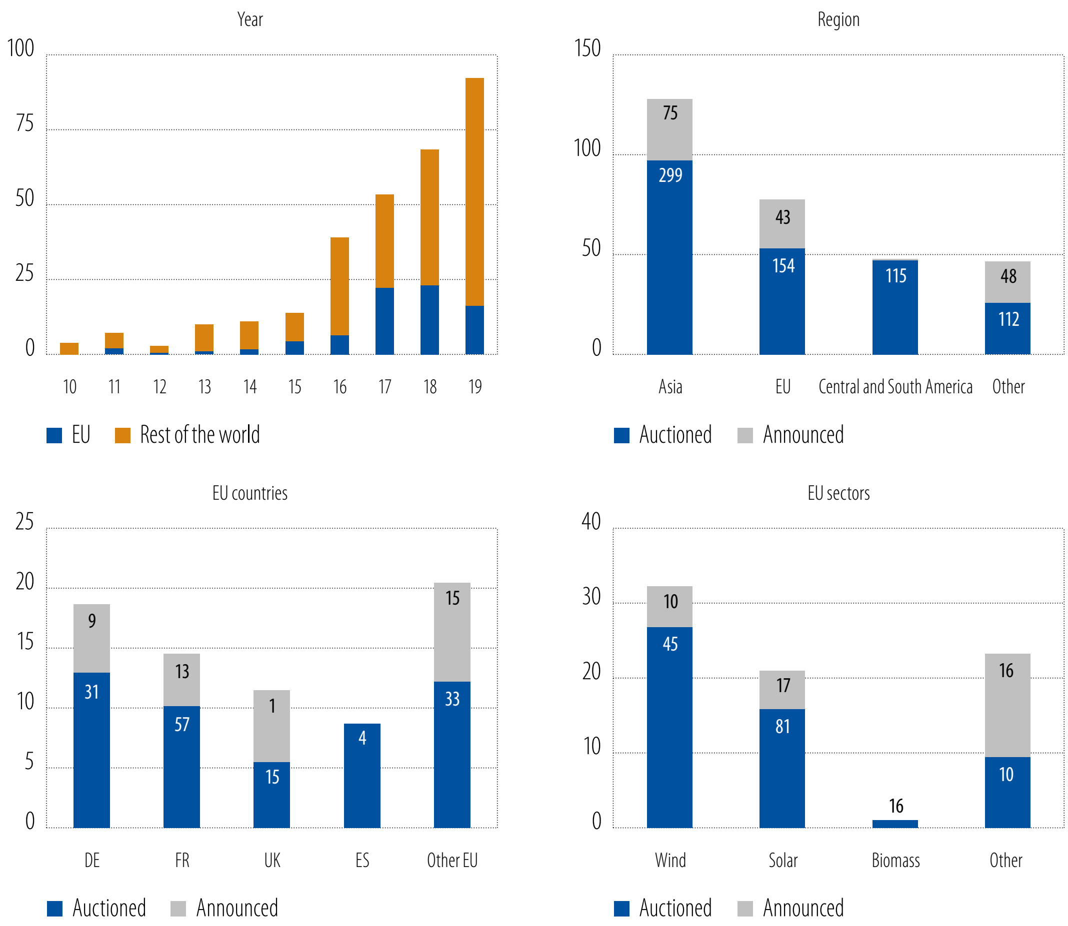


Source: *CEER (Council of European Energy Regulators) and EIB estimations.*
Note: *Economic efficiency is defined as the difference between the support level and the generation cost.*

However, the high initial support for solar photovoltaic lowered the economic efficiency of support schemes across the European Union and raised concerns about their costs. Figure 11 shows that solar PV required higher levels of support compared to wind generation, which was much cheaper. Early mover countries such as Italy, Germany, Greece, Spain and the Czech Republic provided more support to solar PV than the rest of the EU countries, which seem to have benefited from the falling capital cost and their later engagement. By contrast, the support levels for wind generation were much lower. To that end, the overall cost of support for renewables was mainly driven by the relative weight of solar PV and to a lesser extent by other renewable technologies.

As the deployment of solar PV vastly accelerated, the cost of support schemes ballooned and forced policymakers to scale back incentives in some EU countries. Several factors played an important role in this, including the financial crisis, budgetary constraints, the occurrence of electricity tariff deficits, which were a potential liability for public finances, and higher retail electricity prices due to rising renewable levies that were affecting competitiveness (European Commission, 2014). Generally, the countries that took retroactive measures were more vulnerable to economic crisis and some of them were under an Economic Adjustment Programme. For example, Spain imposed an annual cap on the number of hours that solar PV projects could sell electricity at the feed-in tariff. Greece and Portugal reduced their financial support for renewable producers by imposing additional financial taxes to compensate for the high feed-in rates and Italy forced large solar producers to accept a reduced feed-in tariff with the possibility of extending their pre-agreed remuneration period. The Czech Republic, Romania and Bulgaria have also taken retroactive measures. All these measures negatively affected investors' confidence and raised the regulatory risks.

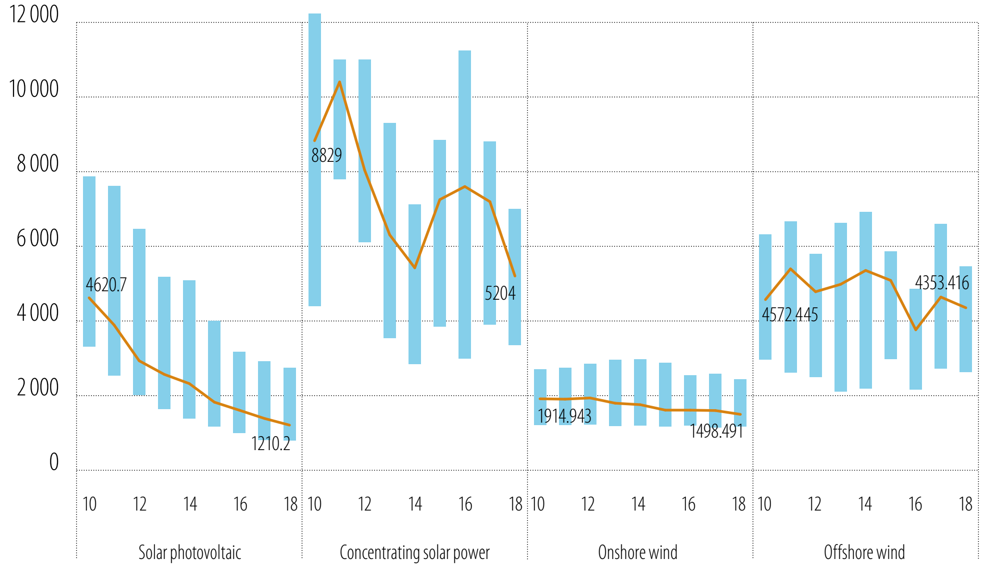
Figure 12
Auctioned capacity by year, region, EU countries and sectors (GW)



Source: *BNEF.*
Note: *Numbers in bars show the number of auctions over 2011-2019.*

Many EU countries switched to auctions to make renewable energy more cost efficient. The move to auctions was also partly a response to the updated European State Aid Guidelines and designed to increase the market integration of renewables. The trends are promising (Figure 12), but the overall capacity auctions seem to be still relatively small (around 22GW in 2018) compared to the overall investment needs for achieving carbon neutrality. The outcome of these auctions, regardless of the EU country, revealed how cheap solar and wind power have become. However, auctions are no panacea; they are not the "golden bullet" that could result in the successful deployment of immature and innovative renewables technologies. In such cases, auctions may need to be complemented with other policies.

Figure 13
Evolution of renewables' total installed costs (2018 USD/kW)



Source: *IRENA.*

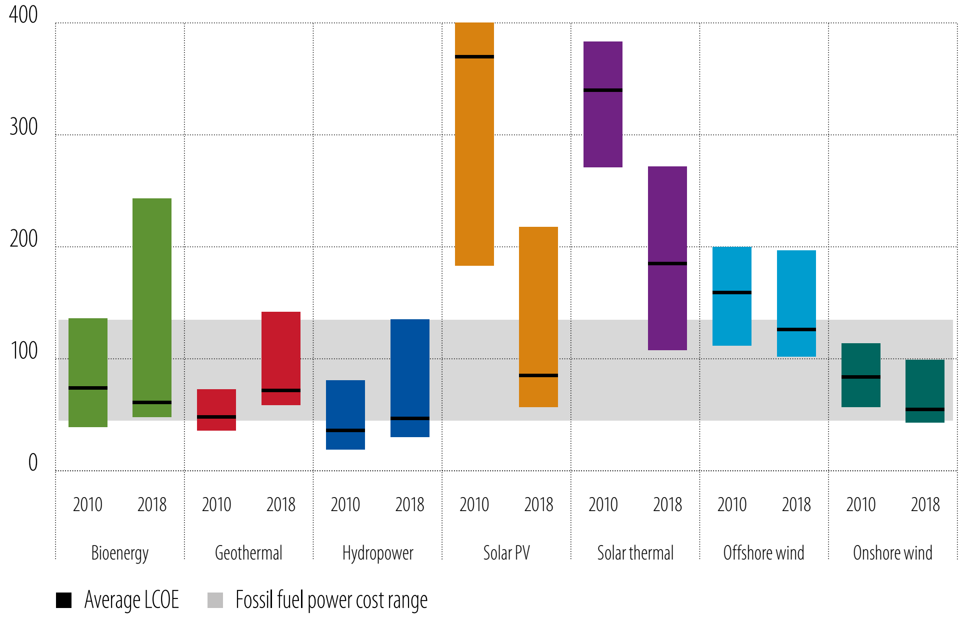
The good news is that the cost competitiveness of renewable energy technologies year after year keeps improving. Today, more than ever, there is a favourable environment for future renewable energy projects, without the need for subsidies. From 2010 to 2018 (Figure 13) solar photovoltaic experienced a steep decline in capital costs, falling almost 75%, followed by concentrated solar power (44%) and onshore wind (22%). Falling capital costs have helped most of the renewable technologies to become highly competitive, especially onshore wind and solar photovoltaic, compared to fossil fuel production. The LCOE (levelised cost of electricity)[15] over the same period decreased by 77% and 35% to EUR 85/MWh and EUR 55/MWh, for solar and wind, which is within the range of the electricity production cost of fossil fuels (Figure 14). These dramatic improvements were achieved thanks to R&D[16], endogenous learning, increased access to green finance and the increased number of project developers globally.

At the same time, the robust demand for renewable energy is attracting new financiers and strategic investors. Multilateral development banks have entered the market and provided finance for green investments, as well as an increasing number of non-traditional investors, including individuals, venture capital, insurance companies and sovereign wealth funds. In parallel, financial instruments such as green bonds have helped to mobilise resources from capital markets for climate change adaptation, renewables and other environment-friendly projects. In 2019, USD 113 billion (Figure 15) was raised in the European Union from various types of climate project bonds (green, sustainability, social, etc.). These bond sales raised far more money than similar sales in the rest of the world (USD 60 billion) and greatly exceeded other supranational sources (USD 75 billion). The majority of the bonds issued were green bonds, which support all sorts of clean energy technologies (renewables, energy efficiency, emissions reduction, water use, etc.). While these amounts represent a small share of total investment needs for the energy transition, they have helped companies to face their financing challenges and get their projects off the ground.

15 LCOE calculations compare generation technologies on an apples-to-apples basis by evaluating the total costs to build (e.g. cost of debt) and operate power plants over their assumed lifetimes.

16 R&D spending led to bigger wind turbines being built, resulting in higher capacities, by lowering their LCOE.

Figure 14
Evolution of levelised cost of energy (LCOE) **for low carbon technologies** (USD 2018/MWh)



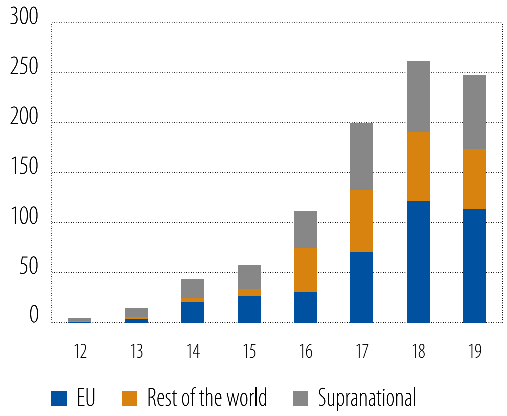
Source: *IRENA.*

Public opinion and shifts in corporate strategies appear to also be an investment game changer. Today, people seem to be more concerned about the negative consequences of climate change and are looking for ways to reduce their carbon footprint by consuming energy from renewable sources. In parallel, a growing number of global corporations want to be part of this transition. Over 60% of Fortune 100 companies and nearly half of the Fortune 500 have set clean energy targets (BNEF, 2019). The main factors driving firms' decisions are declining capital costs, investors' and consumers' pressure to change their business model and adopt environmental, social and governance (ESG) criteria, the need to respond to climate-related risks, and finally the pressure coming from industry peers that support the energy transition.

However, many challenges remain, not least among them the continued subsidies for fossil fuels that impair the cost competitiveness of renewable energy. Coady et al. (2019) have projected that environmentally harmful subsidies[17] increased to USD 5.2 trillion (6.5% of GDP) in 2017 compared to USD 4.7 trillion (6.3% of global GDP) in 2015. According to the authors' estimations (Figure 16), the largest subsidies in 2015 came from China (USD 1.4 trillion), the United States (USD 649 billion), Russia (USD 551 billion), the European Union (USD 289 billion), and India (USD 209 billion). About three-quarters of global subsidies are a response to domestic factors; energy-pricing reform thus remains largely in countries' own national interest. Coal and petroleum together account for 85% of global subsidies. In particular, coal remains the largest source of subsidies (44%), followed by petroleum (41%), natural gas (10%), and electricity output (4%). These subsidies still affect the competitiveness of renewable projects, especially when compared to coal power plants.

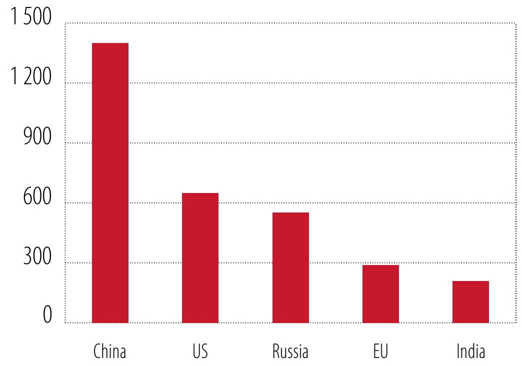
17 According to the OECD, an environmentally harmful subsidy is a result of a government action that confers an advantage on consumers or producers to supplement their income or lower their costs, but in doing so, discriminates against sound environmental practices.

Figure 15
Sustainable debt issued by region
(USD billion)



Source: BNEF.

Figure 16
Environmentally harmful subsidies, 2015
(USD billion)



Source: International Monetary Fund.

In addition, until recently, low carbon prices have been less successful in promoting the deployment of renewable energy. Historically, direct support for renewable investment has proven more effective than charging industry for carbon emission (Emissions Trading System prices). The low carbon prices observed since the Emissions Trading System (ETS) was created in 2005 have not had any noticeable impact on the structure of power markets or the deployment of renewable energy. Today, carbon prices have started climbing again to around EUR 30 per tonne of carbon, driving up electricity wholesale prices too. Recent tenders in various markets have shown that renewables can be competitive in an electricity wholesale price range of EUR 30-50/MWh (depending on the technology), which means that higher carbon prices create a favourable environment for renewable energy projects. Fixed and stronger revenue will encourage investors and lenders to fund projects and help to build a subsidy-free market.

An empirical investigation of the role of these factors confirms most of the previously mentioned facts.[18] First of all, the results in Table 2 suggest there is a positive and statistically significant relationship between long-term policy instruments, such as feed-in tariffs, and investments in renewables. Equally important is policy support, meaning any steps governments take to foster renewable energy, including targets and strategic plans. By contrast, short-term policy instruments, such as grants, tax incentives or rebates and auctions appear to be less relevant to renewable investments. The impact of auctions is most likely affected by the fact that they have been recently implemented in most EU countries.[19]

18 For more information, see the forthcoming EIB working paper (Kalantzis and Niakaros, 2019).
19 Their coefficients were not statistically significant and were not included here for the sake of space.

Table 2

Empirical estimation of the determinants of renewable investments in the EU

VARIABLES	OLS	FE	GMM
Log of investment in rewewables (t-1)	0.704***	0.298***	0.437***
Log of new additions	0.728***	0.898***	0.856***
Rule of law	0.147	10.33**	7.524**
Log of GHG/capita	-0.546**	1.644	2.285
FiTs (dummy variable)	0.238	0.633***	0.560**
Policy support (dummy variable)	0.447***	0.546**	0.508**
Market capitalisation/GDP (%)	0.007**	0.022*	0.022**
Credit to financial sector/GDP (%)	0.202	0.542	0.591
Time effects	YES	YES	YES
Group effects	NO	YES	YES
Observations	337	337	294
R^2	76%	42%	
Groups		43	43
Instruments			30

Source: *EIB estimations.*
Note: *Collapsed instrument set, orthogonal instruments and robust errors were used; p-value of AR(2)=0.65 and of Hansen test==0.15; OLS, FE and GMM stand for ordinary least squares, panel fixed effects and generalised methods of moments. The dependent variable is the log of investment in wind and solar PV per country for the European Union from 2004 to 2017; *, **, *** indicate significance at 10%, 5% and 1%, respectively.*

Past investments, access to finance and the quality of governance appear to be critical variables for current investments. The findings show that the lagged investment values positively affect current investment values, which implies that past investment acts as signal for investors and likely represents a healthy investment environment and a well-functioning market. In the same context, better governance influences positively the level of investments, as it contributes to stability and credibility by lowering regulatory risks. Investment is not only driven by additions to installed capacity, but are also affected by falling capital costs (negative time effects). Finally, yet importantly, the findings indicate that the high upfront cost of investment in renewables makes access to credit and equity funds imperative.

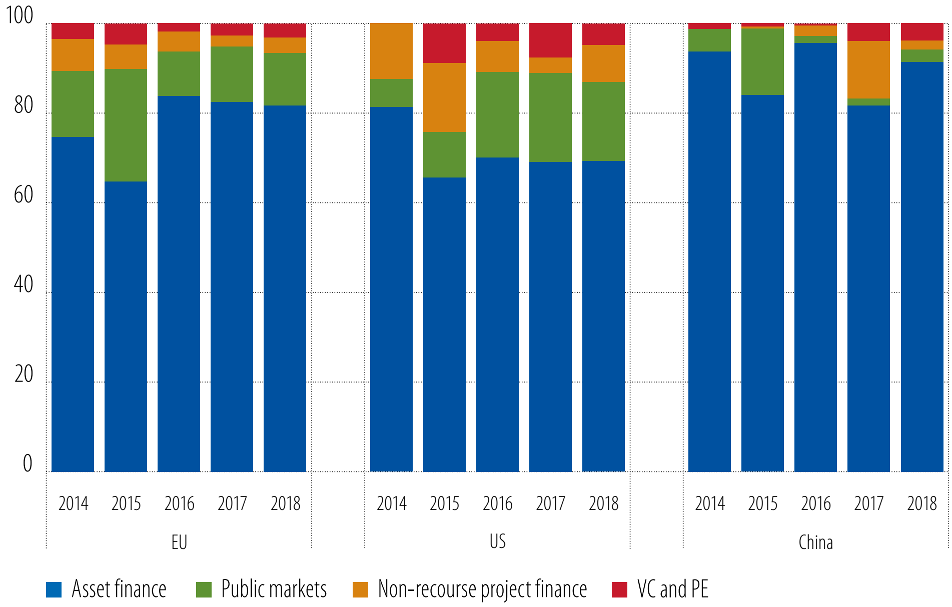
The role of different financing sources in renewable investments

Private investments are the largest source of capital for renewable energy projects. Over the last 15 years the bulk of investments in Europe, the United States and China has come from four sectors: asset financing, venture capital and private equity, non-recourse project finance[20] and public markets.

Historically, asset financing has been the main source of renewable investment in all three regions (Figure 17). Asset financing is more pronounced in China and in the European Union than the United States. The share of asset financing accounted for 89% in China and 74% in the European Union in 2004-2018, while for the United States it was close to 65%. In addition, in the United States the share of asset financing peaked in 2011 at 78%, and started to decline some years after the economic crisis. By contrast, asset financing in China peaked in 2015 at 96% and at 83% in the European Union.

20 Non-recourse project 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 other assets of the borrower.

Figure 17
Shares of financing sources for renewable projects in the EU, US and China (%)



Source: *BNEF.*

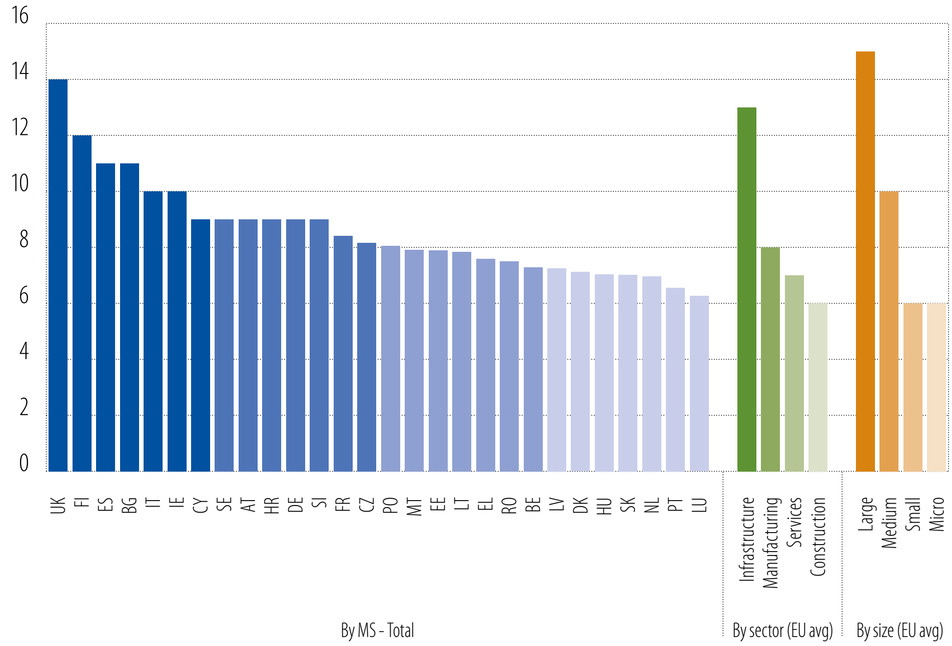
Non-recourse project finance, which is mainly driven by bank lending, is the second largest source of financing for renewables. The projects financed by this type of finance concern mainly technologies with a smaller penetration, such as rooftop and other small-scale solar projects of less than 1MW. On average, the European Union and the United States witnessed similar shares of non-recourse project finance (around 13-15%). In China, however, the share was much lower at 6%. In China and the European Union, the share dropped considerably after 2010 and 2012.

Public markets and venture capital and private equity are the least preferred source of financing of renewable projects. Companies in the European Union and the United States have used the public markets to raise capital for their renewable projects (16% and 14%, respectively) more than in China (2%). Similarly, the role of venture capital and private equity has been more important in the United States and Europe, where markets are more developed, than in China. In China, the contribution of venture capital and private equity funding was close to 1%, whereas in the United States it was more than 4% and in the European Union 3%.

Energy efficiency investments: evidence from the EIB survey

Energy efficiency investment is unevenly distributed in the European Union, varying across Member States, sectors and firm size. EIBIS (EIB Investment Survey) data (2017, 2018) indicate that in the United Kingdom, Finland and Spain, firms' energy efficiency investment as a share of total investment is twice as high as that in Luxembourg, the Netherlands and Portugal (Figure 18). The same magnitude of difference holds across sectors: firms in the infrastructure sector spent, relative to their total investment budget, twice as much on energy efficiency as firms in the construction and services sectors, with manufacturing situated in the middle. Energy efficiency investment in the transport sector grew by 25% to EUR 9.3 billion from 2017 to 2018, while energy efficiency investment in the industrial sector remained flat. Differences also exist across firms of different sizes. The share of total investment dedicated to energy efficiency measures is twice as high for large firms as for micro and small firms.

Figure 18
Proportion of total investments for measures to improve energy efficiency (%)



Source: *EIBIS.*

The importance of adequate financing is underlined by the magnitude of the gap in reaching the 2030 energy efficiency target, despite the EU's leading position in this area. This funding shortfall, which is a common problem not only for the EU but also for many other regions worldwide, has led many researchers to investigate why firms fail to adopt cost-efficient energy efficiency measures (known as the "energy efficiency gap", Jaffe and Stavins, 1994). According to the literature, the most commonly cited barriers to energy efficiency investments are high information costs and other transaction costs, hidden costs, financial and technological risks, capital market restrictions, split incentives, as well as organisational and behavioural constraints (Sorrell et al., 2004).

Firm size and industry sector appear to be the most important factors determining energy efficiency investments (Kalantzis and Monostori, 2019). An empirical study of the motivational factors and firm characteristics determining energy efficiency measures, based on EIBIS and more specifically on the dominance analysis (Table 3), shows that these size and sector characteristics explain more than one-third of the variation of the dependent variable (among the explanatory variables included in the analysis). The estimated coefficients indicate that the likelihood of firms investing in energy efficiency is higher for larger firms and for the manufacturing and infrastructure sectors. This is in line with the existing literature (Czarnitzki et al., 2007), which supports the idea that certain sectors, most notably energy-intensive ones, are looking for ways to reduce their energy costs.

Energy audits and innovative activities are the second and third most important factors in firms' decisions to go ahead with energy efficiency measures. Both variables explain equally more than one-fifth of the variation of the dependent variable based on the dominance analysis. The findings indicate that firms that carried out an energy audit are 13% more likely to invest in energy efficiency and 15% more likely if they have innovative activities. The result is in line with the findings of Kalantzis and Revoltella (2019), who suggested that energy audits help firms to overcome the information barriers to efficiency measures. Moreover, innovative firms embark on energy efficiency measures to improve their financial and operational performance, as well as to reduce their carbon footprint (Horbach et al., 2012).

Table 3
Empirical estimation of the determinants of energy efficiency investments in the EU

VARIABLES	Coeff.	Marginal Effects	Std Domin stat.	Ranking
Construction	-0.178***	-0.0371***		
Services	-0.171***	-0.0357***		
Infrastructure	0.0330	0.00699		
Small	0.157***	0.0318***		
Medium	0.506***	0.107***		
Large	1.021***	0.223***		
Finance constraint	-0.150**	-0.0311**	1%	8
Innovative firm	0.721***	0.150***	21%	3
Energy audit	0.608***	0.127***	22%	2
Energy cost – major obstacle	0.413***	0.0859***	5%	5
Quality of buildings	0.418***	0.0870***	5%	4
Exporter	-0.174***	-0.0361***	1%	7
Age	0.0965***	0.0201***	3%	6
2019	0.102***	0.0213***	0%	9
Manufacturing, micro	-208.1***		41%	1
Country fixed effects	YES	YES	YES	YES
Observations	17 233	17 233	17 233	17 233

Source: *EIB estimations.*
Note: **, **, *** indicate significance at 10%, 5% and 1%, respectively; the dependent variable is a binary and is valued at one if there was an investment and zero otherwise, based on EIBIS 2018 and 2019.*

Higher energy cost concerns, finance constraints and firms' age appear to be additional factors determining energy efficiency measures. As expected, such investments are more attractive to firms for which energy cost is a major concern because it affects their competitiveness. Similarly, funding is important to firms adopting efficiency measures because such investments are not considered to be a core business activity. The age of the firm and the quality of its buildings are also positively linked to the probability of going ahead with investment in energy efficiency measures. Finally, the good news is that in the last wave of the EIB survey compared to the previous wave (time effect), more firms were willing to spend money on such measures.

Persuading firms to think out of the box on energy efficiency investments

Firms tend to focus on efficiency measures' direct impact on energy consumption, neglecting other significant non-energy benefits. This tunnel vision affects the attractiveness of energy efficiency measures and many investment opportunities are missed. Non-energy benefits are difficult to distinguish and quantify. To that end, little is known about how firms understand these benefits and if and how firms incorporate them into their decision-making processes.

The IEA (2014) summarised the findings of the existing literature on the benefits of energy efficiency investments, by identifying 15 classes of multiple benefits. Then, it classified them into five categories based on their level of influence (individual, sectoral, national and international): the impact on the wider economy, the public budget, health and well-being, energy delivery and the industrial sector. Benefits for industry include reductions in resource use and pollution, improved production and capacity utilisation, and less operation and maintenance, which leads to improved productivity and competitiveness. More recently, Nehler (2018) provided an updated systematic review of the academic literature on non-energy benefits, discussing issues such as methods for observation, measurement, quantification and monetisation of the benefits.

Nearly all studies on non-energy benefits have followed a case study format that analyses the additional benefits of energy efficiency investment, before and after the implementation of specific measures. Only Montalbano and Nenci (2018) have investigated empirically the impact of energy efficiency improvements on the productivity and exporting behaviour of firms in Latin America. They applied a Cobb-Douglas production function and assessed the correlation between energy intensity and productivity, after taking into account the heterogeneity of firms. Their results suggested a positive and heterogeneous impact across sectors and size classes, but as the authors acknowledged, energy intensity is considered to be an imperfect proxy of energy efficiency (Proskuryakova and Kovalev, 2015).

Do higher energy efficiency standards improve productivity? Many case studies have shown that an improved working environment, comfort, health, safety and reduced noise induced workers to be more engaged, productive and happier. An energy efficient building controls the flow of air, heat and moisture throughout the building effectively. An efficient building maintains moderate temperatures, low humidity and increased air quality. A recent case study, conducted by researchers at the Harvard T.H. Chan School of Public Health's Centre for Health and the Global Environment and SUNY Upstate Medical, proved that working in high-performing, green-certified buildings could improve employee decision-making. Workers in weak performing buildings appear to be less focused on their tasks and record higher rates of absenteeism.

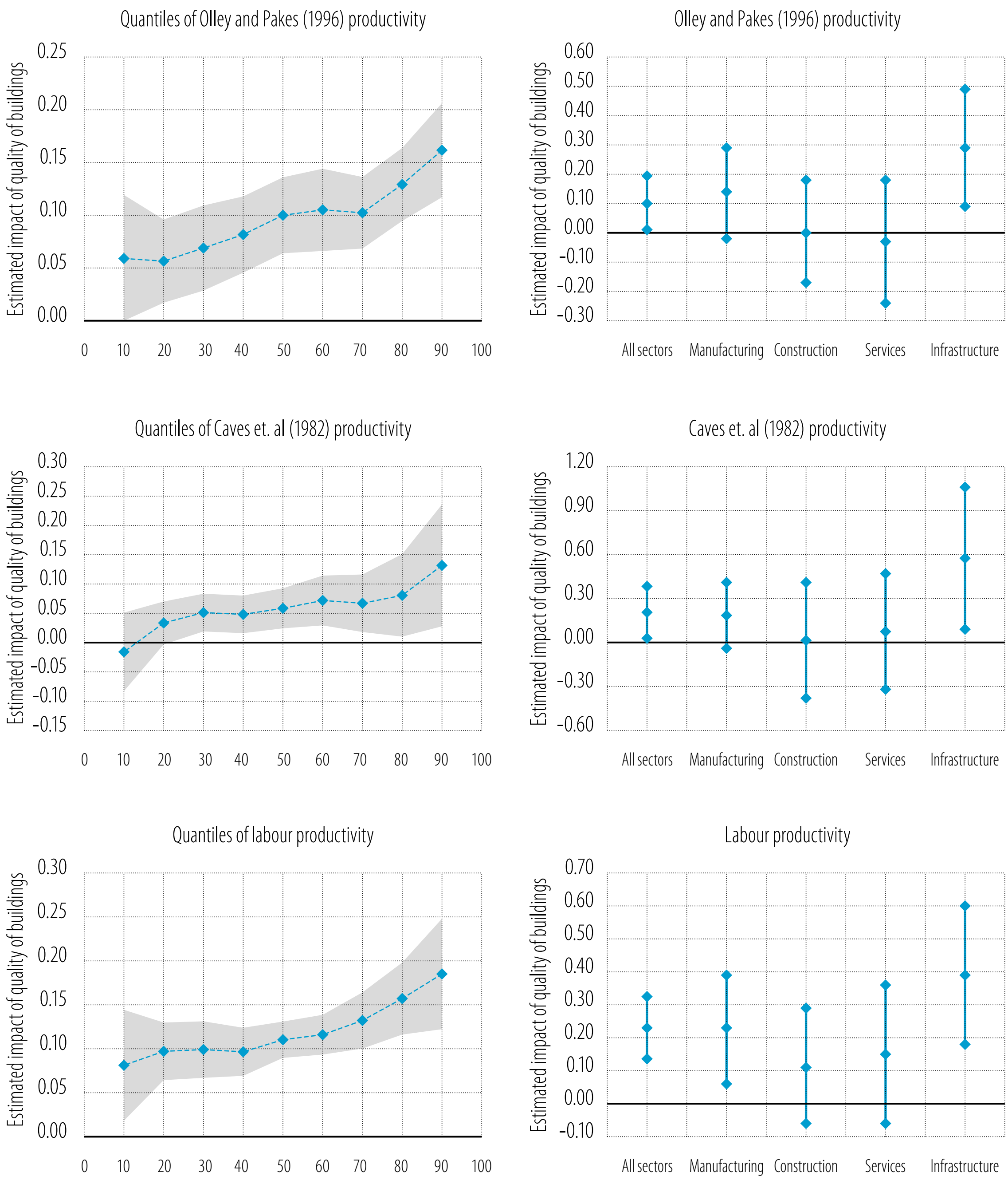
The empirical investigation of the impact of better performing buildings on firms' productivity based on EIBIS data suggests that there is a positive and causal relationship (Kalantzis, 2019). The various case studies seem to confirm the idea that improved indoor environment, comfort, health, safety and reduced noise outweigh the investment costs of various energy efficiency measures and induce employees to be more engaged, happy and productive. Firms whose buildings meet 10% higher energy efficiency standards have, at least, 1% higher productivity levels based on the instrumental variable approach (Figure 19).

The analysis also indicates that the relationship between productivity and energy efficiency standards is not constant across quantiles. By disentangling the effects of building stock energy efficiency standards on different levels of productivity measures, it was observed that the quality of building stock is more relevant for highly productive firms than for low productive firms. The quantile regression approach shows that the medium estimates obtained by the Ordinary Least Squares (OLS) regressions do not capture the complex dynamics and heterogeneity of EU firms' productivity.

The finding of a causal relationship between building infrastructure and productivity could positively influence the decisions of firms to undertake energy efficiency projects. It is important for firms to understand that whatever the cost savings expected from energy efficiency investments, they should weigh the many benefits of such projects and make an overall informed decision. In this way, the financial attractiveness of energy efficiency investments may increase and firms will contribute to bridging the energy efficiency gap.

Figure 19

Estimated impact of building stock energy efficiency standards on firms' productivity



Source: *EIB estimations.*

Note: *LHS presents the results of the quantile regressions and RHS presents the results of the General Method of Moments (GMM) estimations for the three productivity measures: Olley and Pakes (1996), Caves et al., (1982) and labour productivity; the shaded area and the vertical lines depict the 95% confidence interval of the quantile and GMM regressions, respectively.*

Conclusion and policy implications

The energy transition has an important role to play in mitigating the worst effects of climate change. In parallel, it can create jobs and business opportunities and increase the competitiveness and resilience of the EU economy. According to the European Union's impact assessment analysis, the energy transition is economically and technically feasible, but requires large changes in many different areas of the EU economy (e.g. energy, transport, industry, the built environment and agriculture). A successful energy transition is also a just transition. This means that it is not only about meeting climate targets but also about making sure that the most vulnerable to climate change are protected and the burden is fairly shared between developed and developing countries.

Despite the European Union's ambitious climate and energy targets, the bloc's investments fall short of projected energy investment needs. The European Union's early focus on decarbonisation put it in a good position for current energy efficiency investments compared to the United States and China. However, it falls short in climate investments in transport and R&D, and the United States and China continue to outpace the European Union in this regard. Although these economies are not fully comparable, China's climate change investments as a share of GDP is three times higher than those of the European Union, partly reflecting China's efforts to catch up. At current investment levels, the European Union runs the risk of missing its climate targets, failing to sufficiently adapt its economy and citizens to the impacts of climate change and losing its first mover advantage in clean energy. The European Union's energy-related investments will have to double to meet its 2030 climate and energy targets. The negative consequences of the shortfall in the European Union's climate investment are already visible today, as at least six Member States are likely to miss their 2020 targets for renewable energy.

Efforts to provide clear energy policy signals should continue, along with a supportive regulatory framework and improved access to climate finance. Clear policies will allow Europe to compete and lead in the field of clean energy technologies. In turn, this will allow firms and investors to roll out strategies and investment plans that are in line with the commitments of the Paris Agreement to keep global warming well below 1.5°C. In this way, the transition will speed up and reduce the risk of non-aligned investments (stranded assets). Clear energy policies would provide clarity for firms with the most to lose in the energy transition, such those dependent on fossil fuels, and enable them to adjust their activities.

Fiscal policies also have a key role to play in addressing the energy transition challenges. The revision of energy taxation could indirectly influence investor and individual behaviour, as well as steer production and consumption towards a sustainable path. In the European Union and in the United States, energy taxation is expected to change, while energy use remains largely untaxed in China. In addition to fostering investments in clean technologies, which are essential to decarbonise the European Union's economy, reformed taxation could remove current subsidies for fossil fuels, in line with the European Union's G20 commitments. Moreover, taxation could improve the global competitiveness of EU industries by applying carbon border adjustment to imported goods. Taxation could also increase social cohesion by channelling revenues back to households in need, thus avoiding social disruption, ensuring energy affordability and addressing inclusiveness. The phase-out of fossil fuel subsidies would level the playing field for clean energy technologies while preventing the European Union from outsourcing its emissions and energy consumption to other parts of the world. A further benefit would be reduced reliance on imported materials.

For low carbon technologies that are less mature, policy measures and economic incentives could complement market-based instruments to ensure clean energy's deployment. For example, initiatives such as the European Battery Alliance, which supports the EU battery industry's efforts to compete with the United States and China, could be intensified. Moreover, the European Union could provide public finance and strategic roadmaps for infrastructure, enabling the rollout and integration of renewables and low carbon technologies, such as electric vehicles, smart appliances and solar panels. The European Union could also consider subsidising low carbon technologies, which are prohibitively expensive for some lower-income groups. At the same time, financing for climate projects needs to improve to make sure that critical infrastructure is resilient to the impact of climate change.

In addition to solving funding challenges, countries could share knowledge and competencies to support the energy transition. This is particularly valid for lower-income countries that face higher energy transition challenges. Burden-sharing is a specific component of the Paris Agreement and the prerequisite for a fair and successful global energy transition. Sharing the burden is increasingly important when considering the taxation of carbon-intensive imported goods, which could be interpreted as protectionism. In addition, firms should be persuaded to incorporate the energy transition and its risks and opportunities into their operational strategies. Countries should also increase awareness among their citizens about the energy transition, encouraging them to play their part in energy conservation and enabling them to adapt to a changing economy. In addition, it is important to identify vulnerable regions and communities and support efforts to build skills in low carbon economic activities.

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Low interest rates for an extended period:
the 10-year AAA euro area government bond yield is currently
-0.35% and the 10-year forward yield is close to **0%**

Very traditional savers:
equity and debt securities account for **21%** of EU households' financial assets, compared with **41%** in the United States

From 2005 to 2019, **corporates increased their cash and deposit holdings** from **14%** of **GDP** to **22%**

EU corporate indebtedness has declined by **7%** of **GDP since 2009**

Fragmented market:
cross-border gross capital flows declined from **33%** to **11%** of GDP

Only 5% of **EU firms are finance constrained, unchanged** from 2018,

but **innovative companies are disproportionately affected**

PART II

Investment finance

Chapter 5

Towards a financial system more supportive of corporate investment

The upturn in the EU economy has weakened somewhat as the headwinds forecast since the end of last year have materialised. Along with a slowdown in economic activity, monetary policy expectations have shifted from tightening to loosening. In the euro area, a new comprehensive easing package has been announced. Long-term interest rates have fallen back into negative territory and dipped below their mid-2016 troughs. The financial system is now more resilient than it was before the crisis, but risks have also increased. The financial system remains ill-suited to supporting corporate investment in this very challenging time.

Domestic financial systems are unevenly developed across the European Union, with limited room for maturity and risk transformation. Household savings are characterised by a high level of cash and deposits – which explains the dominant position of banks in the EU financial system – and low equity investment. On the one hand, financial stability, savings protection, liquidity management and an aversion to risk constrain banks' ability to engage in maturity transformation. On the other hand, investment funds are underdeveloped, typically smaller than in other developed economies and more costly. Despite limited progress made over the last ten years, savings cannot easily finance corporate investment, especially if this investment is long-term or innovative.

The EU financial system is not properly integrated. Before the crisis, banks drove the integration. They were encouraged by a higher risk appetite and favourable cyclical conditions. Since then, banks have pulled back from foreign holdings, focusing instead on domestic and regional holdings. Cross-border capital flows are now seeing a tepid recovery. The crisis has shown the need to strengthen genuine financial integration so that savings reach the best investment opportunities across Europe. The European Union's post-crisis financial regulatory packages may eventually help savings reach those investments, but so far little progress has been made.

Introduction

This chapter examines the EU financial system from the supply side, reviewing the major developments in the bloc's financial sector and in the three regions considered in the report.[1] Taking stock of the evolution since the beginning of 2000s, we look at the major changes that have taken place since the crisis. We then assess the progress of the EU financial system and its capacity to channel savings to the most productive use. We emphasise the gaps in the financial system, looking at its capacity to perform maturity transformation and strengthen cross-border integration.

The remainder of the chapter consists of three sections followed by a conclusion outlining policy implications. The first section reviews the major financial developments in the European Union since the last Investment Report, and attempts to gauge the risks and the resilience of the economy. In the next two sections, we take a historical perspective to analyse the major changes that have occurred within Europe since the previous upturn, prior to the crisis. In the second section, we review the main blocs and characteristics of the financial system in EU regions, while in the third section, we examine cross-border capital flows, home bias and financial integration in the European Union.

The EU economy in the macro and financial cycles

Some of the headwinds expected to emerge at the end of last year have materialised, as the effect of uncertainty began to impact activity. The EU upturn weakened somewhat but the downturn is expected to be contained. Removing undue uncertainty is key to limiting its magnitude.

Along with the slowdown in economic activity, monetary policy expectations have shifted from tightening to loosening. Long-term rates have re-entered negative territory and dipped below the lows of mid-2016. The current environment of negative long-term yields for highly rated sovereigns partly reflects the scarcity of safe assets in Europe.

Compared to before the crisis, the financial system has been made much more resilient, but risks have also increased as the side effects of five years of negative short-term rates and persistently ample liquidity begin to show.

Output gap and inflation

Since the middle of 2018 (the cut-off date of the previous Investment Report), the upturn has continued, but weakened substantially. In 2018, output in the European Union was above its pre-crisis level by around 12% in real terms, while it was well above its pre-crisis level in Western and Northern Europe (by 15%) and in Central and Eastern Europe (26%). Conversely, a gap of about 2% remains in Southern Europe. In the most recent upturn, corporate investment is lagging behind GDP growth across the European Union as well as in Southern and Central and Eastern Europe.[2] EU real output has slowed recently from an annual growth rate of 2.6% in 2017 to 2.1% in 2018.

Uncertainty about the future is behind the headwinds. At the beginning of the year, major international institutions revised their activity forecasts downwards (Figure 1). From a projected growth rate of 2.3% in the European Commission spring 2018 projections, EU real GDP growth in 2019 was revised down to 1.4% in the spring 2019 projections. To date, the anticipated slowdown remains transitory and contained.

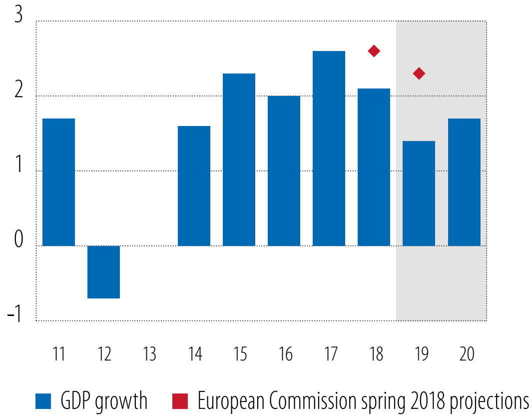
1 Consistently throughout the report, three EU regions are considered: Western and Northern Europe: Austria, Belgium, Denmark, Ireland, Germany, Finland, France, Luxembourg, Netherlands and Sweden; Southern Europe: Cyprus, Greece, Italy, Malta, Spain and Portugal; and Central and Eastern Europe: Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia.

2 This is mostly due to the end of the MFF/reduction in cohesion funds.

Several sources of uncertainty exist: Brexit, the trade wars, tensions in the Middle East and financial stress in emerging markets. For the European Union in particular, the impact of Brexit is a big unknown, especially for the financial system. As shown in Figure 2, uncertainty indicators have increased over the year, globally and in the European Union. After peaking in early 2019, those indicators have receded somewhat.

Figure 1

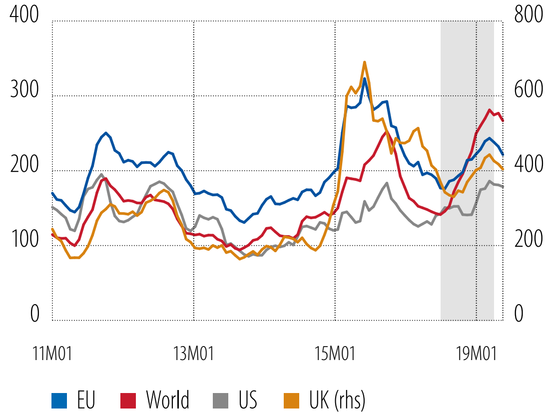
Annual real GDP growth in the EU: history and projections



Source: EIB Economics Department calculations based on Eurostat and European Commission.
Note: The projection refers to the Spring 2019 European Commission forecast. The revisions are calculated as differences compared to the Spring 2018 European Commission forecast.

Figure 2

Estimates of policy uncertainty



Source: Baker, Nicholas, Bloom and Davis at www.PolicyUncertainty.com
Note: Three-month moving average. The grey area represents the period since the cut-off date for the previous Investment Report. A rise in the index reflects increased uncertainty.

Removing undue uncertainty is key to supporting investment and avoiding a major slowdown. In the euro area and in most of the European Union, avoiding a major slowdown is of the utmost importance. Monetary policy is already loose and the fiscal space available to react to a recession is limited. As the EIB Investment Survey shows, uncertainty is one of the major factors impeding investment growth – an assessment shared across most EU economies.[3] The empirical literature agrees that uncertainty is detrimental to activity, and even more so to investment. For instance, Ebeke and Siminitz (2018) focus on trade uncertainty and find that that the investment-to-GDP ratio is on average 0.8 percentage points lower for five quarters following a one standard deviation increase in the level of trade uncertainty.

Inflation remains weak and below-target. Figure 3 depicts the evolution of core inflation in the European Union and the euro area as well as its distribution across EU economies. Over the entire period, inflation dynamics have been similar in the two areas. From 2012 to the beginning of 2015, the annual rate declined from around 2% to below 1%. It then remained almost unchanged until the beginning of 2017. Since then, the inflation rate has remained in a relatively narrow range, below 1.5% in the European Union, and even lower in the euro area.

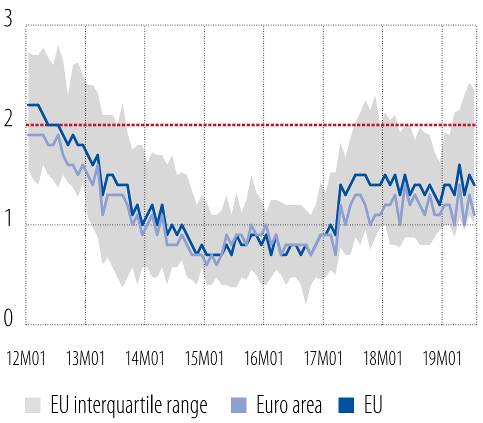
Is the link between inflation and the output gap in the European Union a conundrum? According to economic theory, inflation accelerates with a reduction in the output gap. Figure 4 plots the relationship between annual inflation, measured by the GDP deflator, and output gap estimates, lagged by one year. The period covered is 2001-2018, and the current upturn that started in 2013 is portrayed with

3 See Chapter 1.

red dots (as well as separately in the right hand panel). Since the beginning of 2000, the left-hand panel shows a clear positive relationship, with a 1 percentage point reduction in the output gap accompanied by an increase of 0.4 percentage points in the annual rate of inflation. However, since the beginning of the upturn, the relationship seems to have weakened significantly.[4] Basically, changes in the output gap have hardly affected inflation since the beginning of the latest upturn.

Figure 3

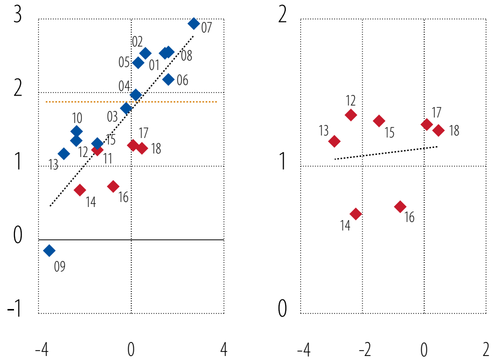
Annual inflation
(consumer price index, excluding energy and unprocessed food, %)



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

Figure 4

Lagged output gap (x-axis, %) **and annual inflation** (y-axis, %)



Source: *EIB Economics Department calculations based on Eurostat and European Commission.*
Note: *Output gap is measured as a percentage of potential output. Inflation refers to GDP deflator.*

Low inflation also persists outside the European Union despite very low unemployment and a closed output gap. Unemployment is around 6% in the European Union, but annual inflation excluding food and unprocessed foods is below 1.5%. Annual Inflation is below 2% in the United States after the longest economic upturn in history over the last century, and in Japan, inflation is slightly above 0.5%. Yet something similar has taken place in some developing countries outside the OECD: inflation has remained low despite the fact that nearly all of these countries escaped the financial crisis. Since many countries have experienced a similar decline in inflation, other global factors must have played an important role in subduing inflation (Jordà et al., 2019).

Monetary policy stance

The balance sheets of major central banks have grown substantially, fuelled by non-standard policy measures. The suspension of the ECB's Asset Purchase Programme (APP) in December 2018 was not accompanied by sharp adjustments in financial markets. Instead, the reinvestment of maturing securities to maintain the size of the ECB's balance sheet is helping to preserve an accommodative monetary stance (Coeuré, 2019). As shown in Figure 5, compared to before the crisis, major central banks' balance sheets have increased significantly. In mid-2019, the ECB and the US Federal Reserve held around EUR 2.2 trillion and EUR 1.9 trillion of government securities, respectively. The tapering started in the United States was suspended in the course of 2019. Quantitative easing policies have sometimes been blamed for

4 Over 2013-2018, the same estimation indicates an elasticity more than ten times lower, and an R-squared of 2%. Obviously, this is an extremely simple relationship. However, the estimation over the entire period indicates an elasticity close to the values reported in the empirical literature (Bobeica and Jarocinski, 2017), and an R-squared of 70%.

contributing to widening wealth inequalities caused by higher asset prices. However, the literature does not provide strong evidence of a significant impact so far (Box A).

With a deposit rate below zero for almost half a decade and a new Targeted Long-Term Refinancing Operation (TLTRO), monetary conditions remain very accommodative.[5] Figure 6 depicts the evolution of short-term monetary policy rates for several major central banks. For all of them except the US Federal Reserve, the rates remain at zero or below.[6] Despite negative interest rates in the euro area, excess liquidity exceeded EUR 1.7 trillion in mid-2019 (ECB, 2019a).[7] The new TLTRO announced in March 2019 will further contribute to increasing liquidity in the overall banking system.

Figure 5
Central banks' balance sheets (% GDP)

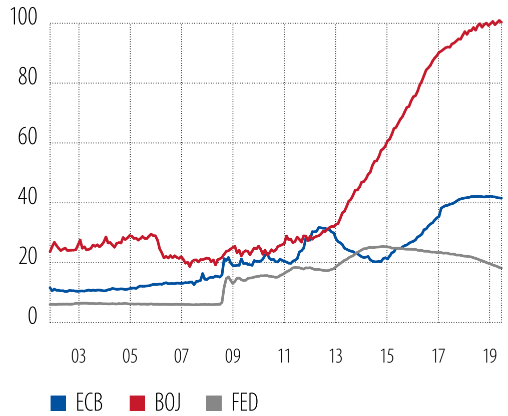
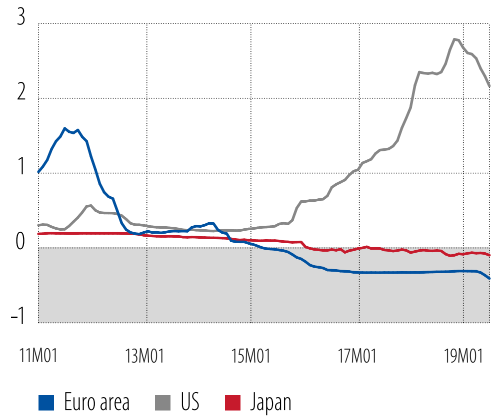


Figure 6
Short-term interest rates (% p.a.)



Source: EIB Economics Department calculations based on Thomson Reuters Datastream.

Throughout the year and on both sides of the Atlantic, monetary policy expectations have reversed and become more dovish, shifting from hikes to cuts. The ECB clarified its exit strategy in June 2018, and the first hikes were expected by mid-2019. More than a year later, as the economy slows down, the ECB has not raised rates but reduced them. In July 2019, the Fed implemented the first cut in its fund rates in more than ten years and shifted its policy stance. The decline came after nine increases in short-term interest rates since December 2015.

Monetary policy is still the only game in town. Very recently, as the signals of a slowdown intensified, major central banks further loosened their monetary stance. The Fed implemented its second consecutive cut in fund rates. The ECB announced a new comprehensive easing package consisting of several measures: a supplementary 10 basis point cut in the deposit facility rate to -0.5%, reinforced forward guidance, a recalibration of TLTRO III, the announcement of the revival of the APP with monthly purchases of EUR 20 billion, and a two-tiered system for reserve remuneration.

5 See Praet et al. (2019) for a long-term perspective on ECB monetary policy since its inception.
6 Denmark's policy rates fell below zero in July 2012. This also happened in the euro area, Sweden, Switzerland and Japan in early 2016.
7 Excess liquidity is defined as all kinds of commercial bank deposits held by the Eurosystem minus the minimum reserve requirements.

Box A

Quantitative easing and wealth inequality: a review of the findings

Central banks focus on delivering low and stable inflation, and this benefits society as a whole. This means that the relationship between monetary policy and inequality has not traditionally been a source of concern. However, more recently, the persistence of low interest rates and the implementation of non-standard monetary policy measures have stoked concerns that these policies favour some segments of society over others. This box reviews recent efforts to understand the distributional aspects of monetary policy and quantitative easing in particular.

The academic literature has identified several channels through which monetary policy affects the distribution of income and wealth (Coibion et al., 2016). The *income composition channel* operates through systematic changes in the relative importance of income sources across the income distribution. In particular, the share of transfer income decreases as household income increases whereas the share of employee and business income increases. In response to an expansionary monetary policy shock, business income tends to rise relative to employee income, contributing to increased income inequality. The *financial segmentation channel* is derived from household heterogeneity in exposure to financial markets. This channel posits that households more exposed to financial markets are in a better position to benefit from asset price changes induced by monetary policy. To the extent that these households are wealthier, an expansionary monetary policy shock increases income and wealth inequality. The *portfolio channel* comes from differences in the composition of household assets and liabilities. If low-income households hold more currency than high-income households do, an expansionary monetary policy shock will, via inflation, increase inequality.

The effect of monetary policy on inequality is unclear. Via the three channels identified above, expansionary monetary policy tends to increase inequality. However, the opposite applies to the following two channels. Through the *savings redistribution channel*, unexpected monetary easing benefits borrowers at the expense of savers. To the extent that borrowers are on average poorer, this reduces inequality. Finally, the *earnings heterogeneity channel* works mainly via transitions into and out of employment. In this case, an expansionary monetary policy shock benefits mainly low-income households, as they are more likely to become employed.

The relationship between monetary policy and inequality can be examined from different angles. First, the analysis can distinguish between standard measures and quantitative easing.[8] Quantitative easing, on the other hand, seeks to affect longer-term rates directly. Second, it is possible to distinguish between income or wealth inequality. While the income composition and earnings heterogeneity channel affect income inequality, the financial segmentation, portfolio, and savings redistribution channel matter for wealth inequality.

To be informative, empirical work has to overcome several challenges. First, it is important to separate the effects of monetary policy from the developments it responds to.[9] Second, when focused on wealth inequality, the empirical work needs adequate measures of household assets and liabilities. Here, surveys such as the Household Finance and Consumption Survey compiled by the Eurosystem are indispensable.

Expansionary monetary policy shocks implemented through standard measures tend to reduce income inequality. Studies for the United States and the euro area find that the earnings heterogeneity channel dominates the income composition channel (Coibion et al., 2017 and Ampudia et al., 2018). Thus, the primary distributional effect of expansionary monetary policy is to help the unemployed find employment. However, while monetary policy can account for part of the cyclical variation in inequality, the effects are small compared to the observed secular increase in inequality.

8 Standard monetary policy works through changes in short-term interest rates and leaves it to market participants to determine long-term rates.
9 In technical terms, monetary policy shocks need to be identified.

Studies of the portfolio channel find that equity price increases benefit mostly the wealthy, while house price increases benefit a broader cross-section of society. Using data from the Household Finance and Consumption Survey, Adam and Tzamourani (2016) look at the distributional consequences of asset price inflation. They simulate the consequences of a 10% increase in bond, equity and house prices. Rising equity prices contribute to inequality, as equity holdings are concentrated among the wealthy. The benefits of rising house prices, on the other hand, are more widely spread, because real estate accounts for a significant share of middle-class wealth. Rising bond prices have negligible distributional consequences. The distributional implications of house price increases vary across euro area countries depending on the rate of home ownership among low-wealth households. Whereas in Finland, the Netherlands, Portugal, and Spain, low-wealth households derive significant benefit from house price increases, this does not apply to Austria, Germany, France, Italy and Malta. Domanski et al. (2016) find that wealthier households obtain on average higher asset returns, resulting in increased inequality since the financial crisis in a majority of countries.

Quantitative easing tends to have a limited impact on wealth inequality. A limitation of these studies is that they cannot directly link asset price increases to quantitative easing. Slacalek and Lenza (2018) use a two-step procedure to estimate the effect of quantitative easing on income and wealth inequality. First, they estimate country-specific Vector Auto Regressive models (VARs) for the four largest euro area economies. They thereby obtain the impact of quantitative easing on interest rates, wages, house prices and unemployment. Then they allocate the aggregate impact to individual households based on data from the Household Finance and Consumption Survey. They observe that quantitative easing temporarily raises the value of publicly traded and private equity. However, the overall impact is driven by housing wealth, which reflects the high share of real estate in household portfolios.

Financial conditions and long-term interest rates

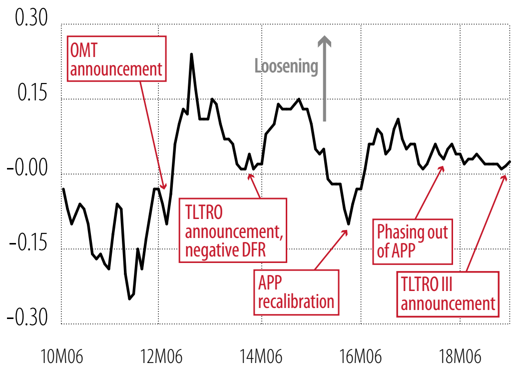
After removing the impact of monetary policy and after controlling for real macro-economic momentum, financial conditions remain accommodative, thereby supporting activity. According to the estimates reported in Figure 7, financing conditions remain loose in the European Union.[10] From a longer-term perspective, financial conditions have stayed accommodative almost continuously since the beginning of 2013. They have helped to support lending, activity and investment.

Side effects of these very accommodative conditions have also materialised along with increased financial risks. With investors searching for yields, asset price increases have been substantial, particularly for residential and commercial property prices but also for stocks. At the same time, high corporate debt purchases across the risk spectrum have compressed risk premiums. Looking forward, the launch of a new Targeted Long-Term Refinancing Operation, TLTRO, will likely be accompanied by a further loosening of financial conditions.[11]

10 The financial condition indicator is the common component of a large set of series on quantities and financial costs related to EU economies and available monthly. Firstly, the series are filtered from their reaction to monetary policy and activity. Secondly, principal component analysis is used to summarise the information contained in the dataset (Darracq-Pariès et al., 2014). The index is dimensionless, of zero mean over March 2003-June 2019.

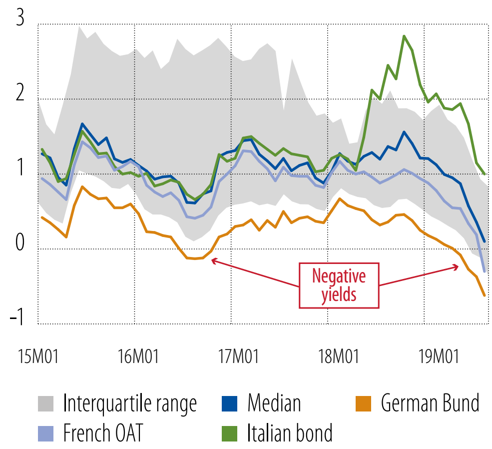
11 The last record in Figure 7 refers to April 2019. TLTRO III was announced in March 2019 with the first wave launched in September 2019.

Figure 7
Financing conditions index



Source: EIB Economics Department calculations based on Darracq-Pariès, Maurin, Moccero (2014).
Note: See footnote 10.

Figure 8
Long-term government bond yields in the EU (10 years, % per annum)



Source: EIB Economics Department calculations based on Thomson Reuters Datastream.

The EU economy has re-entered a period of negative long-term yields. Long-term yields went back into negative territory in the second quarter of 2019. On average, they declined by almost 100 basis points across the European Union in the year up to the third quarter of 2019. At ten years maturity, the yields on the German Bund and the French government bonds dropped to record lows in August 2019 (-62 bps and -30 bps, respectively). These returns are more than 40 basis points below the minimum yields previously recorded in the summer of 2016. Escaping the low rate environment may take longer than previously anticipated as expectations of rate hikes have disappeared along with the economic slowdown.

Beyond the ultra-low level of monetary policy rates and the impact of quantitative easing, negative long-term yields for highly rated sovereign bonds reflect the scarcity of safe assets in Europe (Caballero et al., 2016). The current situation illustrates, once again, the need for a large pool of safe assets in Europe, especially the euro area.[12] For many participants in the financial sector, it is necessary to hold highly rated sovereign securities. They are very liquid, not capital-intensive and can be posted as collateral without being discounted with a large haircut. Moreover, the demand for safer assets may have increased along with uncertainty (Figure 2). Conversely, the relative supply of highly rated debt has declined and more than 20% of the stock of euro area sovereign debt securities has been removed from the market owing to the ECB's asset purchases. These contrasted movements inflate the price of safe assets and cause returns to deteriorate.

Financial risks – an increasing source of concern

The regulatory changes connected with the post-Basel III reforms have strengthened the financial sector, and banks even more. Most analyses concur to suggest that the many items of regulation introduced since the crisis (for example, MIFID, EMIR, CRR and CRDIV, and BRRD) have increased the resilience of the EU banking sector (Bolton et al., 2019, EC, 2019, FSB, 2019). For banks, the unprecedented capital increase driven by more stringent regulation introduced after the financial crisis has been a major component – costly for the economy in the short term, but beneficial in the long term (Budnik et al., 2019, Kanngiesser et al., 2019). Gambacorta and Shin (2016) show that well-capitalised banks absorb adverse shocks better, financing investment and raising long-term growth rates.

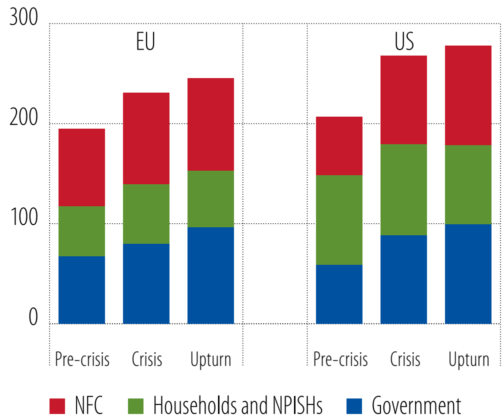
12 See Box D for a parallel discussion on risk sharing.

The broad agenda set by the international community has given rise to new standards that have contributed to a more resilient financial system: one that is less leveraged, more liquid, and better and more intensively supervised, especially at large banks (IMF, 2018). The forms of shadow banking more closely related to the global financial crisis have been curtailed, and most countries now have macro prudential authorities and some tools with which to oversee and contain risks to the whole financial system (FSB, 2018).

But risks remain high (IMF, 2019). Higher indebtedness – especially for national governments – is a legacy of the crisis. Figure 9 compares the evolution of non-financial sector indebtedness in the European Union and the United States since before the crisis. It shows a continuous increase in debt, accelerated for national governments during the crisis. Yet, in Europe, indebtedness ratios remain below those in the United States (US debt rose strongly during the crisis). Indebtedness is also unevenly distributed across EU regions: the share of sovereign debt held by the non-financial sector is somewhat higher in Southern Europe, while sovereign debt accounts for almost all indebtedness in Central and Eastern Europe.

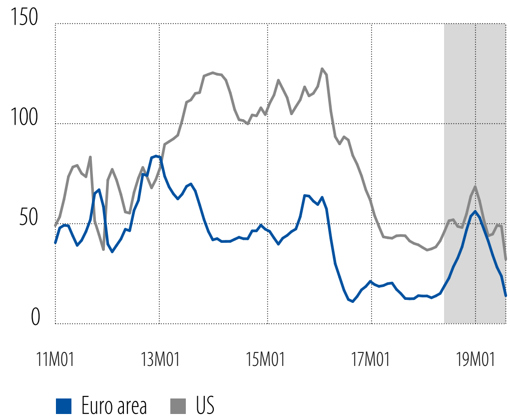
Risk spreads remain compressed even after the termination of the Asset Purchase Programme (APP). Figure 10 indicates that after a sharp rise at the turn of 2018, risk spreads narrowed. In the third quarter of 2019, they are almost where they were one year before. On the one hand, this indicates a smooth termination of the policy support as fears of a disruptive end to the APP have not materialised. On the other hand, compressed risk spreads are symptomatic of the low-rate environment that pushes investors to search for yields. In such an environment, abundant liquidity may distort the pricing of risk, which tends to be undervalued. Rebalancing or increased risk aversion can then result in a sharp deterioration in the value of risky assets and reduce the solvency of investors holding these assets. Given that the economy is well advanced in the economic and financial cycle, these risks are genuine (IMF, 2019).

Figure 9
Non-financial sector indebtedness
(% of GDP)



Source: *EIB Economics Department calculations based on Bank for International Settlements (BIS).*
Note: *NPISHs: Non-profit institutions serving households.*

Figure 10
Risk spreads
(BBB-A, 5 years, % per annum)

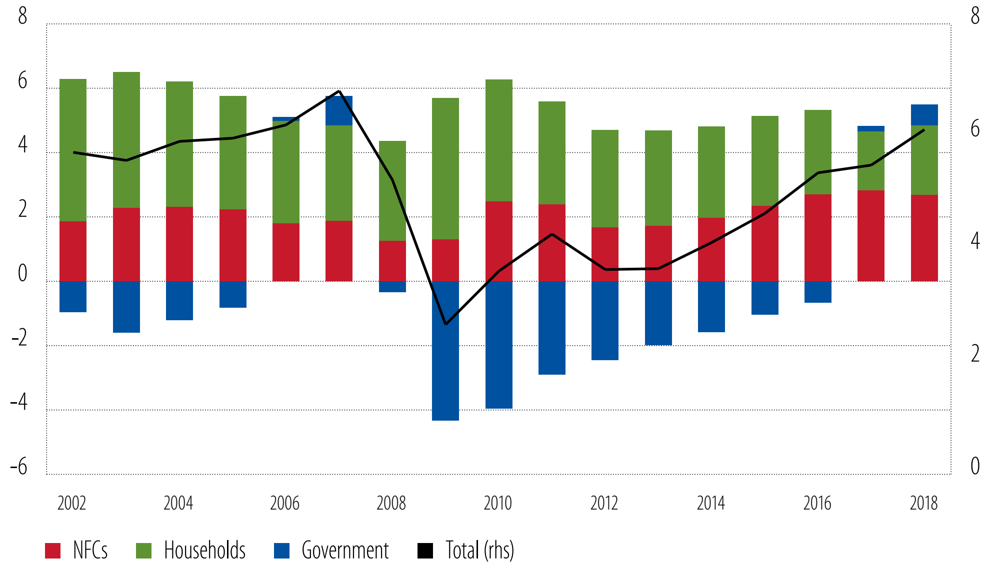


Source: *EIB Economics Department calculations based on Thomson Reuters Datastream.*

The structure of the financial system in the European Union and its regions

As shown by the increasing current account surplus, net savings in the European Union are substantial. The development of domestic financial systems is uneven, with a higher level of development in more advanced economies. Despite limited progress achieved since before the crisis, savings still do not finance corporate investment easily, especially long-term and innovative investment.

Figure 11
EU net savings by main institutional sector (% GDP)



Source: EIB Economics Department calculations based on Eurostat.

Since the early 2000s, the EU economy has been accumulating net savings (Figure 11). Since the beginning of the upturn, businesses have increased their contribution, while historically households were the main provider of financing to the economy, both internally and to the rest of the world. As governments restored their finances after the crisis, they required less of these savings. Overall, the domestic net saving balance has increased and is exported through cross-border financial flows. This peculiar situation needs to be understood when examining the investment opportunities in the European Union.

European savings feature high levels of cash and deposits, explaining the dominant position of banks in the EU financial system and low equity and market debt investment. Banks may not be the most efficient instrument for recycling household savings. On the one hand, financial stability and the protection of savers act as a burden on banks' ability to transform credit lengths and to manage liquidity risks. On the other hand, banks are consolidating and face enhanced competition from Fintechs.

As more patient investors, pension funds, insurance and investment funds should play a larger role in ensuring the circulation of savings in Europe. But they are affected by specific regulations impeding their capacity to finance long-term, innovative and more risky projects. Investment funds are underdeveloped and typically smaller and more costly than in other developed economies. Finally, private equity and venture capital remain structurally fragmented and overall too small in Europe.

Household savings in relation to the domestic financial sector

The financial wealth of households – the main net savers in the economy – has increased since the crisis. From 2005-2008 until 2013-2018, EU households' financial wealth increased from 1.9x to 2x GDP, an increase shared by all EU economies except Italy and Romania. Household financial wealth differs across EU economies, as measured as a ratio to GDP, and ranges from less than 1x GDP in most Central and Eastern European economies to more than 2.5x in several Northern and Western European economies (Figure 12). If anything, since the crisis, the ratio of household financial wealth as a share of GDP has slightly increased. Overall, financial wealth as a share of GDP tends to be larger in countries with more advanced economies.

Due to leverage, the unconsolidated assets of the financial sector are more than three times larger than the value of financial wealth held by households. Across EU economies, there seems to be a robust relationship between local household financial wealth and the size of the financial sector. As shown in Figure 12, the higher the financial wealth, the more developed the financial sector (this very simple relationship displays an R-squared of 79%).

To some extent, the correlation between financial wealth and the size of the financial sector shows a preference for the domestic financial sector. This feature partly reflects the impact of regulation but also entrenched habits and a preference for keeping money at home.[13] If anything, compared to before the crisis, the link between household financial wealth and the size of the domestic financial sector has increased, both in terms of intensity and magnitude. This suggests a retrenchment of savings from cross-border exposure, and less circulation of capital within the European Union.[14] The intermediation of savings is mostly dispersed across EU economies and takes place at a national level. Apart from very specific cases, there is no clear specialisation of some economies in intermediating the savings of Europeans.

Economies with a larger financial system have recorded a quicker rebound in investment. Figure 13 plots the change in the investment share since the crisis in relation to the average size of the financial sector across EU economies. The change in the investment share is measured as corporate investment to GDP in nominal terms during the upturn compared to the pre-crisis period. The investment share is pro-cyclical: in downturns, investment grows more slowly than output while in upturns, it grows at a faster pace. Furthermore, it remains constant on average over cycles. Following the crisis, the rebound in investment was quicker in economies with a larger financial system (Figure 13), either because the decline was not as pronounced or because the recovery was stronger. The increasing relationship depicted in Figure 13 therefore suggests that a larger financial system can support a faster recovery in investment, or a less pronounced fall in capital expenditure. This implies that a larger and more developed financial sector helps to dampen the magnitude of business cycles.

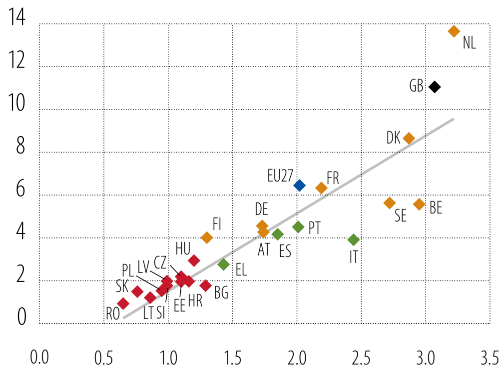
As a percentage of GDP, households´ financial wealth is similar in Southern Europe and Western and Northern Europe but the ratio declines in Central and Eastern Europe. Figure 14 shows the share of the assets held by the three regions as well as in the United States. Since 2005, household financial wealth has shifted from 1.9x to 2.1x GDP in Western and Northern as well as in Southern Europe. In Southern Europe, the ratio fell during the crisis as these economies were hit more severely and asset prices declined strongly. In comparison, in the United States, household financial wealth is much higher and has increased more as a multiple of GDP, from 3.4x to 4.5x.

13 See below, the section on cross-border capital flows and financial integration.

14 The standard deviation of households' financial wealth as a share of GDP rose from 0.7 in 2005-2008 to 0.8 in 2013-2018.

Figure 12

Financial assets as ratios to GDP: households (x-axis) **and financial sector** (y-axis)

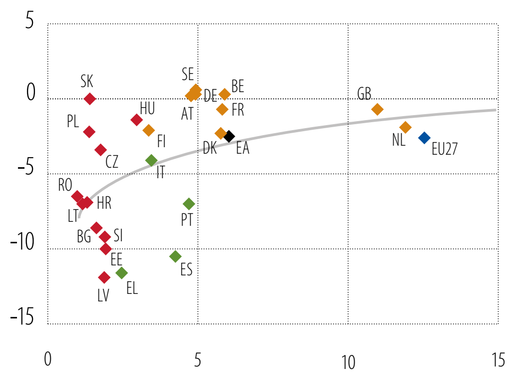


Source: *EIB Economics Department calculations based on Eurostat.*

Note: *Based on non-consolidated accounts. Average over 2013:Q1-2018:Q4. Luxembourg, Ireland, Malta and Cyprus omitted.*

Figure 13

Size of the financial sector (x-axis, % GDP) **and change in the investment share** (y-axis, in p.p.)



Source: *EIB Economics Department calculations based on Eurostat.*

Note: *Change in the investment share from before the crisis (2005:Q1-2008:Q3) to the upturn (2013:Q1-2018:Q4).*

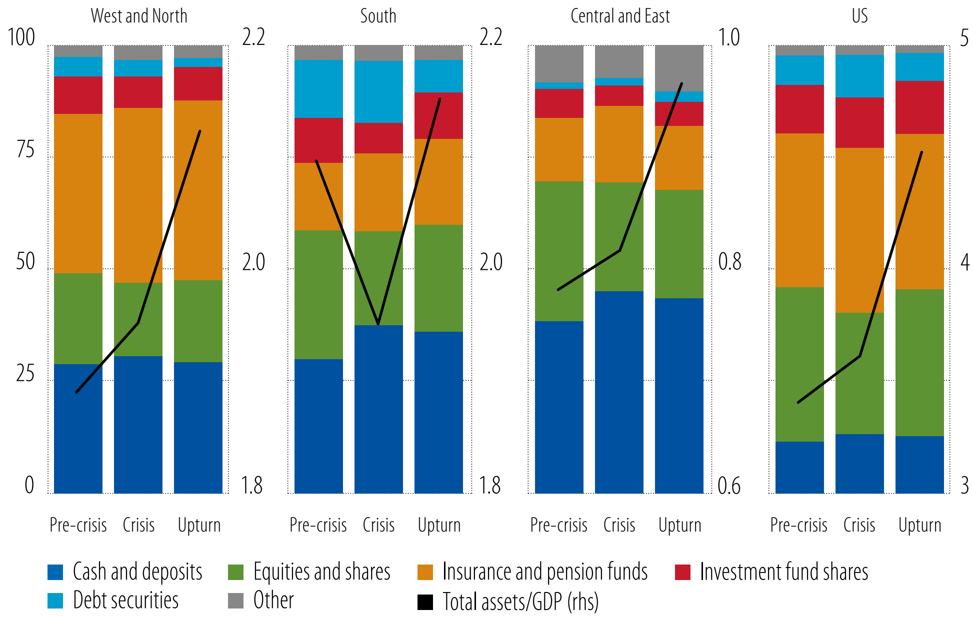
European households favour cash and deposits at the expense of equities. Compared to the United States, the biggest differences in household financial wealth can be seen in cash and deposits as well as in equity and debt security holdings (Figure 14). On the one hand, cash and bank deposits amount to 30% of total EU household assets, compared to 12% in the United States. On the other hand, equity and debt securities in Europe account for 21% of wealth, compared to 41% in the United States. The risk aversion of European households, the cultural habit of allocating savings to banks and other differences between the two regions (e.g. tax treatment, financial development and bank credit policies) are the main factors. Figure 14 suggests that these patterns have not changed much since the crisis.

The composition of household financial wealth varies largely across EU regions. Figure 14 shows the share of assets held by the three regions, comparing them to the United States. In Western and Northern Europe, households hold fewer equities and debt securities and more cash and deposits as well as money in insurance and pension funds. The differences appear to be more pronounced in Southern Europe, where cash holdings are even bigger. Debt securities represent a larger share in this region, however.[15] Finally, in Central and Eastern Europe, cash and deposits account for 44% of household financial wealth, close to four times more than in the United States. There, as well as in Southern Europe, the share of cash and deposits has increased since the crisis.

Despite the increase in EU households' financial assets since 2003, retail investments channelled through capital markets, such as equity investments and debt securities, continue to represent only a small part of household financial wealth. The main drivers behind the increase in financial wealth are cash and deposit holdings and investment in insurance and pension funds (their shares have seen an increase of 2 percentage points and 5 percentage points, respectively). Over the same period, the share of market securities changed by around 20 percentage points.

15 This striking feature reflects the impact of Italy, where households invest a large part of their portfolio in direct holdings of domestic sovereign bonds.

Figure 14
Households´ financial wealth: Composition (%, lhs) **and ratio to GDP** (rhs)



Source: *EIB Economics Department calculations based on Eurostat and OECD.*
Note: *Average over periods. The pre-crisis, crisis and upturn periods respectively refer to 2005:Q1-2008:Q3, 2008:Q4-2012:Q4 and 2013:Q1-2018:Q4.*

The prominent role of banks

Financial systems can be bank-based or market-based, depending on the country. Allen et al. (2017) show that financial intermediaries and markets can alleviate market friction by producing information and sharing risks in different ways. The financial structure's influence on economic growth depends on the overall development of the real economy and the country's institutions. These associations change during a period of crisis. Market-based systems tend to have be more advantageous for financially dependent industries in good times but are a disadvantage in bad times.

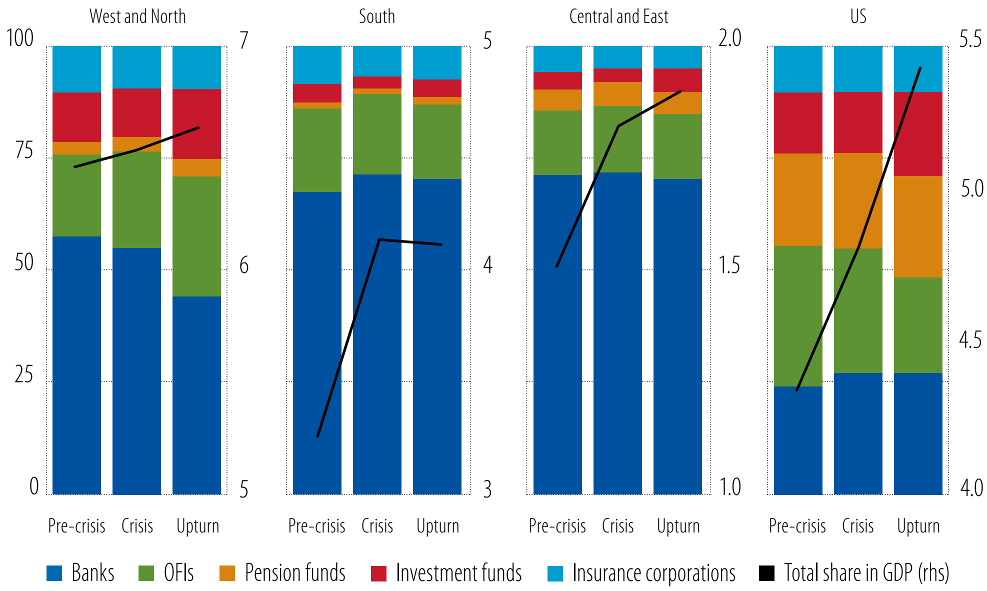
The literature comparing bank and capital market financing is inconclusive for developed economies. Some studies highlight the irrelevance of whether the financial system is based more on banks or capital markets to the growth of an economy (Levine, 2005), while others conclude that more highly intermediated financial systems are associated with less dynamic growth (Langfield and Pagano, 2014). Indeed, the relationship is conditional on many factors, which cannot be incorporated simultaneously into the estimation of the relationship between the structure of the financial system and economic growth, owing to a lack of observations.

In the European Union, banks remains the largest pillar of the financial system. In Figure 15, the European Union is compared to the United States. The large share of cash and deposits at banks underpins their importance in the financial sector. Banks' higher share of those deposits in Southern and Central and Eastern European regions give them an even more prominent role. If anything, in these regions, banks' dominance has increased since before the crisis. Conversely, banks lost ground in Western and Northern Europe, with their share declining by 15 percentage points, from 60% before the crisis to 45% in the upturn.

Banks account for a larger share of investments as households' preference for cash and deposits increases. Banks are by far the first supplier of such products in the financial system. The shape of the financial system is to some extent defined by households' financial preferences. In Southern, Central and Eastern Europe, where cash is preferred, the financial system is even more bank-based.

Conversely, investment funds are only important in Western and Northern Europe, where they represent around 10% household wealth. In Southern, Central and Eastern Europe, the share is well below 5%. Only Western and Northern Europe is on a par with the United States regarding the development of the investment fund sector.

Figure 15
Institutional breakdown of the financial sector (%, lhs)



Source: EIB Economics Department calculations based on Eurostat and OECD.

The EU banking sector has been consolidating, especially in Southern Europe. Banking sector consolidation is two-sided (Nouy, 2017). On the one hand, it increases productivity, reduces costs and is therefore beneficial to the economy. On the other hand, it concentrates risk by making large banks even bigger. As shown in Figure 16, since 2003 the number of banks in the European Union has dramatically decreased (by around one-third), a reduction mostly accounted for by Western, Northern, and Southern Europe.[16] As the market consolidated, many banks closed.

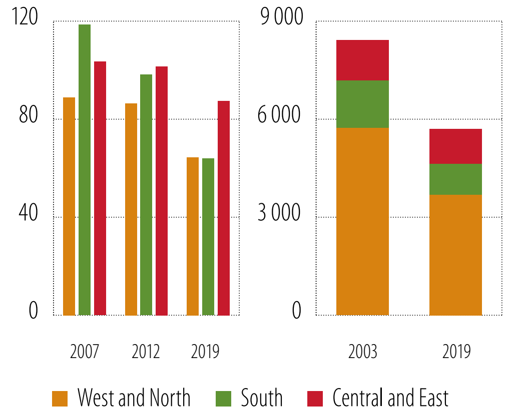
Mergers and acquisitions (M&As) in the banking sector have remained rare, particularly since the crisis. The few M&As seen were mostly between banks within the same jurisdiction (Duijm, P. and Schoenmaker, D. 2018). Besides purchases of Portuguese banks by Spanish banks, no major cross-border M&As have taken place in the European Union over the last ten years. Cross-border M&As favour geographical diversification, fostering risk sharing and reducing banks' overall risk by reducing geographical concentration. From 2014 to 2018, the total assets of EU credit institution subsidiaries outside the country of their parent bank declined from 26% to 17% of euro area GDP and from 33% to 23% of EU GDP.[17] These changes suggest that EU banks are withdrawing from cross-border operations.

16 ECB (2019) provides, for most EU economies, the Herfindahl index of the total assets of the five top banks. Averaging across countries with GDP weights, we find that from 2014 to 2018, the index has increased by 6% in the European Union, mostly owing to Southern (+27%) and Central and Eastern Europe (+11%).

17 From ECB (2019), total assets of EU credit institution subsidiaries outside the country of their parent bank, excluding the United Kingdom. Over the same period, the share of total assets of non-EU credit institution subsidiaries in GDP remained stable, at 6% in the euro area and 12% in the European Union.

Figure 16

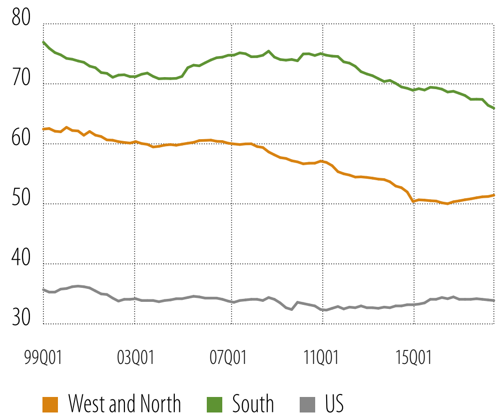
Number of monetary and financial institutions (lhs, as index, 2003=100 and rhs, number of entities)



Source: EIB Economics Department calculations based on ECB.

Figure 17

Banks' share of credits to the non-financial private sector (%)



Source: EIB Economics Department calculations based on Bank for International Settlements (BIS) data.

Regulation, a low interest risk environment and trends like Fintech are pushing consolidation. Bank returns remain low after several years of negative short-term rates and a very flat term structure.[18] Despite being stronger, the EU banking sector faces many challenges, such as adjusting to digitalisation to better compete with Fintechs (Petralia et al., 2019), which are becoming increasingly relevant (Box B). Since the return on equity is below the cost of equity, raising capital to support development and invest in digital systems is difficult. This challenging environment is reflected in slumping valuations: banks price-to-book ratios are well below 1 and only marginally higher than at their low levels during the sovereign debt crisis at the beginning of 2011.

The EU financial system has continued to expand, supported by a strong contribution from non-banks. Figure 17 reports the share of credits to the non-financial private sector provided by banks, both in Western and Northern and in Southern Europe. In both cases, the share of banks has declined, as the share of non-bank lending to the private sector has increased. Non-banking lending includes insurers, pension funds and other financial intermediaries (OFIs). The presence of other sources of finance bodes well for the EU economy because non-bank finance can replace traditional sources when needed – sort of a spare tyre (Signorini, 2019, Levine et al., 2016).

The EU financial sector remains much more bank-based than in the United States, despite a reduction in the gap. Figure 17 shows that the share of banks in the United States has hardly changed, and remains well below the level in Western and Northern and Southern Europe (around half that of Southern Europe).[19] Interestingly, the role of banks in Southern Europe is more developed, with a difference of around 15 percentage points. If anything, the gap has increased since the beginning of the 2000s, as banks' share in Western and Northern Europe declined more quickly.

18 Banks tend to finance their activities with liabilities of shorter maturity than the assets they are investing in. As a result, after controlling for banks and macroeconomic factors, bank returns are generally found to be positively affected by the slope of the yield curve.

19 It should be noted that the reported statistics probably overestimate the gap. They are based on credits to the non-financial private sector that include mortgages, which in the United States are originated by banks. The credits are then sold and removed from bank balance sheets to a large extent, often to government sponsored entities such as Freddie Mac and Fanny Mae, thereby reducing the weight of banks in these statistics. The breakdown of the non-financial private sector into credits to non-financial corporations and households is not available from the source used to compile the figure.

Box B

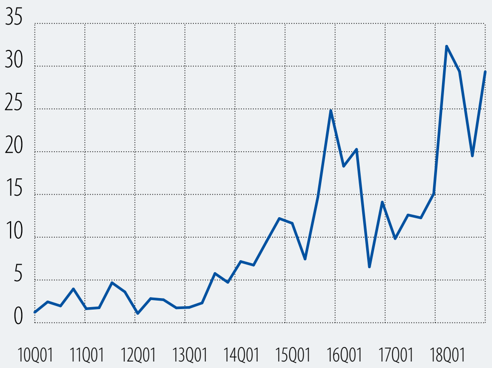
The integration of Fintechs into the financial system

During 2018, the global Fintech market continued to grow at an exponential rate (Figure B.1). Despite a small dip in the third quarter, Fintech investments more than doubled in 2018, reaching EUR 110 billion of investments. From 2010 to 2018, investments in Fintech companies occurred mainly in M&A, accounting for 40% of overall investments, followed by private equity (35%) and venture capital (25%). The bulk of investments flowed to US-based companies, with the European Union receiving only 23% (Figure B.2). In recent years, the Asian market has become more important at the expense of the EU's market share (Kraemer-Eis et al., 2018).

While Fintechs are often start-up companies, recent years have seen the emergence of Fintech giants – established technological market players ("big techs") such as Amazon and PayPal, which are positioning themselves to be dominant players in the financial services industry. For example, Amazon has not only been building impressive payment infrastructure (e.g. Amazon Pay, Amazon Cash), but "from payments to lending to insurance to checking accounts, Amazon is attacking financial services from every angle without applying to be a conventional bank" (CB Insights, 2018). Other US examples are PayPal (which recently launched a small business lending initiative), Google, eBay and Apple. Examples from China include Alibaba, Baidu and Tencent.

Figure B.1

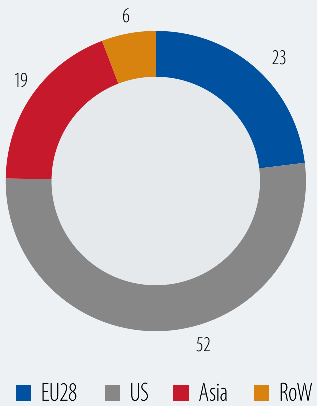
Global investments in Fintech companies 2010-2018 (EUR billion)



Source: *European Small Business Finance Outlook (ESBFO) based on PitchBook data.*
Note: *Sum of M&A, VC and PE investments*

Figure B.2

Geographical breakdown of Fintech investment (%)



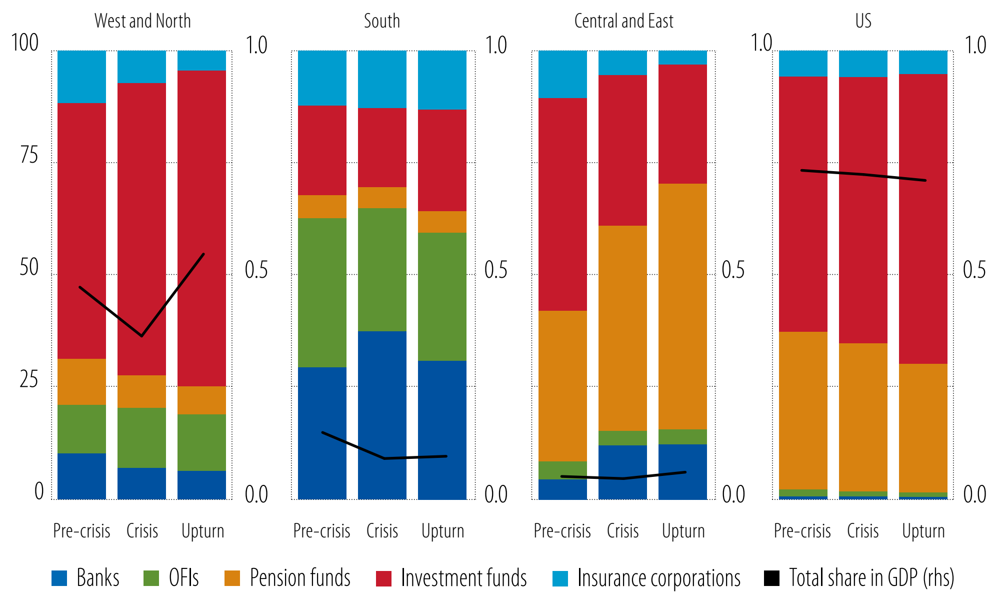
Source: *ESBFO based on PitchBook data.*
Note: *Average over 2010-2018.*

Unlike smaller Fintechs, these giants can compete with incumbents on a much larger scale, combining big data with technology, and posing a new disruptive threat in an ever-changing financial market. Their entry into financial services can lead to efficiency gains and improved financial inclusion, but also presents challenges as regards financial stability, data protection and competition. In this context, it is important to improve data collection and ensure a level playing field between incumbent firms, big techs and Fintech start-ups (BIS, 2019 and Buch, 2019).

Equity holdings

The importance of listed equities varies for different EU regions,[20] ranging from 5% to 55% of GDP (below the 75% recorded for the United States). Household equity holdings are only significant in Western and Northern Europe, and are below 10% of GDP in both Southern and Central and Eastern Europe. In these two regions, the share has remained almost unchanged for more than ten years while it has doubled in Western and Northern Europe.

Figure 18
Who holds listed equities? Composition (%, lhs) **and ratio to GDP** (rhs)



Source: *EIB Economics Department calculations based on Eurostat and OECD.*
Note *Based on non-consolidated data.*

The level of listed equity holdings in the European Union is well below that of the United States, especially in Central and Eastern and Southern Europe. As shown in Figure 18, listed equity holdings average 72% of GDP in the United States, and 46%, 11% and 5% respectively in Western and Northern, Southern, and Central and Eastern Europe. In terms of holding structure, the differences are also very pronounced in Southern and Central and Eastern Europe, where investment funds are much smaller and banks are more present.[21] The picture in Western and Northern Europe resembles that in the United States, although the larger role of banks and other financial institutions compensates for the smaller role of pension funds.

The structure of the financial sector contributes to determining the level of equity holdings. Investment funds are the main holders of equities in the United States and in Western and Northern Europe. Pension funds are second in the United States and at a very low level in most of the European Union, except in Central and Eastern Europe. The underdevelopment of pension funds in Europe, where most pension schemes are based on a pay-as-you-go system, may also explain the underdevelopment of listed equities.

Investment funds are essential conduits for channelling household savings to capital markets. As shown in Figure 18, investment funds are the biggest holder of equities across institution types. However, the market remains fragmented, so that economies of scale cannot be reached and transaction costs are

20 See EIB (2018) for a comprehensive analysis of the benefits of a stronger equity base.
21 Data are unconsolidated, meaning the portion of equities held by banks also reflects cross-participation within the banking sector.

elevated. The recently adopted Personal European Pension Product may change this in the long term, as it creates a large-scale portable long-term savings product (Lannoo and Thomadakis, 2019).

The number of exchange traded funds (ETFs) is not proportionate to the size of listed equities markets in the European Union. Figure 19 shows the fund industry relative to the size of the listed equity markets in the world's four largest economies: the European Union, the United States, China and Japan. Figure 19 clearly indicates that the average size of ETFs is comparable to that of listed company shares, except in the European Union, where it is well below. While there are three-and-a-half times more ETFs in the European Union than in the United States, their total turnover represents only 7% of that of their US peers. Consequently, on average, ETFs in the European Union are close to 25 times smaller than their US counterparts.[22]

Fees and costs charged to investors are relatively high in the European Union, with expenses, sales and redemption fees before inflation resulting in an average reduction in fund returns of around 20%. This figure can reach up to 31% and exceeds 25% in five out of 14 EU countries. At the lower-end of this scale are Denmark, the Netherlands, Sweden and the United Kingdom, with reductions of less than 15% (Hespeler, 2017).

Figure 19

Number and size of exchange traded funds and listed equities

(lhs = millions, rhs = number of)

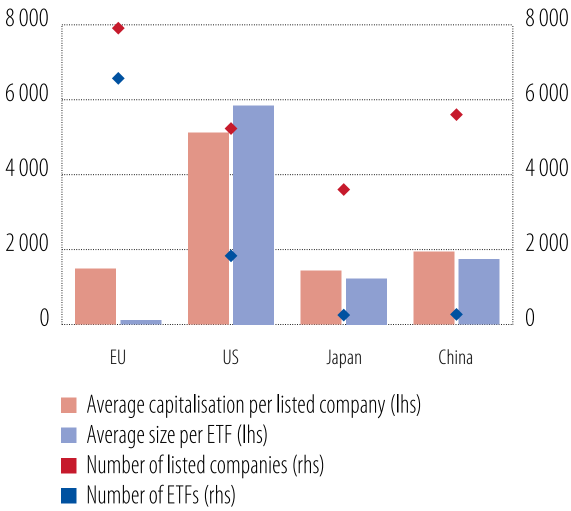
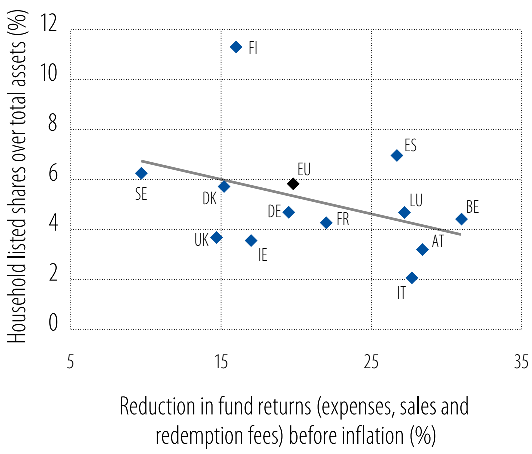


Figure 20

Household savings allocations and fees collected by investment funds



Source: EIB Economics Department calculations based on European Securities and Markets Authority (ESMA), Centre for European Policy Studies (CEPS) and Eurostat.

The largest listed equity portfolios are located in less expensive areas. Figure 20 plots the relationship between the share of households' equity holdings – direct and indirect – in total financial wealth and the reduction in fund returns (for the EU economies for which information is available). One can observe a decreasing relationship, also supported by a simple cross sectional regression.

A simple estimation indicates that each percentage point increase in fund costs is associated with a reduction of one-seventh in the share of financial wealth households allocate to equity holdings. There is, however, a "chicken-and-egg" dimension to this relationship, which may not be causal as lower equity holding by households may prevent them from efficiently amortising the costs of analysing

22 See Tomadakis (2018) for an explanation of these differences.

information and may result in higher fund costs. Less turnover may increase liquidity premiums and reduce the base for amortising information and IT costs. Consolidation may cut costs and therefore foster equity holding by households.

Savings allocation and the design of the financial system may not best support investment. The financial system's structure and households' preferred habits interact to provide financing to the economy. The amount of savings placed in cash holdings and deposits contributes to maintaining the dominant position of banks in the EU financial system. Banks perform maturity transformation and manage liquidity risk, recycling these savings and financing capital expenditure. However, various factors – such as rules to guarantee financial stability and protect household savings – impede or limit this transformation.

To better support investment and further innovation and technological changes, businesses need more long-term funding and a higher appetite for risk. This can be provided by long-term investors, such as pension funds and insurers, as well as, for smaller companies, private equity and venture capital investors.

Private equity and venture capital[23]

Private equity is a form of equity investment in private companies not listed on the stock exchange.[24] It is a medium to long-term investment characterised by active ownership, for example by strengthening management expertise, delivering operational improvements and helping companies to access new markets. Venture capital is a type of private equity focused on start-up companies with high growth potential. Venture capital assists entrepreneurs with innovative ideas who need investment and expertise to help grow their companies.

Over the past 20 years, European private equity activity has seen booms and busts. In 2018, fundraising and investment approached record levels. At their most famous peaks – in 2000 and 2006 – private equity funds located in Europe raised EUR 48 billion and EUR 112 billion, respectively, and invested EUR 35 billion and EUR 71 billion (Figure 21).[25] The peaks were followed by significant downturns: the dotcom crisis in the early 2000s and the financial and economic crisis from 2007. In 2018, the total funds raised by private equity firms located in Europe rose to EUR 97 billion, a slight increase of 1% from the previous year. This is the highest level since 2006. During 2018, private equity funds located in Europe invested EUR 80 billion (up 5% compared to the year before). When divestments are included, the total declines to EUR 32 billion (up 28%).[26]

The European venture capital market remains fragmented and is far less geographically homogeneous than its US counterpart. Figure 22 provides an overview of venture capital investments as a share of GDP for European and selected OECD countries, as well as the European average. In all EU economies, venture capital investments are well below those in the United States. While the traditional core markets in Europe (e.g. the United Kingdom and Scandinavia) have maintained relatively well developed market activity since the crisis, only a few markets, like Spain, have caught up. However, in total, the EU venture capital market is one-seventh the size of the US market. EU markets suffer not only from their small size but also from an institutional investor base that is not sufficiently ready to invest in this asset class (Kraemer-Eis et al., 2019).

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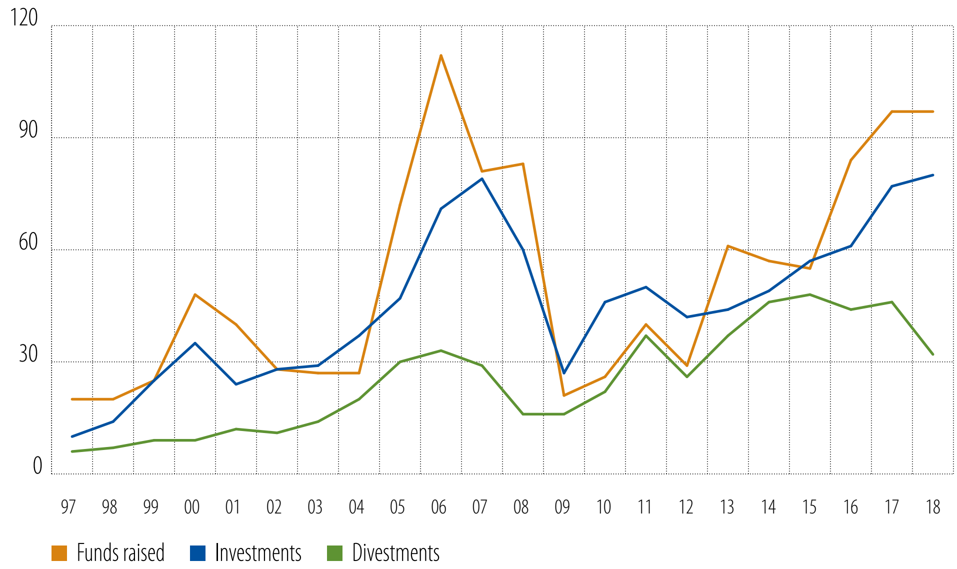
23 Large parts of this section are based on Kraemer-Eis et al. (2019), i.e. the latest issue of EIF's European Small Business Finance Outlook (ESBFO). The ESBFO is published twice per year (typically in June and December) and provides an overview of small business financing in Europe.

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

25 These figures and those that follow are based on statistics from Invest Europe, the association representing Europe's private equity, venture capital and infrastructure sectors, as well as their investors. See Invest Europe. (2019), the Invest Europe website (www.investeurope.eu) and Kraemer-Eis et al. (2019) for more information on Invest Europe private equity activity statistics.

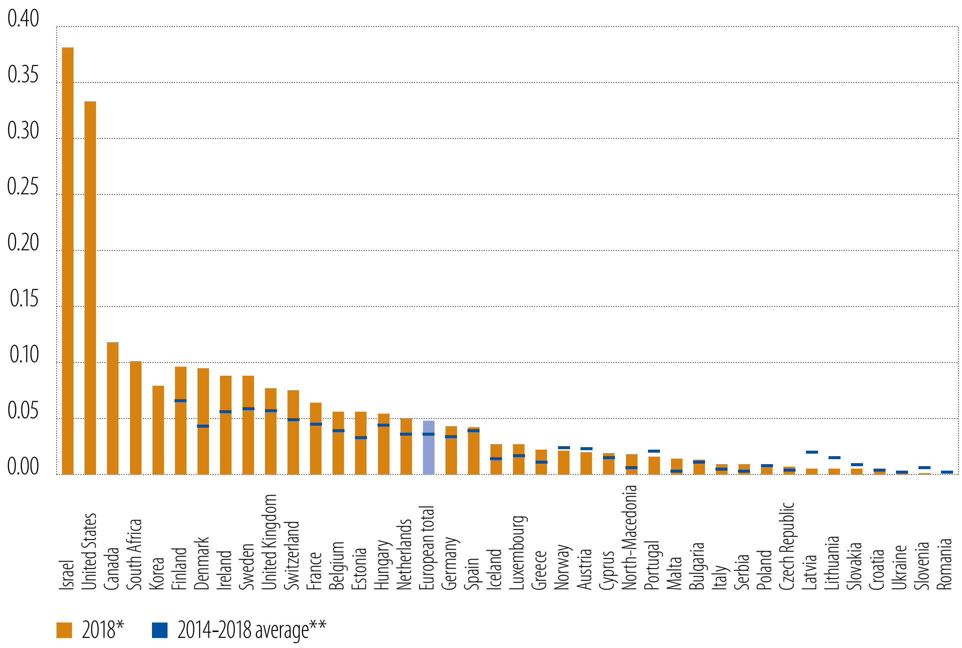
26 Invest Europe statistics show divestment amounts at cost, that is, the total amount divested is shown as the total amount that had been previously invested, and does not include any profit on the investment.

Figure 21
Fundraising, investment and divestment amounts by private equity firms located in Europe (EUR billion)



Source: *European Small Business Finance Outlook (ESBFO), based on data from Invest Europe.*

Figure 22
Venture capital investments by country of the portfolio company (% of GDP, 2018 or latest available year)



Source: *ESBFO, based on Invest Europe and OECD (2018).*
Note: *European total corresponds to Europe as covered by Invest Europe (i.e. European Union minus Cyprus and Malta, but plus Norway, Switzerland, Ukraine, and the former Yugoslavian countries that are not part of the European Union). See OECD (2017) for an overview of the international comparability of venture capital data.*

In the European Union, venture capital investors tend to target tech hubs rather than regions and it is difficult to interpret differences in the investment rate across countries. Looking at the geographic dispersion of European venture capital activity in more detail, the picture becomes more complex. European hubs are at the core of a complex network of national and international investments. Data on investment amounts show that 23% of these investments remain in the hub, 40% reach out to other in-country locations and the remaining 37% travel beyond the national frontier (Kraemer-Eis et al., 2016). Another reason for improved cross-border investments is that the main hubs have attracted talents from different countries who retain links to their home countries and in turn attract additional human capital and/or companies to the various hubs. This provides insight for more cross-border activities and fosters an international venture capital ecosystem for investment. However, differences across countries in company structure, legal system, regulation, and taxation remain impediments to integration.

From 2007 to 2015, the average venture capital-backed US company received five times more money than its EU counterpart, or EUR 6.3 million compared to EUR 1.3 million (AFME, 2017). Larger investment rounds can be achieved by having more investors (syndicate size) and/or larger investment amounts per investor (ticket size). Both syndicate sizes and ticket sizes are bigger in the United States than in Europe. For example, looking across all funds from 2005 to 2015, 28% of US funds were larger than USD 250 million, compared with only 10% in Europe (Duruflé et al., 2017). Venture capital has grown over time in the European Union, but activity has increased at a much faster pace in Asia (including China).

The gap between venture capital financing in the United States and Europe is visible at all development stages, but is especially wide when start-ups are scaling up. At the start-up stage, there is little difference in fund size between the United States and Europe. However, US companies are financed by significantly larger funds at the scale-up stage, when companies need to consolidate their position in the competitive international market (AFME, 2017). In the growth capital segment, the amounts invested in the United States are more than three times those in Europe.

In 2018, venture capital investments – which are of particular importance for the financing of young innovative companies with high growth potential – rose to a record high. During that year, the increase in total private equity investments was mainly driven by a surge in investments in the buyout segment (up 10% to EUR 58.8 billion) of the private equity market, but a modest increase was also recorded for growth capital (up 0.4% to EUR 11.9 billion) (Figure 23).[27] Venture capital investments jumped by 13% to EUR 8.2 billion,[28] with results from the EIF VC Survey indicating persistently high market activity. Within the venture capital market segment, investments into start-up firms surged by 29% to EUR 5 billion (Figure 23), while seed (down 7% to EUR 0.7 billion) and later-stage venture investments (down 3% to EUR 2.6 billion) decreased. Before the crisis, later-stage ventures had been the driver of venture capital investment. Conversely, since 2009, investments at the start-up stage have been higher, on average, than later-stage venture capital investments.

During and after the crisis, the European venture capital ecosystem benefited substantially from market-stabilising public intervention. From 2012, the environment returned to normal, although public sector support still plays an important role (Box C). These changes can be seen in the investor base variations over the past few years.[29] According to Invest Europe figures, the share of government agency contributions to venture capital fundraising increased from 13% in 2007 to 35% in 2011, before falling back again in the subsequent years. However, although it is not appropriate for government agencies to occupy such an important position in the long term, it should be noted that they did play their part by supporting the market in a counter-cyclical manner, in particular during the financial crisis when total venture capital fundraising levels more than halved. This led to

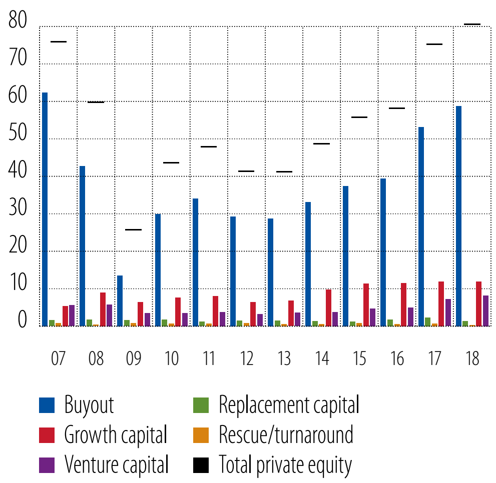
27 The breakdown by investment and funding stage focus has been available since 2007.

28 Note that the equity investment activities of business angels are not included in the Invest Europe statistics. Business angels are, however, important for the financing of small and medium-sized enterprises and for innovation. See Kraemer-Eis et al. (2019) for a general overview of this market segment and recent developments.

29 See Kraemer-Eis et al. (2019) for an overview of the developments in the investor base over time.

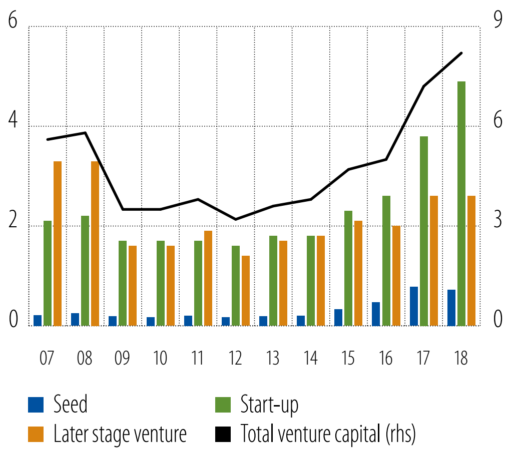
an increased share of government agency fund investors. In 2018, the total volume contributed by government agencies to venture capital fundraising amounted to EUR 1.6 billion, a decrease of 31% compared to the year before. Consequently, the share of government agency contributions to venture capital fundraising decreased from 27% in 2017 to 18% in 2018.

Figure 23
Private equity investments in European portfolio companies by stage focus (EUR billion)



Source: ESBFO, based on data from Invest Europe.

Figure 24
Venture capital investment amounts by stage (EUR billion)



Source: ESBFO, based on data from Invest Europe.

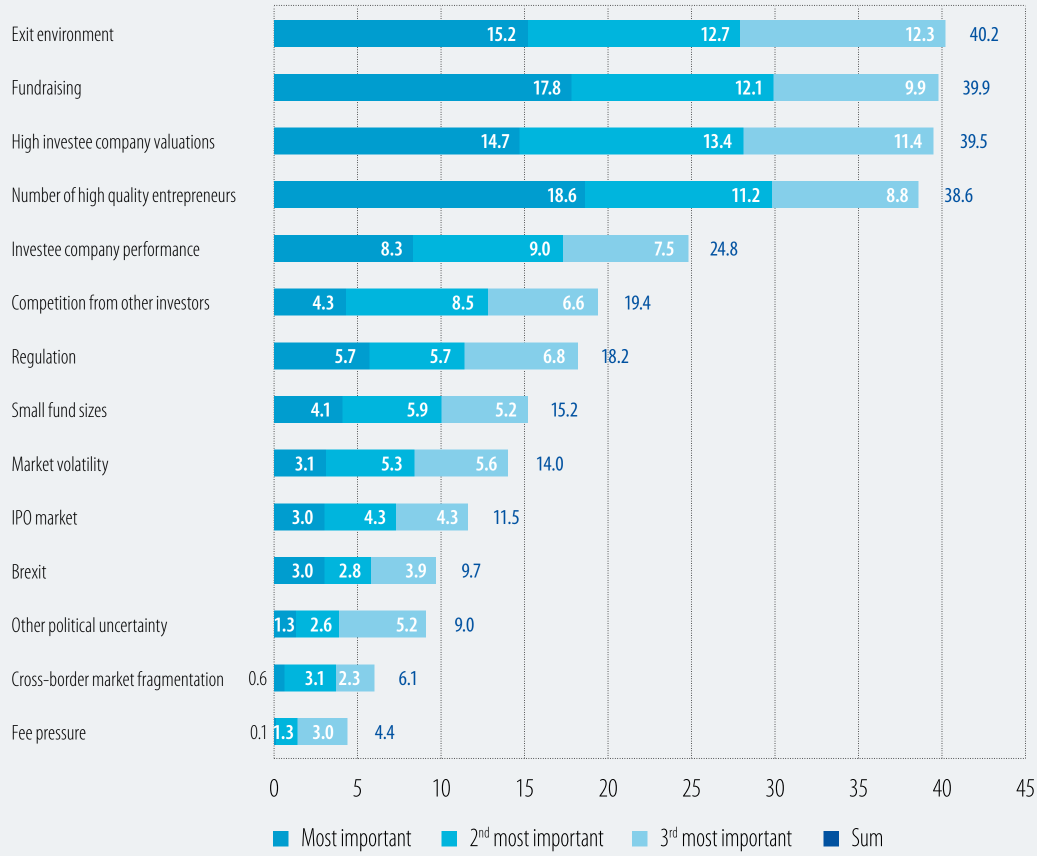
Box C
The 2019 EIF Venture Capital (VC) and Business Angel (BA) surveys

The second wave of the EIF VC Survey was conducted in February/March 2019.[30] The questionnaire covered the areas of market sentiment, venture capital's socio-economic characteristics, environmental and social governance considerations and impact investing, policy recommendations (in particular related to regulation and taxation) and EIF product and mandate development.[31] The survey focuses on the biggest challenges facing venture capital. In the EIF VC Survey 2019, European fund managers stated the exit environment, fundraising, high investee company valuations and the number of high quality entrepreneurs to be their biggest challenges (Figure C.1).

30 The EIF VC Survey targets venture capital general partner and management companies investing in Europe. The surveyed population includes companies in which the EIF has invested as well as other companies. The first EIF VC Survey was conducted in November/December 2017 and covered three areas: (i) VC market sentiment; (ii) market weaknesses and public intervention; and (iii) the value added, products and processes of the EIF. The results of the first two parts are provided in Kraemer-Eis, Botsari, Gvetadze, and Lang (2018a) and summarised in Kraemer-Eis, Botsari, Gvetadze, Lang, and Torfs (2018c). The results of the third part are presented in Kraemer-Eis, Botsari, Gvetadze, and Lang (2018b).

31 The first part of the EIF VC Survey 2019 outcomes (dedicated to market sentiment and policy recommendations) was published in Botsari, Crisanti and Lang (2019). Further parts will be published in the EIF Working Paper series and selected results were presented in Kraemer-Eis, Botsari, Gvetadze, Lang and Torfs (2019).

Figure C.1
Biggest challenges in the venture capital business (% of respondents)



Source: *EIF VC Survey 2019.*
Note: *The diagram shows the results for the EIF VC Survey 2019 question "Select up to three of the biggest challenges you currently see in the venture capital business."*

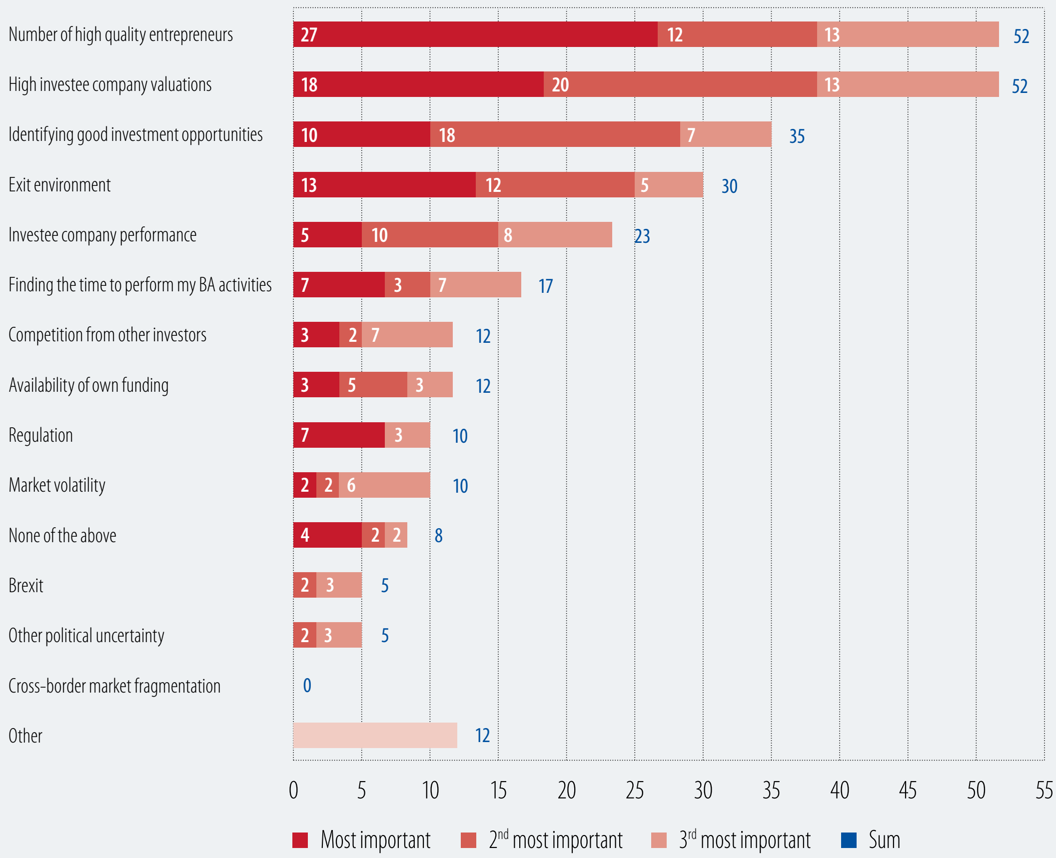
The EIF Business Angel Survey

Business angel financing is a segment of the private equity market for which the availability of data is particularly scarce in Europe. To improve the market information about business angels in Europe, the EIF launched a new BA Survey in 2019. The EIF BA Survey is carried out among EIF-supported business angels under the European Angels Fund, meaning the results do not claim to represent all business angels and may represent a specific group that is different to those represented in other studies (e.g. by the European Business Angels Network or the European Commission; see EBAN (2018) and European Commission (2017)). The survey was inspired by the successful introduction of the EIF VC Survey in 2018, among other factors. The first EIF BA Survey wave was conducted from 28 March to 10 May 2019 and included questions addressing the topics of socio-economic characteristics of the business angels, general characteristics of their activities, the added value of EIF activities under the angels fund, market sentiment, public support for business angel investing and environmental and social governance and other considerations.[32]

32 The results of the EIF BA Survey will be published in the EIF Working Paper series, which is available online on the EIF website: https://www.eif.org/news_centre/research/index.htm

The 2019 EIF BA Survey examines the biggest challenges for business angels in Europe. The number of high quality entrepreneurs was cited by 52% of survey respondents as one of the three most important challenges (including 27% of the respondents highlighting it as being the most important challenge), followed by high company valuations, identifying good investment opportunities and the exit environment. In a nutshell, the survey results indicate that macro-level challenges – which affect a business angel's activities only indirectly (e.g. regulation, market volatility or political uncertainty) – rank relatively low. By contrast, micro-level challenges that are directly related to a business angel's activity (e.g. valuations or investment opportunities) are mentioned much more prominently, reflecting the current market situation – the tapering-off of a boom phase.

Figure C.2
Biggest challenges in business angels activity



Source: *EIF BA Survey 2019.*
Note: *The diagram shows the results for the EIF BA Survey 2019 question "Select up to three of the biggest challenges you currently see in your BA activity."*

Cross-border capital flows and integration of the EU financial system

The EU financial system is not properly integrated. Owing to stigmas and the awareness that the pre-crisis boom was an anomaly, cross-border capital flows are seeing a tepid recovery. Financial integration before the crisis was driven by banks with low risk aversion and under very favourable cyclical conditions. Since then, banks have retrenched, pulling back from foreign holdings and preferring investments at home or in their region. This retrenchment has had a negative effect on the allocation of savings and is inefficient.

The crisis has shown the need to strengthen financial integration so that savings reach the best investment opportunities across Europe. The European Union's new financial regulatory packages introduced after the crisis may well achieve this goal in the future but so far little progress has been made. The second stage of the Capital Markets Union should support this goal.

Cross-border financial flows prior to the crisis: was the boom genuine?

Several factors explain movements in cross-border capital flows. Graciela and Kaminski (2019) differentiate structural factors from cyclical ones. Structural factors encompass the quality of institutions, capital account openness, the existence of institutional investors, the role of the government in the economy and access to information and communication technology. Cyclical factors cover global risk aversion, the cyclical position of the economy, asset returns and country risk.

Disentangling structural and cyclical factors can help with understanding the decline in cross-border capital flows not only in Europe, but also across the world. Prior to the crisis, the increased integration of the world economy, the growing share of external trade, current account liberalisation and, in Europe, the removal of exchange rate risk and the entry of the countries of Central and Eastern Europe into the European Union were a bonanza for cross-border financial flows.

The boom period, which was associated with a reduction in global risk aversion and high asset returns, also provided impetus to cross-border flows (Bruno and Shin, 2015a and b). Since then, fears caused by the bursting of the credit bubble and the sovereign debt crisis have haunted financial institutions engaged in cross-border financial flows (Enria, 2018). At the same time, structural factors have plateaued.

Gross cross-border capital flows must be taken into account when analysing the evolution of cross-border flows. By definition, net financial flows mirror current account flows, meaning that the sharp rebalancing of current accounts in the wake of the crisis explains the reduction recorded in net flows. Figure 25 shows that after several years of decline, flows within the European Union have rebalanced, stabilising and sometimes even increasing.[33]

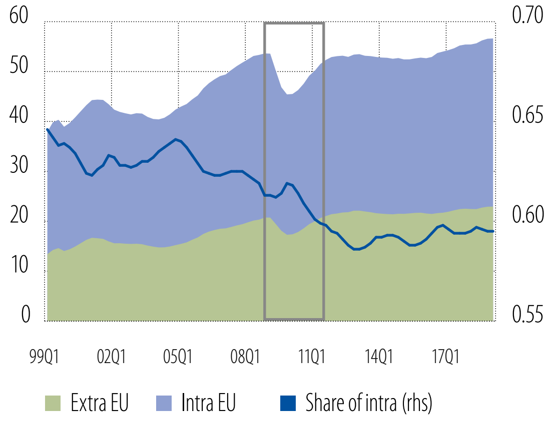
The reduced intensity of gross financial flows is likely to persist as the boom before the crisis was not sustainable (Figure 26). In the European Union, the collapse in gross financial flows was shared by all country groups but was most pronounced for Western and Northern Europe, which typically record higher levels of gross flows. The slow recovery recorded since the crisis (shared by Western and Northern Europe and Southern Europe but not Central and Eastern Europe) suggests that lower gross capital flows in Europe are more than a temporary phenomenon.

Financial integration before the crisis was mostly supported by banking flows. During the recent upturn, the international claims of euro area banks stopped declining, but are still at lower levels than before the crisis. Looking at the components of gross financial flows, the decline is mostly explained by other investments, which primarily reflect cross-border and cross-bank financial flows. Figure 27 shows

33 The geographical breakdown of the balance of payments is not published for most EU economies, and it is therefore not possible to discern whether the reduction in gross flows relates to flows inside or outside the European Union.

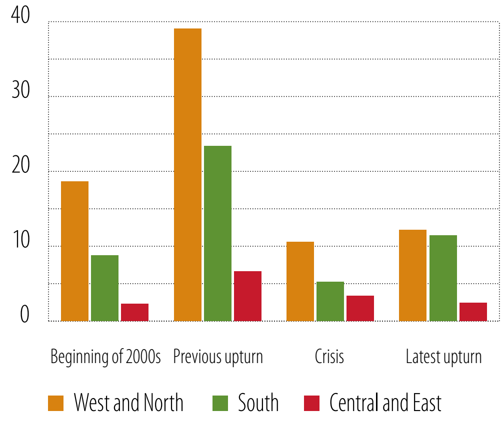
the decline in the international exposure of EU banks in the wake of the crisis. More recently, the decline has come to a halt and as a share of GDP, the international bank claims of EU banks have plateaued. However, the geographical composition has changed, and foreign bank holdings are mostly directed towards economies outside the European Union.

Figure 25
Intra-EU exchanges
(current account, % of GDP)



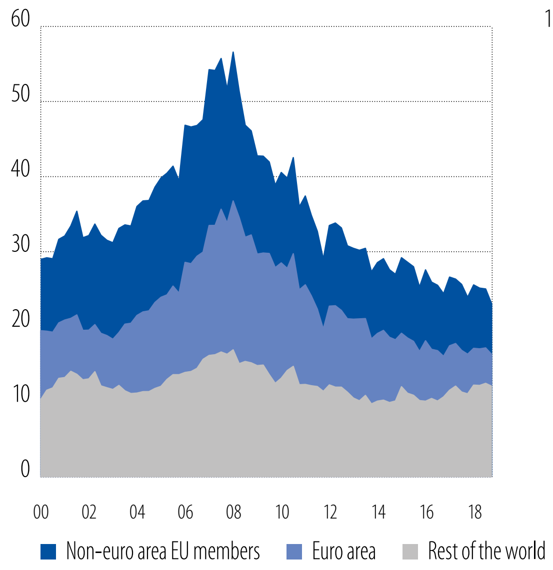
Source: EIB Economics Department calculations based on IMF and Eurostat.

Figure 26
Cross-border flows (average of inflows and outflows as % of GDP)



Source: EIB Economics Department calculations based on Eurostat.

Figure 27
International claims of EU banks
(% of EU GDP)



Source: EIB Economics Department calculations based on BIS consolidated claims data.

Figure 28
Geographical breakdown of main assets held by euro area banks
(%, lhs, and total in EUR trillion, rhs)

Source: EIB Economics Department calculations based on ECB.

For all asset classes, the exposure of euro banks to non-domestic assets increased in the run-up to the crisis and has declined since then. Figure 28 shows the geographical breakdown of the main assets of euro area banks into domestic, euro area and non-euro area economic categories. For corporate loans, government bonds and debt securities, in relative terms, domestic exposure declined from its pre-crisis level, which was about 60%. Domestic exposure has since increased and in some countries is now above pre-crisis levels. The retrenchment is especially pronounced for corporate and government securities. In the most recent period, since 2014, the share of domestic loans has returned to levels seen when the euro was introduced, and the share of domestic sovereign bonds is even higher.

Distinguishing genuine financial integration

Financial integration strengthened up to the crisis, then sharply receded and has recovered mildly since then (Figure 29). Our estimated financial integration indicator[34,35] displays a pattern that is very similar to the evolution of gross financial flows. Looking at the response of each series to the financial integration factor, we see that this evolution mostly reflects that of foreign holdings of corporate securities and government bonds by banks (Figure 30). Consistently, for these components, banks first increased their international exposure and then reduced it (Figure 28).

True financial integration is difficult to dissociate from boom-bust cycles. Estimated financial integration increases during upturns and recedes in downturns, and therefore contains a very strong cyclical component. To dissociate it, we identified the boom-bust component using sign restrictions in the BFAVAR model, then removed its contribution from the evolution of the financial integration indicator to get an estimate of the true financial integration. The results (Figure 29) show that financial integration was previously overestimated, since a substantial share of the hike was cyclical. Conversely, the drop during the crisis was also overestimated.

Genuine financial integration has increased moderately since the beginning of the 2000s. Besides the enlargement, very little changed in the European Union in terms of regulation and access to markets from the beginning of the 2000s until the crisis. Financial integration continued to rise in the early 2000s, mostly following the introduction of the euro, but was not triggered by major changes.

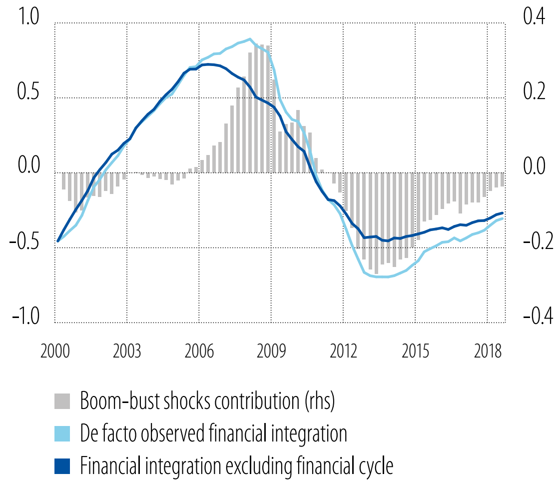
Integrated capital markets affect economic growth as well as economic stability and resilience. Holding a more geographically diversified portfolio of financial assets provides asset returns that are not only less volatile but are also less correlated with domestic income (i.e. the capital market channel of risk sharing). This means that when a country is hit by an economic shock, cross-border flows enable households and investors to lend or borrow to offset its impact (i.e. the credit market channel of risk sharing). Improving funding diversification therefore enhances cross-border risk taking and enables capital markets to play a greater role in reducing the domestic impact of a shock (Pisani-Ferry and Zettelmeyer, 2019).

The excessively high degree and speed of financial integration in the ten years after the introduction of the euro and the fragmentation that followed the debt crisis are not independent of the relatively poor performance of financial markets in providing stabilisation through cross-country risk sharing. As financial integration occurred mostly through cross-border bank lending, which led to the accumulation of debt, the start of the crisis saw a sudden halt in lending instead of risk sharing (Box D).

34 The index is built using a Bayesian Factor Vector Autoregressive model. The auxiliary dataset comprises around 100 series related to EU cross-border financial transactions. See Lake and Maurin (2019, forthcoming) and EIB Investment Report (2017). The index is dimensionless and with a mean of 0. In Figure 29, 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 dark blue line plots the difference between the two.

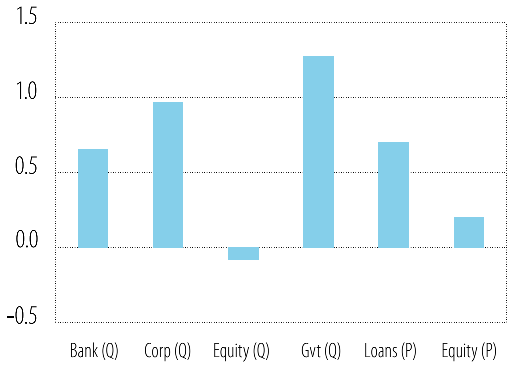
35 In Figure 30, Q denotes quantity indicators, P denotes price indicators, Bank denotes the bank debt market, Corp denotes the corporate debt market, Loans denotes bank loans (both to non-financial corporates and households), Equity denotes the listed equity market, and Gvt denotes the government bond market.

Figure 29
Genuine EU financial integration indicator



Source: Based on Lake and Maurin (2019, forthcoming). See also: EIB Investment Report (2017).
Note: See footnote 34.

Figure 30
Average factor loadings



Source: Based on Lake and Maurin (2019, forthcoming).
Note: See footnote 35.

Looking forward, the regulatory overhaul and strengthening of the EU framework taken on since the crisis should aid structural financial integration. While helping to increase the resilience of the banking sector, however, the banking union has not fostered much integration or generated gains in cross-border consolidation and portfolio diversification, so far at least. This development is too recent for estimates to be made, and the dynamic is dwarfed by others such as Brexit-related uncertainty. Moreover, some components of the mechanism (such as the European Deposit Insurance Scheme) have yet to be agreed.

Box D
Market risk sharing as a response to asymmetric shocks

The aftermath of the sovereign debt crisis that started in 2010 brought to the forefront discussions on the capacity of the euro area to deal with shocks. While the issue had generated academic research and policy debate in the years preceding the introduction of the euro, the topic then disappeared for about two decades. The crisis showed that the higher financial integration fostered by the euro did not result in greater cross-country risk sharing. In this box, we focus on two specific issues: identifying the nature of shocks in the context of a monetary union and the implications of shock absorption policies.

Business cycle fluctuations vs asymmetric shocks

Most macroeconomic literature on stabilisation policies investigates the capacity of fiscal policy to counter shocks.[36] When comparing cross-country stabilisation capacity, the literature usually considers GDP and how discretionary fiscal measures respond to country-specific cyclical fluctuations. The reason for this focus is the assumption that changes in GDP reflect changes in unemployment and vice-versa. Automatic stabilisers, which are counter-cyclical by definition, account for the responses to changes in unemployment. They usually do not require a policy decision and vary across countries.

36 These are defined as business cycle fluctuations and usually measured as deviations from the country's potential and long-term growth.

Within the analysis of the functioning of monetary unions, the literature examining the stabilisation capacity of fiscal policy, and more broadly the mechanisms used to smooth the impact of shocks, usually assesses responsiveness to asymmetric shocks rather than to fluctuations in the business cycle. Unlike business cycle fluctuations, asymmetric shocks are relative and defined as deviations of a country's GDP from the average of the monetary union, rather than from its long-term GDP. As pointed out in Alcidi (2017), both of these metrics are important in the Economic and Monetary Union (EMU), where national governments have full control of fiscal policy. However, the metrics reflect different perspectives and do not necessarily deliver the same assessment about stabilisation efforts or automatically point to the same policy recommendations.

The emphasis on asymmetric shocks in monetary unions is in part a legacy of the optimum currency area debate, according to which the cost of having abandoned monetary policy sovereignty increases when exposure to asymmetric, and potentially large, shocks is high. Under this theory, the synchronisation of cycles is the main solution to the problem (Bayoumi and Eichengreen, 1992). Deviations from the average are very small or virtually non-existent, suggesting that underlying shocks are not significantly idiosyncratic and a single monetary policy can respond to cyclical fluctuations, which are the same in all countries. In reality, this is the case if synchronisation implies not only co-movements in the national business cycles but also that cycles are of a similar magnitude. The theory posits that the two metrics identified above coincide.

The euro experience suggests that this is not necessarily the case. As shown in Belke et al. (2016) and Alcidi et al. (2017), euro area business cycles tend to be highly and positively correlated. While the degree of correlation was extremely high in the first years of the euro, it has declined drastically in recent years. In addition, some EU members tend to exhibit cyclical fluctuations of different amplitudes. A breakdown of asymmetric shocks defined as deviation from the weighted average of the euro suggests more volatility and idiosyncratic shocks in peripheral countries (with the exception of Italy) than in core countries.

The results have two implications. First, monetary policy is likely appropriate for most EU members, but for some it could amplify shocks: both negative shocks, by being too tight in recessions, or positive ones, by being too loose during expansions. Second, since there is little doubt that domestic fiscal policy responds to GDP shocks as defined by business cycles rather than relative to the euro area average, fiscal policy should not be expected to play a key role in addressing negative asymmetric shocks, unless those shocks coincide with domestic recessions. Other mechanisms, based on the functioning of financial markets, can absorb or smooth the impact of asymmetric shocks.

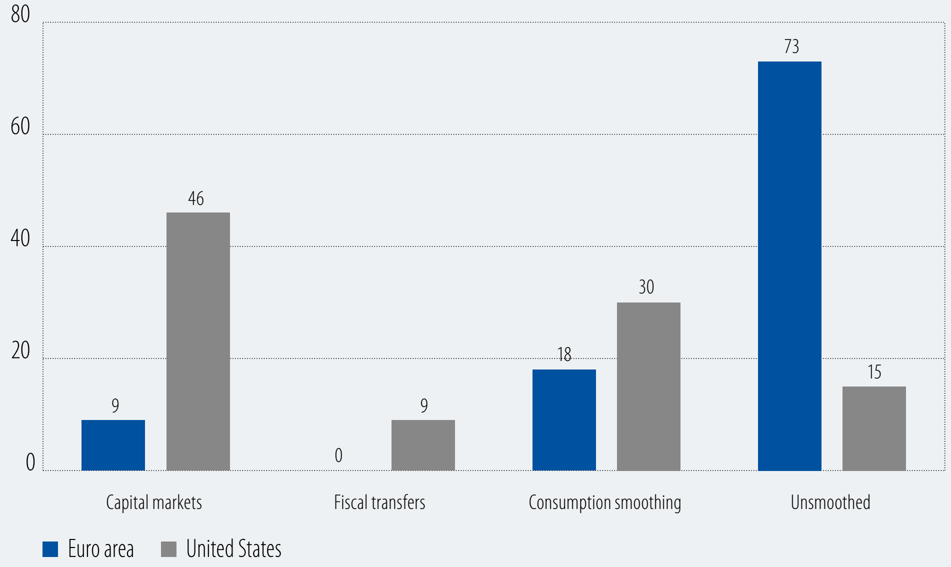
Shock absorption capacity in the euro area: the role of market integration

The methodology proposed in Asdrubali et al. (1996) and its extensions – as in Areazza et al. (1999), Alcidi et al. (2017a), Alcidi et al. (2017b), and Alcidi and Thirion (2017) – provides a comprehensive and in-depth analysis of how shocks to GDP are smoothed in the euro area. The methodology is used to quantify private risk-sharing, consumption-saving intertemporal decisions across EU markets and the role played by international credit markets. The authors repeat the same exercise for the United States and use the United States' capacity to deal with shocks, measured on fully comparable data, as the euro area analysis benchmark (Figure D.1). A number of results are strongly in line with the existing literature.

First, the euro area's ability to absorb shocks has always been weaker than that of the United States, particularly since 2010. This means that a fall in euro area GDP results in a much greater fall in private consumption than in the United States. *Second*, US capital markets are the most powerful channel for absorbing the impact of idiosyncratic shocks. This capacity is around 50%, despite a sharp decline and ensuing recovery since 2008. In the euro area, the capacity is much smaller at about 30%.[37] After 2009, though, capital markets seemed to become completely dysfunctional and served only to amplify the impact of shocks rather than smooth them. *Third*, euro area net savings – both private, in particular the corporate sector, and public, as fiscal policy – are more important in smoothing the impact of shocks than capital markets.[38] *In addition*, the results also suggest that asymmetric shocks are persistent in the euro area, at least relative to the United States, with some countries remaining systematically above or below average growth for many years.[39] The combination of persistent shocks and the weak role of capital markets can explain low shock absorption in the euro area.

Figure D.1

Income and consumption smoothing in the US and euro area, 1998-2016



Source: *Alcidi and Thirion (2017).*
Note: *Percentage of shocks to gross state product (US) and gross domestic product (euro area) absorbed at each level of smoothing. US: 50 US states. Euro area: Austria, Belgium, Finland, France, Germany, Greece, Italy, Ireland, the Netherlands, Portugal, Spain.*

The assumption that the fiscal policies of individual EU members is enough to deal with asymmetric shocks, which is central to the optimum currency area theory, is unlikely to reflect reality. In a monetary union, asymmetric shocks may be very different from country-specific recessions or booms, and national governments are concerned with stabilising domestic business cycles rather than reducing the deviation from the monetary bloc's average.

In a monetary union, the key channels for absorbing the impact of asymmetric shocks are cross-country risk sharing, either led by markets or by common fiscal resources, and consumption smoothing through credit markets. Focusing on the first channel only, we can say that the poorer performance of capital and credit markets in absorbing asymmetric shocks in the euro area (as compared to the United States) indicates that there is still room to improve cross-country risk sharing through financial

37 The use of fully comparable data reveals that until 2008, the capacity of capital markets was higher than the usually estimated 10% most often found in the literature. This difference is attributed to the fact that under US accounting rules, companies' retained earnings are counted as international factor income and not as savings. See Alcidi et al. (2017a) for more details.

38 This channel refers to cross-Member State private transfers associated with cross-border ownership of assets.

39 As shown in Alcidi et al. (2017), Italy is an extreme case: on the one hand, the Italian real GDP growth rate has been below the average for the last 20 years; on the other hand, the magnitude of the deviations has always been relatively small. In contrast, Ireland's deviations have been positive for most of the sample, with the exception of the years 2008-2012. Volatility in Ireland has been very high.

markets. A pre-requisite for the effectiveness of both the capital and credit market channel is that integration not be driven by cross-border lending only. The crisis has shown that credit flows can abruptly stop and even reverse if claims and inflows are concentrated, as was the case in the euro area until 2010. Cross-border debt flows are not an instrument for risk sharing, but they can smooth consumption over time in the face of temporary shocks. By contrast, geographically diversified ownership of capital fosters market risk sharing and can smooth the impact of asymmetric shocks, even when they are persistent. The exact aim of the Capital Markets Union and the banking union is to foster integration within capital markets. If this aim is successfully achieved, it could have an impact on the absorption capacity for asymmetric shocks in a monetary union.

Estimates of home bias

Home bias refers to the tendency of investors to hold a larger proportion of domestic assets in their portfolios than they should relative to foreign assets. Specifically, the International Capital Asset Pricing Model suggests that investors should hold a globally diversified portfolio as global diversification eliminates idiosyncratic risk and generates a better risk/return trade-off than domestic diversification. Home bias does not enable investors to reap the full benefits of geographical diversification. Its existence reflects the fact that information asymmetry is reduced for local firms and locally issued securities (Van Nieuwerburgh and Veldkamp, 2009, Mondria and Wu, 2010). Investors may also prefer to hold local securities in their portfolio to avoid the foreign exchange cost of hedging.

Aversion to bilateral cross-border financial positions may also be explained by other factors. These include potential double taxation of profits generated by foreign securities (once in the country of the company and once in the country of the security holder) while returns on domestic securities are taxed only once. Besides lower physical distance (Portes and Rey, 2005), investors prefer assets from countries with the same language, similar legislation, and well developed trade exchanges (Aviat and Coeurdacier, 2007, Lane and Milesi-Feretti, 2005).[40]

Home bias and financial integration are inversely related. The higher the home bias, the weaker the financial integration. Conversely, a reduction in home bias implies a pickup in financial integration as long as domestic EU investors integrate foreign assets from other EU countries into their portfolios. Research suggests home bias declined in Europe before the global financial crisis (Schoenmaker and Bosch, 2008). This conclusion is consistent with the rise in the estimated financial integration indicator depicted in Figure 29 from 2000 to 2007.

The lack of homogenous and comparable data complicates the estimation of home bias, but simple indications can be obtained. We have compared the evolution of the actual geographical distribution of a portfolio to a simple benchmark provided by a country's share in world GDP.[41] Our indicator measures the degree to which investors from a given country overweight domestic assets and underweight international assets compared to a benchmark portfolio where the weights of home and foreign assets would correspond to their respective shares in world GDP.[42]

There is a relatively strong home bias in Europe overall and within regions. Figure 31 reports the estimated home bias computed separately for the three EU regions.[43] The figure plots the relative exposure to each region compared to the change in the relative GDP. A ratio of over one indicates over-exposure and a

40 Relative institutional quality across countries may also affect bilateral financial positions as investors opt for financial securities from markets with strong regulation, accounting standards, rule of law and absence of corruption (EIB, 2018).

41 Owing to data inconsistency and limitations, it was not possible to benchmark holdings with the share of the local market capitalisation in the world market.

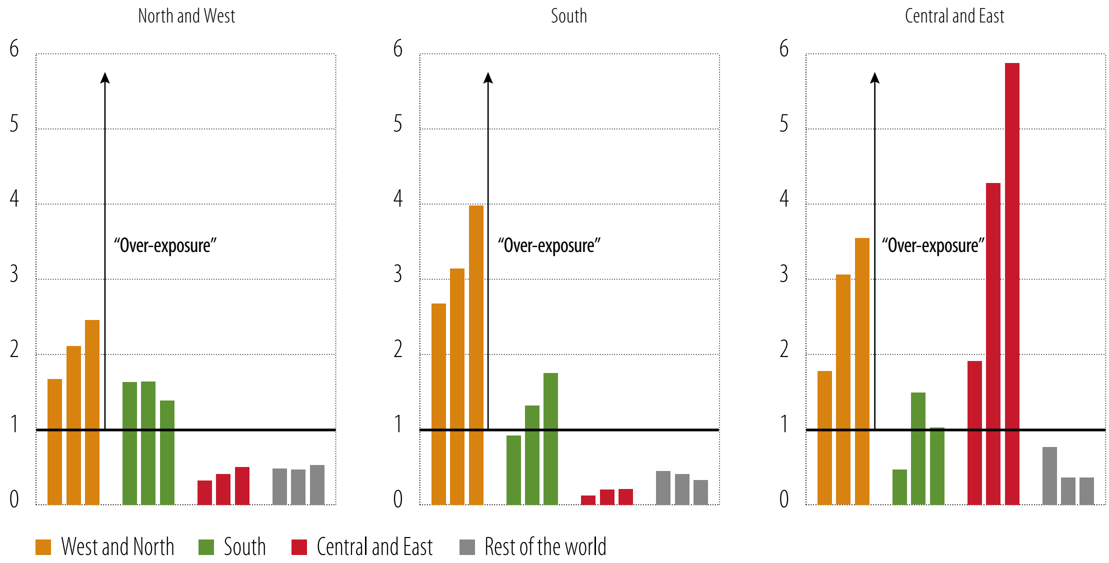
42 This method relies on the assumption that outstanding amounts of securities are proportionate to GDP, and that financial depth is similar across economies. This may be valid, in relative terms, for Western and Northern Europe, and possibly for Southern Europe, but is much less so for Central and Eastern Europe and the rest of the world.

43 The calculation of home bias relies on bilateral portfolio investment flows for total securities, debt and equity from one country to the other, as reported in the IMF's Coordinated Portfolio Investment Survey. The survey provides data on bilateral exposure from 2003 to 2018.

decline indicatives a relative retrenchment while an increase indicates a reinforced relative engagement. By construction, the weighted average of the ratios across the four regions is equal to one. Within Europe, there is a strong home bias as the rest of the world is under-weighted in the three regions, meaning Europe is more financially integrated in relative terms. Western and Northern Europe and Central and Eastern Europe tend to be more integrated within themselves. In Southern Europe, while there is a regional bias, the bias towards exposure to Western and Northern Europe is even stronger.

Home bias has evolved differently over time in the three different EU regions. Each EU region tends to overweight their exposure to Western and Northern Europe. To some extent, this reflects the deeper financial markets in this region, as the bias for equities is stronger than the bias for bonds. Conversely, exposure to Central and Eastern Europe is under-weighted except within this region, likely also to reflect a less developed financial sector (Figure 12).

Figure 31
Geographical breakdown of foreign exposure relative to GDP weights



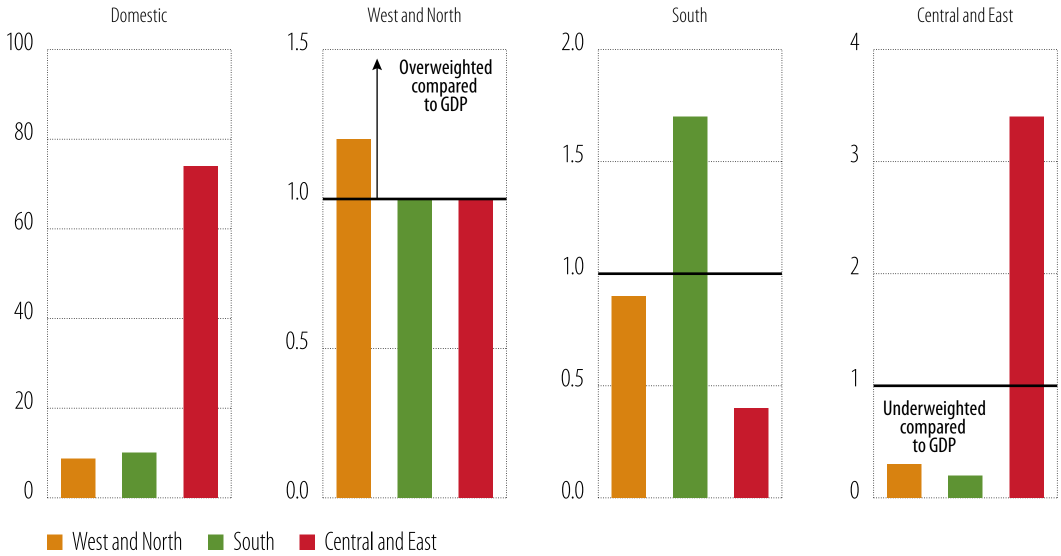
Source: *EIB Economics Department calculations based on IMF.*
Note: *Ratio of the regional exposure in the total foreign portfolio reported to relative GDP, averages. Orange, green, red and grey bars indicate the changes in the exposure to Western and Northern Europe, Southern Europe, Central and Eastern Europe and the rest of the word (non-EU), respectively. For each, the first, second and third bars refer to pre-crisis, crisis and upturn periods (03-07, 08-12 and 13-18), respectively.*

The relative retrenchment of Western and Northern Europe and Central and Eastern Europe from Southern Europe. From the crisis to the recent upturn, relative exposure to Southern Europe dropped significantly in Western and Northern Europe (from 1.6 to 1.4) and in Central and Eastern Europe (from 1.5 to 1.0). At the same time, regional bias within Southern Europe increased somewhat. The breakdown indicates that the decline was mostly driven by bonds as foreign investors reduced their exposure to sovereign debt issued by the countries of Southern Europe during the financial crisis.

A similar analysis focused on the insurance sector is shown in Figure 32. The source enables us to compute the average home bias within each region (left hand panel) but not to gauge any changes as the data were collected for a specific exercise. National home bias appears to be much higher than regional bias. On average, for countries belonging to Western and Northern Europe, the relative exposure to domestic assets is nine times the relative GDP. It is stronger in Southern Europe (ten times) and in Central and Eastern Europe (70 times). Regional bias remains, however, being especially pronounced in Central and Eastern Europe, but also in Southern Europe.

Figure 32

Geographical breakdown of investment and home/regional bias of insurance companies (exposure compared to GDP weight, bias above 1)



Source: *EIB Economics Department calculations based on European Insurance and Occupational Pensions Authority (EIOPA) insurance statistics, 2017:Q4.*

Holding shares in a multinational company can also act as risk sharing. Most traditional measures of risk sharing rely on home bias estimated with financial data. However, Ghironi and Wolfe (2018) show analytically that serving foreign markets by producing locally can act as a substitute for international asset trade and terms of trade adjustment in delivering perfect risk sharing across countries. To some extent, domestic savings invested in large and open corporations can help smooth the impact of idiosyncratic shocks on domestic income.

Conclusion and policy implications

Some of the long-awaited headwinds have materialised since the end of 2018 and the EU upturn has weakened somewhat. The slowdown has not been as strong as some feared, at least so far, but it is sufficient to shift monetary policy expectations from tightening to loosening. Some long-term yields for EU members re-entered negative territory and dipped to levels below those seen in the summer of 2016. Furthermore, risks are mounting, namely the higher indebtedness of sovereigns, households and specific segments of the financial markets.

On the back of years of monetary policy stimulus in Europe, liquidity is abundant, but not reallocated efficiently. This is costly in terms of growth and investment. There are some signs of changes in the structure of the financial sector since the beginning of the 2000s: a relative decline of bank finance, and, in Western and Northern Europe, a smaller proportion of savings allocated to cash and deposits. However, the changes are a long way from ensuring that the EU financial system provides adequate support for corporate investment, especially long-term and innovative investment. The financial system currently does not facilitate maturity transformation at a time when long-term investment needs are very high. It also does not provide enough incentives for taking risks and supporting technological advances.

Financial integration is insufficient to provide optimal savings allocation and is costly in terms of growth and investment. Pre-crisis integration was partly bonanza-driven and boom-bust related. When the crisis erupted, the retrenchment was sharp and since then the rebound has been tepid. Home bias remains high, and there is also evidence of regional bias. This could result in a polarisation of the EU economy that would impede the convergence process.

How to ensure the persistent expansion and development of financial integration is a key question for the policy agenda and further research. The regulatory overhaul succeeded in strengthening banks but has so far failed to reignite financial integration and move the financial sector towards a structure more prone to finance capital expenditure. The financial system must be incentivised to foster equity investment and favour the financing of risk-taking activities. The Capital Markets Union and the regulatory overhaul must pursue these goals.

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Chapter 6

Financing corporate investment

The current upturn in corporate activity and capital expenditure is relatively muted, but firms have increased their balance sheet resilience. They have deleveraged, and in parallel, increased their capital base. Moreover, they benefit from very supportive finance costs. After years of adjustment following the financial crisis, EU firms appear stronger and more resilient to a possible downturn.

Increased resilience has come at the cost of lower investment, and this does not bode well for the future. Contrasting with historical patterns, firms continue to be net savers. Besides reducing indebtedness, they also continue to pile up cash and deposits, remunerated at very low rates, instead of investing. This seems at odds with the pent-up capital demand accumulated during years of low or receding economic activity. Uncertainty, both political and technological, is one of the likely culprits, along with the move towards intangible investment. This type of investment is not easy to collateralise, meaning that financing needs to be covered by internal resources. Finally, reduced competition and increased rents in some specific domains may also contribute to explaining why, in the current favorable environment, firms are not investing more and piling up cash.

Financing constraints in the EU corporate sector are unchanged from the previous years and remain highly varied across countries and business segments. The overall improvement in the conditions for accessing external finance masks a persistent variation across the EU regions and economies. External financing conditions are structurally more adverse in Central and Eastern Europe while they have improved substantially in Southern Europe. And, while overall access to finance is not among the most prominent impediments to firm investment, clear bottlenecks remain for specific types of firms: especially small, young, R&D active, and those investing in intangibles.

There is a need to enhance the financial offer and business environment. Lack of finance is more of an obstacle to corporate investment in bank-dependent economies. Moreover, R&D-intensive firms tend to report stronger financial constraints. After uncertainty and lack of skilled staff, regulations (both labour and business) are cited as the most important impediment to investment, especially in Southern Europe. These constraints suggest the need for policy actions on the structure and regulatory environment of the EU economy.

Introduction

This chapter analyses the changes in firms' financial structure since the crisis, with a view to assessing how much progress has been achieved and how firms would be able to withstand a slowdown or a "standard" recession in the EU economy.

External financing flows are recovering from the crisis but the pick-up remains modest and the business sector continues to be a net saver, accumulating financial assets or reducing debt, a long way from its historical position of net investor. The overall subdued rebound in investment is especially striking when set against the very accommodative monetary and financial conditions. In parallel, however, the slow rebound enables firms to strengthen their balance sheets, in terms of capital or liquidity, with the accumulation of cash.

The remainder of the chapter consists of four sections followed by a conclusion drawing policy implications. The first section focuses on the evolution of corporate balance sheets, profit and loss and internal financing capacity together with their overall implications for corporate investment. The second section draws on the EIB Investment Survey to elaborate on the drivers of finance for European firms, touching on the overall corporate environment and its support for capital expenditure. The third section focuses on the particular situation of small and medium-sized businesses. The fourth section focuses on financing of specific types of assets: first intangible investment, especially R&D expenditure, and second, energy efficiency.

How much have balance sheets strengthened?

Corporate investment has continued to expand in the European Union since the middle of 2018, but remains below GDP growth. Figure 1 shows the evolution of the investment share, internal financing resources and net lending,[1] over time and for the three EU regions. In 2018, investment share in GDP continued to increase in the European Union, although the strength varied across regions. In Western and Northern Europe, corporate investment rose below GDP growth. In Central and Eastern Europe, investment grew in line with GDP. In Southern Europe, it grew faster than GDP. At the end of 2018, investment's share of GDP was below its historical mean (since 1999) only in Central and Eastern Europe.

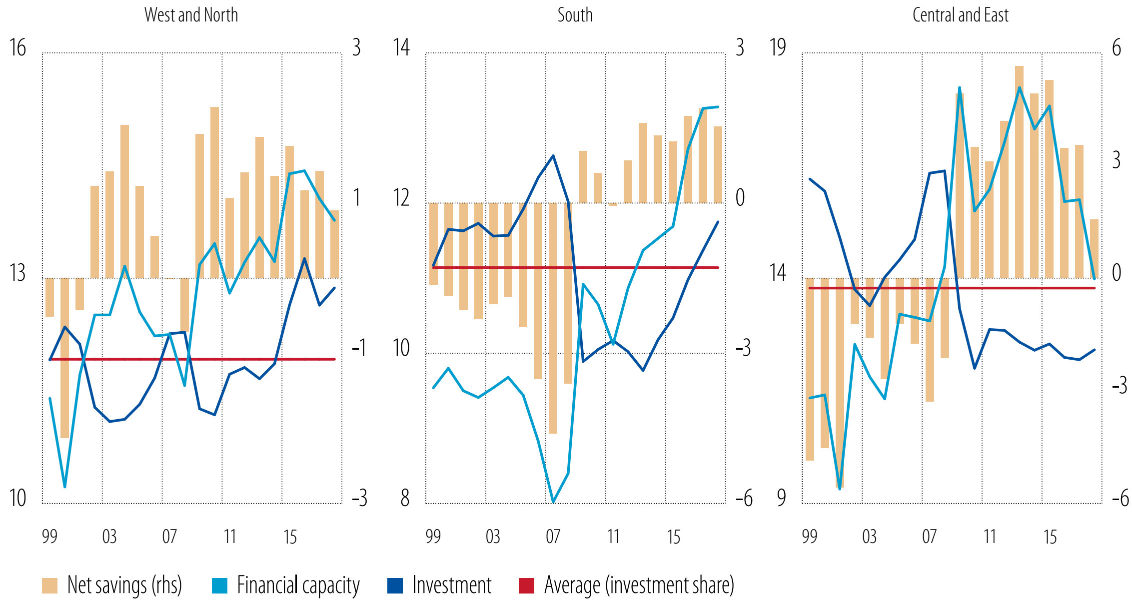
During the most recent upturn, the EU corporate sector remains a net saver as business is reluctant to invest. Capital expenditure continues to fall short of the financing capacity of the corporate sector as a whole (Figure 1). This contrasts with historical trends from the end of the 1990s until the end of 2008. Both in Southern and Central and Eastern Europe, corporates switched from being net borrowers during the pre-crisis period to becoming net savers in the current upturn. More generally, it contrasts with the traditional view that households are net savers while firms are net investors (Figure 11 in Chapter 5). The reasons for businesses' reluctance to invest, despite very low interest rates, are multifaceted, but political or technological uncertainty plays an important role (Bughin et al., 2017).

Remaining net savers, European firms are continuing to strengthen their financial structure, partly by reducing indebtedness and partly by accumulating financial assets. As shown in Figure 1, in 2018, as a % of GDP, net saving ratios declined in Western and Northern and Central and Eastern Europe, but fluctuated within a narrow range in Southern Europe. The decline was due to a stronger deceleration in internal financing resources than in corporate investment. In 2018, net savings of corporates amounted to 1, 1.5 and 2% respectively in Western and Northern, Central and Eastern and Southern Europe.

1 Internal financing resources are calculated as the sum of investment and net lending.

Figure 1

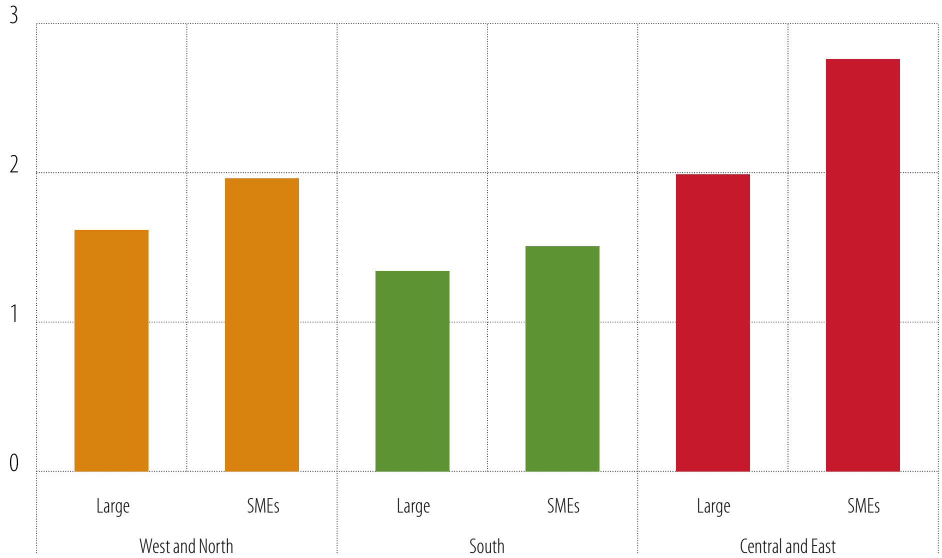
Investment and contributions from internal financing sources (% of GDP)



Source: *EIB Economics department calculations based on Eurostat.*
Note: *The red horizontal line depicts the average corporate investment share of GDP. Last record is 2018:Q4.*

Figure 2

Ratio of internal vs external sources used to finance investment (average, 2016-2018)



Source: *EIBIS 16, 17 and 18.*

Firms tend to finance their investment activities predominantly through internal sources (Figure 2). If anything, the reliance on internal funds has increased since 2016. The ratio of internal funds over external funds rose from 1.7 to 1.8 in Western and Northern Europe and in the European Union as a whole.

The increase was similar in Southern Europe, from 1.4 to 1.5. It was more pronounced in Central and Eastern Europe, from 2.1 to 2.5. The fact that firms meet the bulk of their financing needs through internal sources is not particular to the firms in our sample, but rather a general characteristic of firms' financing mixes. As shown in Figure 2, this characteristic is even more pronounced for small and medium-sized businesses (SMEs). This reflects the pecking order theory of corporate finance: a firm uses internal funds first and only borrows when such funds are insufficient.[2]

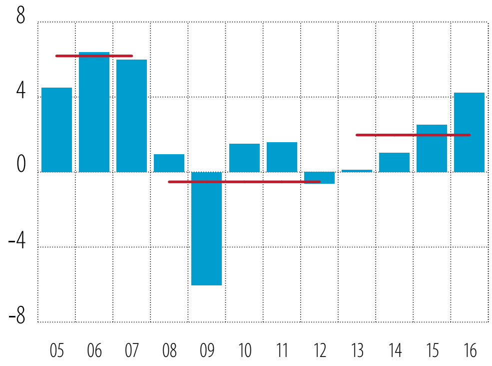
Evolution of internal financing capacity

Despite the upturn, the acceleration in corporate sales has remained moderate until very recently. Figure 3 plots the annual increase in corporate sales. On average, the median annual increase in sales declined from 6.2% pre-crisis to -0.5% during the crisis and has rebounded to only 1.9% during the current upturn. However, the latest records, up to 2016, suggest a marked acceleration.[3]

While sales growth is higher for more indebted companies, after deducting net interest expenses, net income is lower for them. For each period, the red dots in Figure 4 show the difference in the median of annual sales growth between highly indebted firms and those with low levels of debt. Since the red dots are always in the positive quadrant, across all periods, the higher the level of indebtedness, the higher the sales growth. This suggests that, on average, debt is used to finance production capacity expansion and enables corporations to fuel higher demand. However, as shown in the figure, after taking into consideration the cost of debt, net income over assets tends to be lower for the most indebted companies.

Figure 3

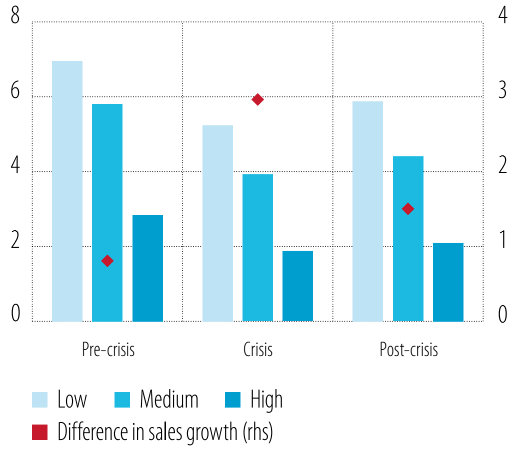
Median annual sales growth (median, annual growth, %)



Source: *EIB Economics department calculations based on the EIBIS-Orbis matched sample.*
Note: *Last record 2017. The horizontal lines report the averages over the pre-crisis, crisis and upturn periods.*

Figure 4

Net income over assets and differences in sales growth (%, conditioned on the indebtedness ratio)



Source: *EIB Economics department calculations EIBIS-Orbis based on the matched sample.*
Note: *Low, medium and high indebtedness ratio refers to the average of the three lower, median and upper deciles. The differences reflect the sales growth in the high decile minus the low decile.*

2 The coverage of the corporate sector in Orbis with micro data lags behind the historical period. In Central and Eastern Europe, the difference between internal and external financing is amplified by the more prominent role played by intra-group funding, which is not reported in the figure.

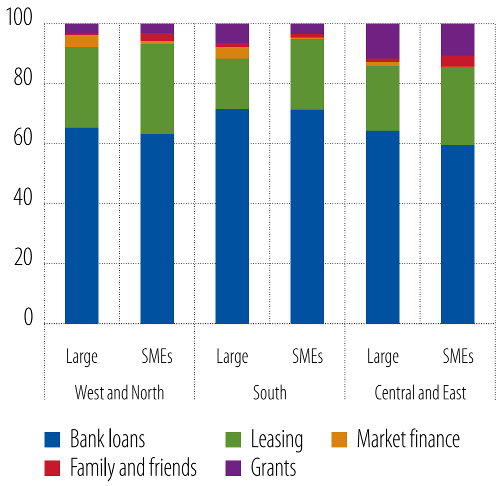
3 Throughout the chapter, the three periods – pre-crisis, crisis and upturn – will be considered consistently. They refer respectively to 2005-07, 2008-12 and 2013 to the latest records (2016 in the case of Figure 3).

The current low interest rate environment remains very supportive of corporates' income. After taking into account the reduction in net interest expenses, the recovery in net income appears stronger than in sales. At the EU level, average income has rebounded, moving from a pre-crisis level of 8%, to 1% during the crisis, to 5% in the current upturn.[4] Looking across regions, the recovery is more pronounced in Southern Europe, where the pace reached 5%, higher than the pre-crisis level of 4%. Conversely, income looks anaemic in Central and Eastern Europe, where the pace is marginally higher than during the crisis and well below the pre-crisis periods.

External financing and components

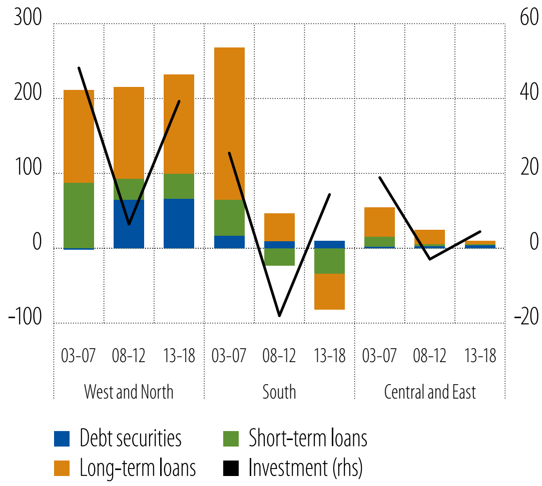
Turning to the types of external sources, bank loans are in first place, followed by leasing (Figure 5). Bank loans tend to be less prominent for small businesses, compensated by a stronger contribution from family and friends and a tendency to use leasing. However, for small businesses, market finance is almost non-existent. It plays a very marginal role for large corporations, and mostly in Western and Northern Europe. This pattern has remained unchanged since the first wave of the EIBIS in 2016.

Figure 5
Breakdown of external sources



Source: EIBIS 16, 17 and 18.

Figure 6
Change in corporate investment and variation in main components of external financing (annual average, EUR billions)



Source: EIB computation based on Eurostat.

Investment patterns remain almost unchanged, although debt securities have increased since the crisis. Figure 6 takes a longer time perspective and depicts the changes in the external financing structure of investment across Europe in the three periods. The contribution of debt securities has clearly increased in Western and Northern Europe, partly on account of the Corporate Bond Purchase Programme conducted by the European Central Bank (ECB).[5] However, for the other periods and regions, the financing mix has not changed much. Over the three periods, the magnitude of external financing moves accordingly to capital expenditure but its composition is mostly unaffected.

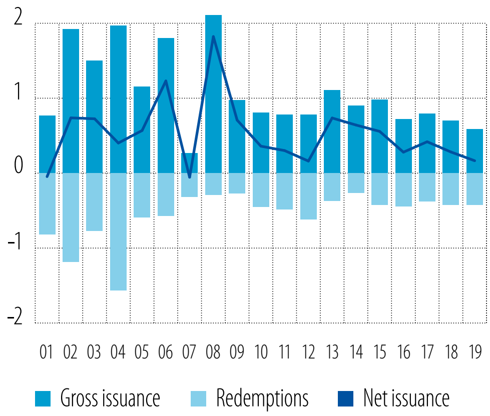
Net equity issuance remains subdued, although not owing to buy-backs. In the United States, net equity issuance is dampened by share buy-backs by firms and merger and acquisition activities (Deloitte, 2019b). This slows down the increase in the equity base despite strong issuance of new equities. We

4 Computations based on Eurostat Sectoral Accounts.
5 EIB (2018), Box C, "Corporate bond market stimulus and access to finance for bank-dependent firms."

analyse the intensity of the phenomenon in Europe. Figure 7 reports the evolution of the stock of European equities broken down into gross issuance and redemptions, which include both buy-backs and closures. Clearly, the level of activity differs between the pre-crisis and post-crisis periods. Moreover, beyond a very slight rebound in 2017, growth in the equity base is decelerating despite the upturn since the beginning of 2013. However, the slowdown is mostly attributable to lower issuance of new equities rather than increased buy-backs.

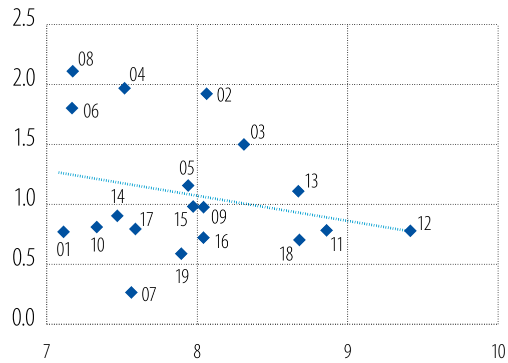
The high cost of European equities helps to explain the weak issuance activity. Using a discounted dividend model, we estimate a proxy for the cost of European equities of European stock.[6] In Figure 8, we correlate gross issuance activity (as gross issuance over the lagged stock) and lagged cost of equity from 2001 until 2019. The figure suggests that the higher cost of equity impedes issuance as there is a negative correlation between the two. In the euro area, despite lower interest rates and the parallel downward shift of the yield curve for safe assets by around 400 basis points since the crisis, the cost of equity remains high.

Figure 7
Equities issuance and redemptions
(annual change and contributions, %)



Source: EIB Economics department computations based on ECB and Thomson Reuters.
Note: Non-financial corporate sector only.

Figure 8
Cost of equity (x-axis, %) **and gross issuance** (y-axis, % per year)



Source: EIB Economics department computations based on ECB and Thomson Reuters.

European companies remain very reluctant to issue equities. Figure 9 reports the percentage of firms that would like equity finance to play a larger role in their funding. In the European Union overall, this is the case for less than one firm in 50. While this lack of interest is shared across the three regions, it is even more pronounced in Southern Europe. There are several reasons for this, including the high cost of equity, the existence of a tax bias in favour of debt, the fear of being diluted and losing control and a lack of financial literacy.[7]

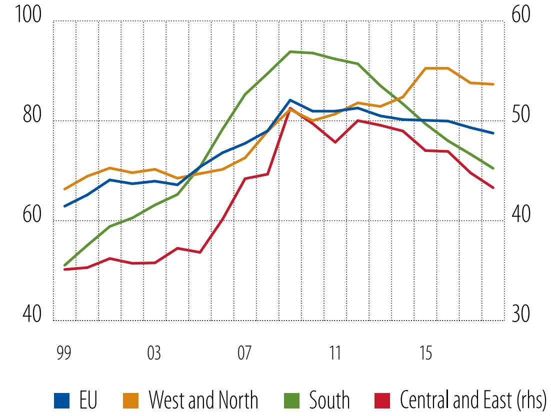
The corporate indebtedness rate is continuing to decline in the European Union. As shown in Figure 10, since peaking at around 84% of GDP in 2009, the decline in corporate indebtedness has been relatively modest overall, about 7 percentage points. However, the evolution throughout the European Union reflects very contrasting movements, with debt ratio having increased by 5% in Western and Northern Europe, and declined by 23% and 8% in Southern and Central and Eastern Europe, respectively. In these two regions, the indebtedness ratio is lower than in 2007, just before the crisis.

6 For more details, see Box A, Chapter 6, EIB (2018). In the estimates reported, a long-term growth rate of 1.5% is assumed.
7 For more details, see Chapter 6 in EIB (2018).

Figure 9
New equities as a preferred source of finance by corporates
(% of respondents)

Source: EIBIS16, 17 and 18.
Note: Based on question Q36: which type of finance would you like to play a larger role? New issued equity.

Figure 10
Corporates' indebtedeness
(loans and securities, % of GDP)



Source: EIB Economics department computations based on Eurostat.

The decline in the debt was sharper for less indebted corporations. Figure 11 portrays the median level of the debt-to-asset ratio of firms in the three regions, for the pre-crisis period and the current upturn. The evolution for firms with low debt (those corresponding to the three first deciles) is compared to that of highly indebted firms (corresponding respectively to the first three and last three deciles). In Western and Northern Europe, the indebtedness rate declined by 10 percentage points for the least indebted firms and 4 percentage points for the most indebted. Over the same period, it declined by 7 percentage points for the most indebted firms and 3 percentage points for the least indebted firms in Southern Europe. In Central and Eastern Europe, it declined by 5 percentage points for the least indebted and did not change for the most indebted. In each region, the decline in the indebtedness ratio was sharper for less indebted companies.

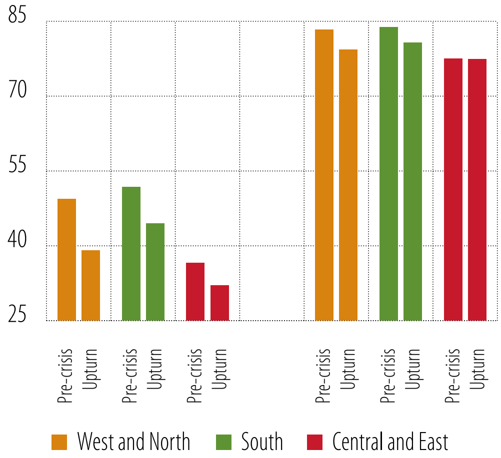
The lower cost of borrowing reflects monetary policy, which remains very accommodative in most EU economies. In the euro area, Sweden and Denmark, both short and long-term term rates remain at historically low levels.[8] Since the crisis, short-term rates have declined by more than 450 basis points and long-term rates by around 500 basis points.[9] Consequently, the compounded cost of finance, averaging the costs of short and long-term debt securities and bank loans, has declined by more than 400 basis points since the crisis. The decline was somewhat stronger in Southern Europe. During the current upturn, the spread between the returns on investment and interest rates has widened in many economies. This movement should have created investment opportunities. But the elevated uncertainty, both technological and political, and entrepreneurs' aversion to risk have been a drag on investment.

The lower cost of finance and reduced indebtedness have alleviated the debt burden for firms overall. Figure 12 shows that interest expenses have been falling continuously since the crisis, reaching historically low levels in 2018. In the European Union, interest expenses as a percentage of GDP declined more than 3.4 percentage points compared to the pre-crisis peak. The decline was of a similar magnitude in Western and Northern Europe and Central and Eastern Europe, between 2.7 and 2.8 percentage points of GDP,

8 See Chapter 5 for more details.
9 The short-term rate refers to the euro interbank offer rate at three months, and the long-term rate refers to the euro area 10-year sovereign bond yield. The variation covers the period August 2008 to August 2019.

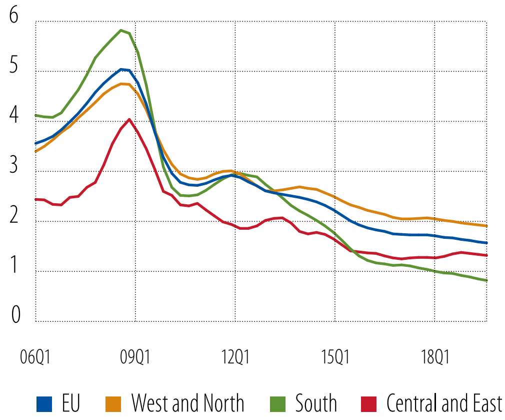
and stronger in the Southern Europe (4.8 percentage points). While the decline continued somewhat throughout the year, the change recorded since the middle of 2018 was very minor for most EU economies.

Figure 11
Indebtedness ratio
(debt to asset, % first quartile, left and third quartile, right)



Source: EIB Economics department computations based on the matched EIBIS-Orbis sample.

Figure 12
Indebtedness expenses (% GDP)



Source: EIB Economics department computations based on Eurostat.

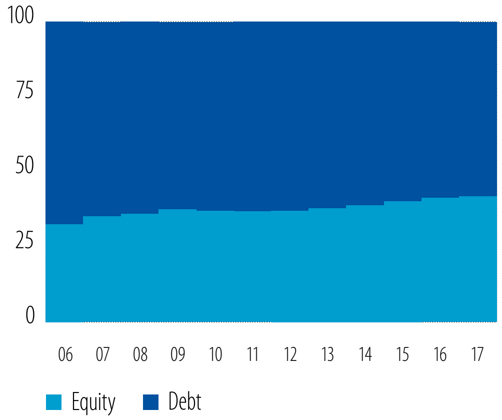
Lower debt should strengthen the corporations' resilience to a possible downturn. The capital ratio of EU corporates has risen by almost 10 percentage points since 2006. This corresponds to an increase of close to 30% (Figure 13). Since equity finance is immune to the rollover risks of other debt and provides a cushion againt losses, the lower dependence on debt and increased preference for equity finance bodes well for the resilience of the corporate sector.

The low rate and uncertain environment is pushing companies to accumulate assets that mostly consist of cash and deposits. Figure 14 clearly shows the upward trend in cash and deposits as a percentage of GDP in the European Union as a whole and the three regions. From 2005, which marked the previous upturn, to 2018, the ratio increased by 8% in the European Union, more in the Western and Northern Europe than in the Southern and Central and Eastern Europe (9%, 7% and 6%, respectively). The lower increase in Southern and Central and Eastern Europe reflects the fact that in these economies, net savings were tilted more towards the reduction of debt than cash accumulation. This evolution may mask opposite trends within the corporate sector that require granular information to detect.

Corporates more concerned about uncertainty accumulate more cash. Figure 15 depicts the change in the cash position of firms from 2017 to 2014, for the European Union overall as well as the three regions. The change is examined with respect to the group of corporates that do not consider uncertainty to be an obstacle to investment and those that see it as a major obstacle. The figure shows that in the European Union, and even more so in the Central and Eastern and Southern Europe, corporations more concerned about uncertainty accumulate more cash.

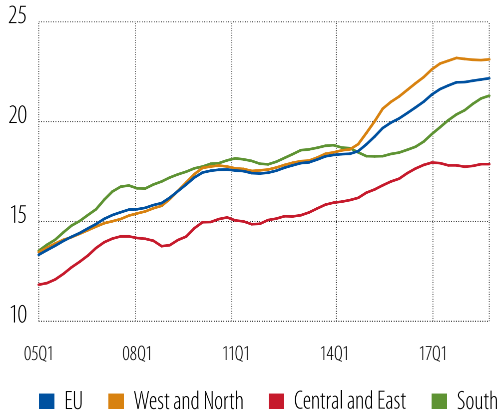
Cash accumulation, combined with weak investment and corporate lending activity, partly reflects the rise in the share of intangible investment (DellAriccia et al., 2018). On the one hand, intangible investment is not properly measured in national accounts. On the other, being more difficult to collateralise, intangible investment is financed internally, and therefore requires accumulated cash. Given the scarcity of external financing, firms investing in intangibles are depending on their cash reserves (Brown et al., 2011 and Brown et al., 2012). Furthermore, most intangible capital is created by skilled workers investing their human capital, so it requires lower upfront outlays. Döttling et al. (2017) show that in the United States, firms focusing on intangible activities have larger cash flows and lower total investment spending. Figure 16 shows the same conclusion for EU firms: firms holding more cash tend to invest relatively more in intangible assets.

Figure 13
Stylised liability structure of European corporates (median ratio, %)



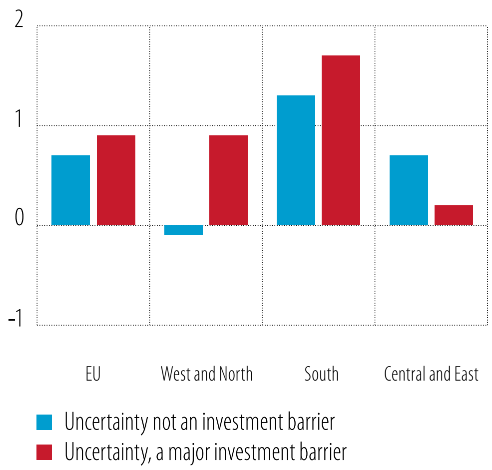
Source: EIB Economics department computations based on Orbis-EIBIS matched sample.

Figure 14
Cash and deposits of corporates (% of GDP)



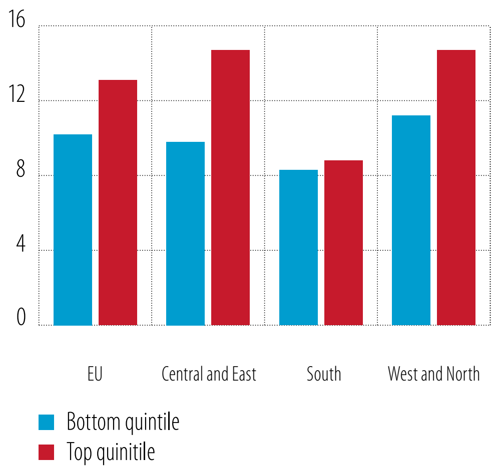
Source: EIB Economics department computations based on Eurostat.

Figure 15
Change in cash position and uncertainty as an investment barrier (%)



Source: EIB Economics department computations based on Orbis-EIBIS matched sample.
Note: Annual change in cash over total asset ratio between 2017 and 2014.

Figure 16
Corporates´ cash holdings by intangible quintiles (% of total assets)



Source: EIB Economics department computations based on Eurostat.

Cash accumulation also partly reflects the rising profits and the tax optimisation of large multinationals (Chen et al., 2017). Trends in firm savings rates are closely related to firm age or size. Increases in overall corporate saving within industry and types of firms, rather than shifts of economic activity between groups, account for the majority of the global rise in corporate savings. The shift, therefore, is unlikely to reflect a more structural change. The main contributor to the increase in savings comes from increases in firm profits. Multinationals may also play a role given their ability to shift profits across countries, and hold the money where tax rates are lower.

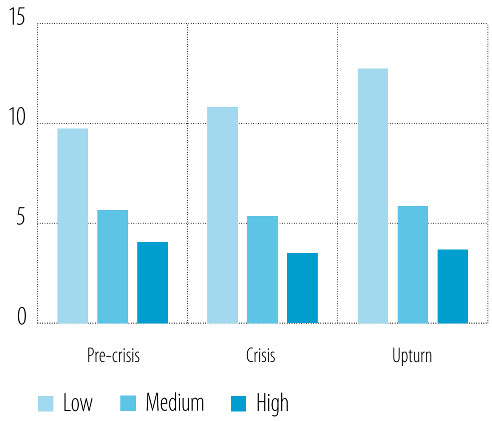
The information collected emphasises the trade-off between cash accumulation and debt reduction. Figure 17 depicts the evolution of the cash ratio, measured as cash and deposits over assets, for the least, medium and highly indebted companies. The cash ratio increases recorded from before the crisis to the current upturn appear only for the least indebted corporations. Conversely, for the most indebted, the ratio slightly declined.

Receding financial frictions and pent-up capital demand

Disentangling the role of financial conditions, changes in demand, expectations and uncertainty is key to understanding the investment dynamic. Focusing on finance constraints, we estimate a simple cross-sectional investment function. Efficiency requires the financing of firms with a market value below the replacement value, as this gap (Tobin's Q) signals that profits are expected to rise. Accordingly, the more firm investment reacts to deviations from a unit value of Q, the more efficient capital spending is. Q measures are not observable, however. We therefore rely on the approach developed by Wurgler (2000)[10] and estimate the elasticity of investment growth (proxying growth in financing) to sales growth (proxying economic growth). To identify breaks, the estimation is replicated separately for the three EU regions.[11] The results are shown in Figure 18.

Figure 17

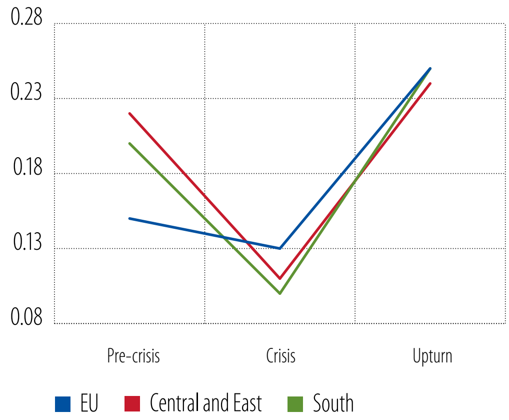
Cash-to-asset ratio of non-financial corporations (% assets, conditioned on the debt-to-asset ratio)



Source: EIB Economics department computations based on the matched EIBIS-Orbis sample.

Figure 18

Estimated investment elasticity to sales



Source: EIB Economics department estimations based EIBIS-Orbis matched sample.

Note: Random effect estimation controlling for real interest rates and lagged effects.

10 Assuming a Cobb-Douglass production function, $Y = K\alpha$ Then $\Delta s = \alpha.inv/K + ...$Hence, $inv/K = 1/\alpha \, . \, \Delta s$ + controls + lags. When estimating, we control for sector and country to reflect the specific characteristics of the production structure.

11 We implement random effect estimations in which we control for lagged effects and the cost of borrowing. Time-specific and country-specific dummies are also introduced.

The investment response to sales declined during the crisis due to financial frictions but has bounced back since the upturn. The decline was more pronounced in Southern and Central and Eastern Europe; conversely, the elasticity hardly changed in Western and Northern Europe (Figure 18). During the crisis period, at the firm level, investment was reacting less to demand. In the current period, the estimation suggests a return to normal as the elasticity has rebounded to the pre-crisis level.

It does not appear that the pent-up capital demand accumulated during the crisis stimulated corporate investment. Financing conditions have remained very favourable during the recent upturn (See Chapter 5, Figure 7) and demand remained relatively high until the middle of 2018. Still, the pick-up in corporate investment has remained relatively modest. If anything, the debate between those claiming corporate investment is normal (Döttling et al., 2017) and others (Constâncio et al., 2017) show the lack of clarity on the issue of whether investment is proceeding normally or is hampered by factors specific to this cycle.

The corporate environment

Access to finance

Financing constraints for EU firms are unchanged from previous years and remain highly varied across countries and business segments. The share of firms that having difficulty finding external finance in the European Union stands at 5%. The figure is in line with last year's value and markedly lower than in 2016 and 2017 (Figure 19).

Figure 19

Proportion of finance constrained firms (%)

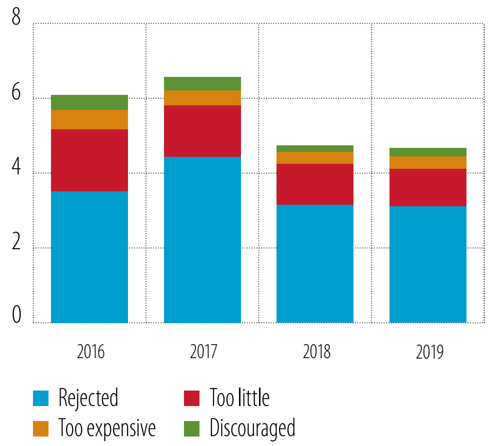
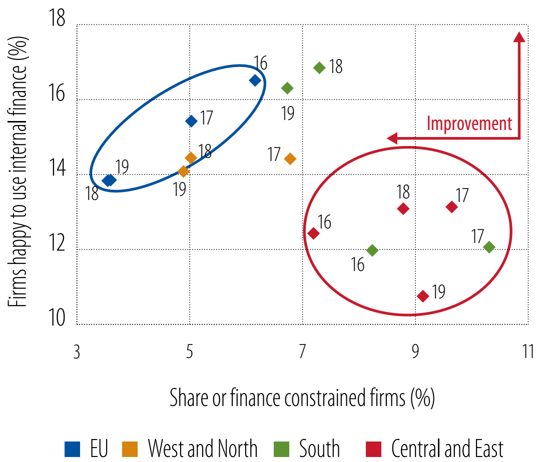


Figure 20

Financial cross (see footnote)



Source: *EIBIS 16, 17, 18 and 19.*

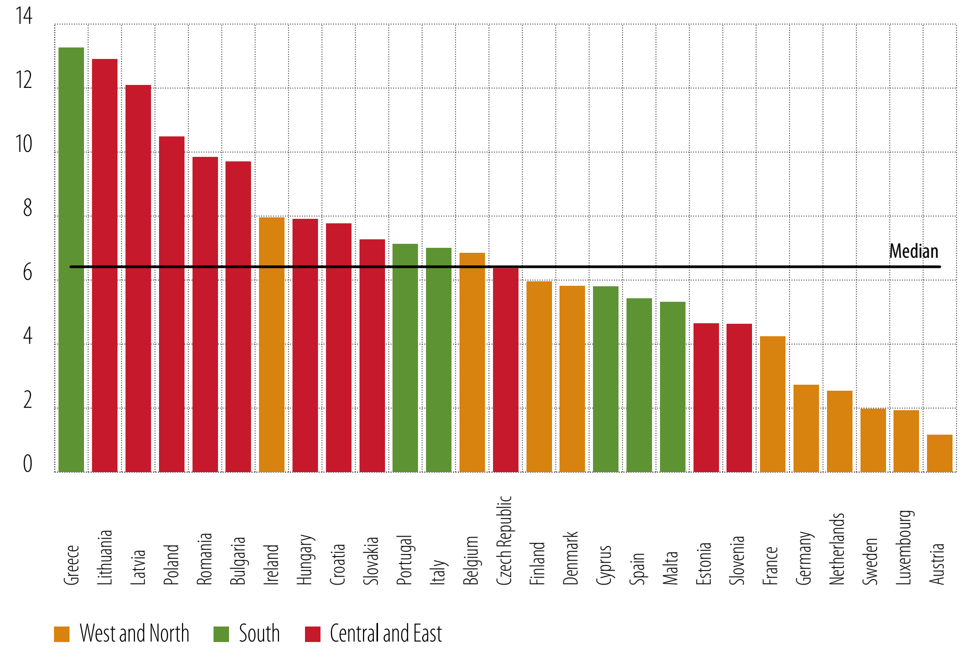
Note: *Financial constraint indicator includes: firms dissatisfied with the amount of finance obtained (received less), firms that sought external finance but did not receive it (rejected), and those that did not seek external finance because they thought borrowing costs would be too high (too expensive)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

External financing conditions are structurally more adverse in Central and Eastern Europe, while they have improved substantially in Southern Europe. In Figure 20, we correlate two results from the EIBIS. The finance constrained indicator and the willingness to use internal finance. Financial constraints are less likely to hamper investment when the desire to access external funds is weaker. Hence, on the figure, when going upwards or to the left, investment financing conditions improve.

Two features emerge: Central and Eastern Europe are in the weakest position, and conversely Western and Northern Europe are in the most favourable position, with both regions recording minor changes. 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. This suggests the absence of stigmas from the crisis in this region.

The overall improvement in the conditions for accessing external finance masks a persistently wide dispersion across the EU regions and economies. Figure 21 plots the proportion of finance constrained firms across countries. It ranges from a minimum of 1.2% in Austria to a maximum of 13.3% in Greece. Consistently with Figure 20, apart from Ireland and Belgium, all the economies where the indicator is above the median belong to Central and Eastern and Southern Europe. Conversely, for most of the economies in Western and Northern Europe, the indicator is below the median.

Figure 21
Share of finance constrained firms by country (share of firms, %)

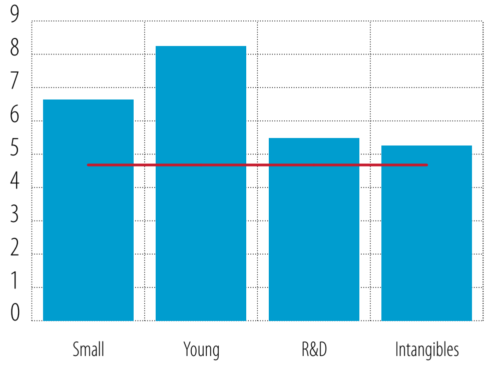


Source: *EIBIS 2019.*
Base: *All firms.*

While lack of finance is not among the most prominent impediments to firms´ investment, in the European Union clear bottlenecks remain (Figure 18 in Chapter 1). Finance is hard to find in some countries and for certain segments, such as smaller and younger firms as well as innovative firms and firms with a higher investments in intangibles (Figure 22).

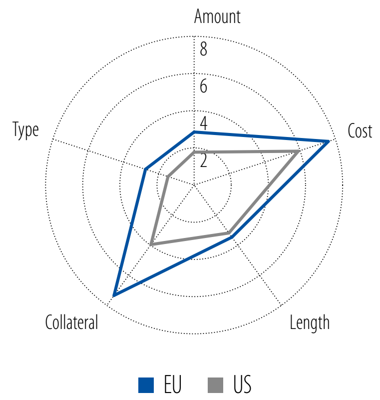
EU firms tend to be less satisfied with the financial offerings than their US peers. Figure 23 shows the share of firms that are dissatisfied with either the type of finance received, the collateral requirement linked to their funding, the maturities available, the cost of finance, or the amount of finance received. It shows that both in the European Union and the United States, firms are most dissatisfied with the collateral requirements and cost of funding. The extent to which this is true, however, varies in the European Union compared to the United States, with the share of EU firms that are unhappy with collateral requirements almost twice the share in the United States. The same is true for the cost of funding (1.3 times).

Figure 22
Finance constrained for specific type of firms (share of firms)



Source: EIBIS 16, 17 and 18.

Figure 23
Sources of dissatisfaction with finance in the EU and US (in %)



Source: EIBIS 16, 17, 18 and BIS.
Note: The x-axis reflects bank dependence, the share of loans over loans, debt and equities from the survey. The y-axis reports the EIBIS (half minor and major, averaged over 16-19).

Finance constrained firms report stronger investment gaps. Figure 24 portrays the investment gaps for firms in the European Union and in each region separately. Clearly, compared to non-finance constrained firms, finance constrained firms tend to report investment gaps more frequently – by about 15 percentage points. Alves et al. (2019) show the need to control for possible omitted variable bias in this association, noting that both the investment gap and the finance constraints reflect the weakness of corporate balance sheets. Indeed, “weaker” firms – i.e. those defined as smaller, and/or more indebted, and/or less profitable and/or with lower liquidity positions – tend to report more impediments. But, after controlling for the firms’ characteristics, reporting an impediment provides a signal for investment. Firms reporting impediments are more likely to indicate an investment gap, and firms reporting a major impediment report a gap even more frequently. The signal intensifies further when it is given by firms that are smaller or more indebted.

Investment barriers

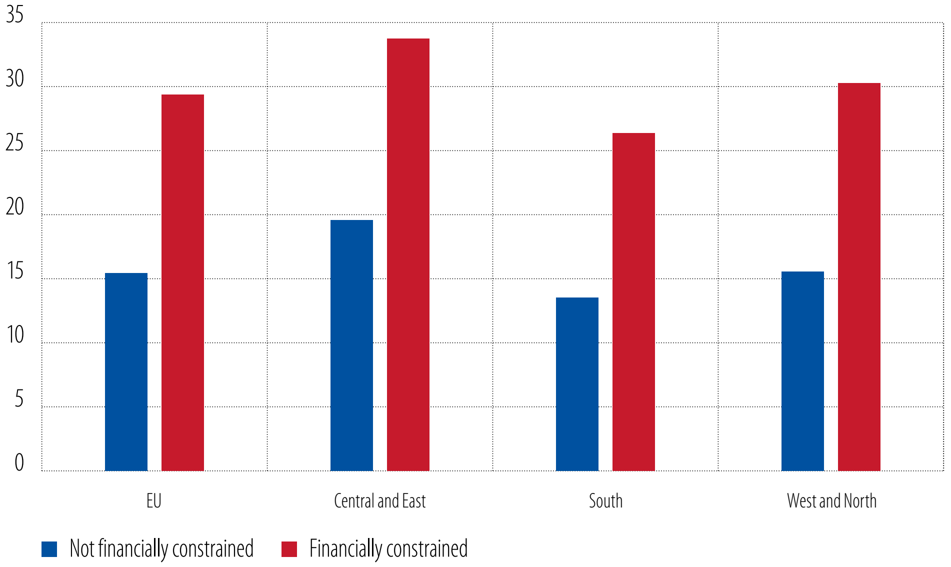
There is some evidence that finance constraints seem to be more of an obstacle in more bank-dependent economies. Figure 25 puts in perspective the two indicators for each of the EU economies. Each percentage point increase in bank dependence is accompanied by a 0.9 percentage point rise in the proportion of companies reporting finance constraints as an obstacle to investment. The relationship, while very simple, displays an R-square of 43%. This suggests that a weaker finance offering, traditionally associated with more bank dependence, tends to generate more financial frictions and more impediment to investment.

Inadequate access to finance can have long-lasting effects on firm competitiveness. If firms are credit constrained when new technological opportunities arise, they can fall behind as economies of scale and winner-takes-all tendencies put them at a disadvantage.[12] It may take a very long time to recover. Europe’s

12 To make this point, in a forthcoming working paper, we interact an exogenous funding shock with sectorial robotisation activities. See Brutscher, P.B. and Saidi, F. (forthcoming).

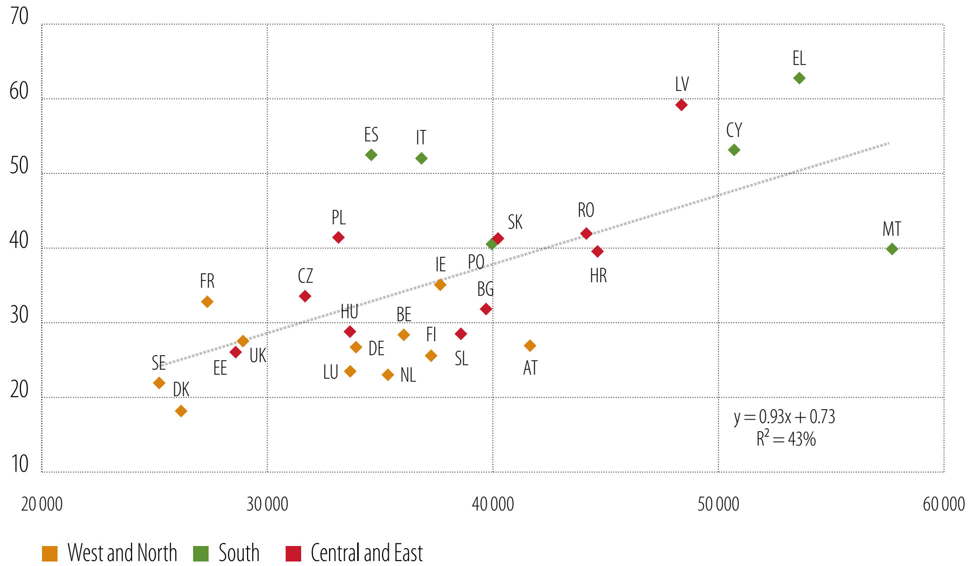
corporate sector is lagging behind that of the United States in terms of digitalisation (Figure 26) and lack of access to finance can be a barrier to adopting digital technologies, especially for small businesses. EIBIS data suggest that firms that do not digitalise face more finance constraints (Chapter 3). Europe is also well behind its main international competitors for start-up creation.

Figure 24
Finance constraints and investment gaps (%)



Source: EIBIS 16, 17 and 18.

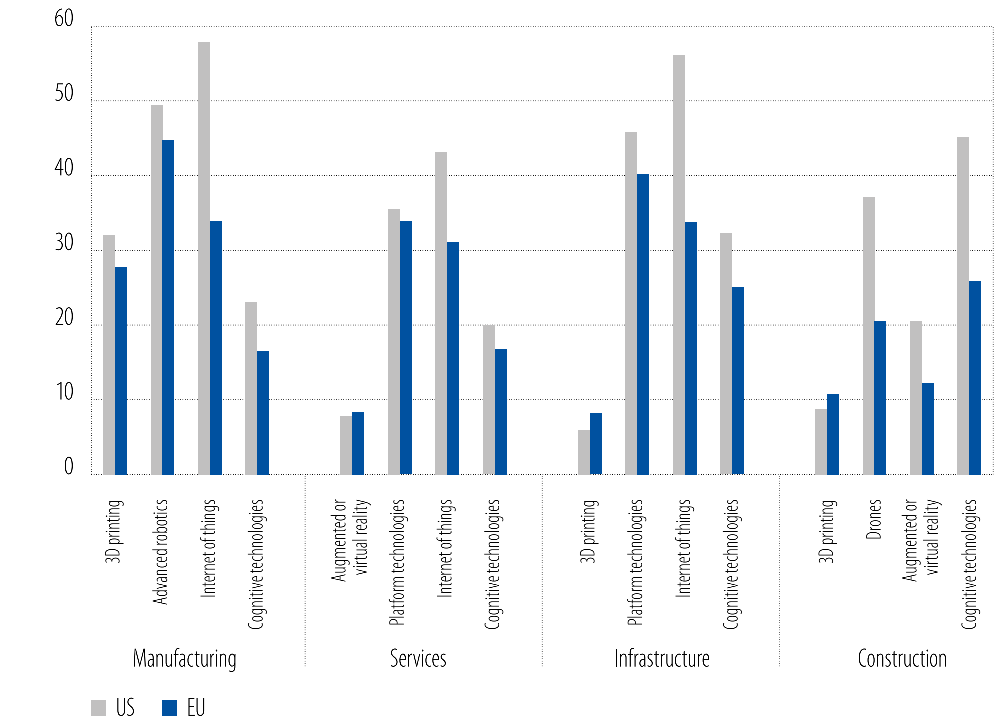
Figure 25
Bank dependence (x-axis, %) **and finance constraints as an obstacle** (y-axis, %)



Source: EIBIS 16, 17, 18 and the Bank for International Settlements.
Note: The x-axis reflects bank dependence, the share of loans over loans, debt and equities from the survey. The y-axis reports the EIBIS (half minor and major, averaged over 16-19).

Figure 26

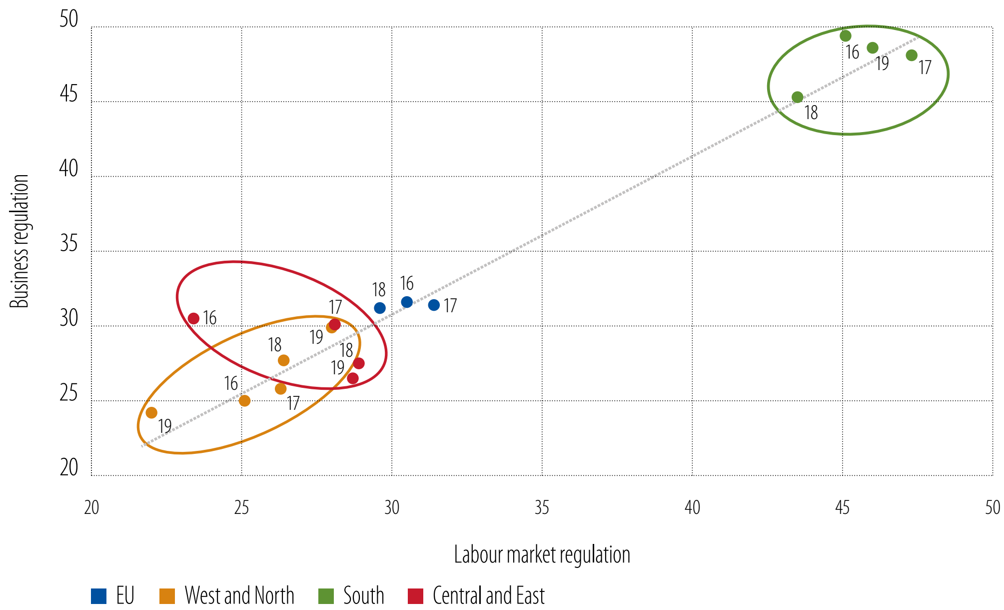
Adoption of digital technology (%)



Source: *EIBIS 19.*
Base: *All firms.*

Figure 27

Regulation as a major obstacle to investment activities (proportion of firms, %)



Source: *EIBIS 16-19.*

Lack of finance is not the main impediment to investment. It comes well after uncertainty, lack of skilled staff, and regulation (Chapter 1). The regulatory environment is a major concern in Southern Europe. For the three regions and over time, Figure 27 plots the proportion of firms reporting business regulation and labour market regulation as major impediments to investment, respectively on the y-axis and x-axis. There is a clear correlation between these two dimensions of the regulatory environment. Besides, regulation is clearly more of a concern in Southern Europe than in Western and Northern or in Central and Eastern Europe.

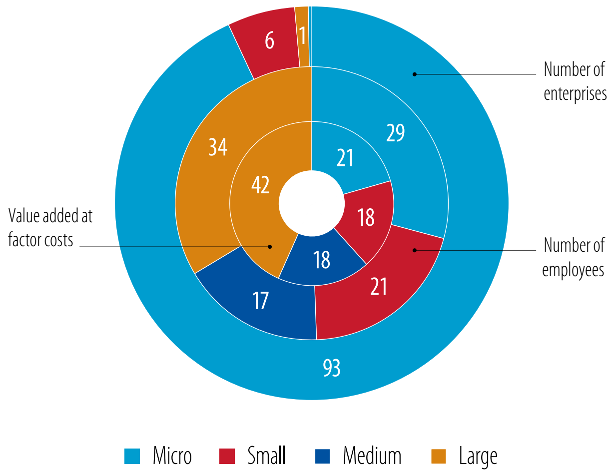
Environment and financing conditions of small businesses

Small businesses are perceived as being riskier than larger firms for several reasons.[13] First, they are young, small, less transparent and, in many cases, family-run or owned by a single individual. Second, their financial structure is more rigid than that of large companies as they more dependent on bank finance and their capacity to obtain external funding is more limited. Third, estimating their creditworthiness is more challenging, as they are younger and subject to fewer reporting obligations. Finally, they are perceived as riskier because they have a higher exposure to idiosyncratic shocks and tend to have less collateral.

Small businesses, however, contribute significantly to European job creation and economic growth. Figure 28 illustrates the crucial role of small firms in European business. In 2017, 24.5 million small businesses 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 56.8% of total added value (EUR 4 161 billion).

While small firms are relevant across the EU corporate ecosystem, their importance differs across economies. Small businesses in Greece, Cyprus and Malta account for more than 80% of all jobs, while in France, Germany and Denmark small businesses account for less than 65% of all jobs, and in the United Kingdom, 54% (European Commission, 2018).

Figure 28
Small businesses in the corporate ecosystem (%)



Source: *European Small Business Finance Outlook (ESBFO), based on European Commission (2018).*

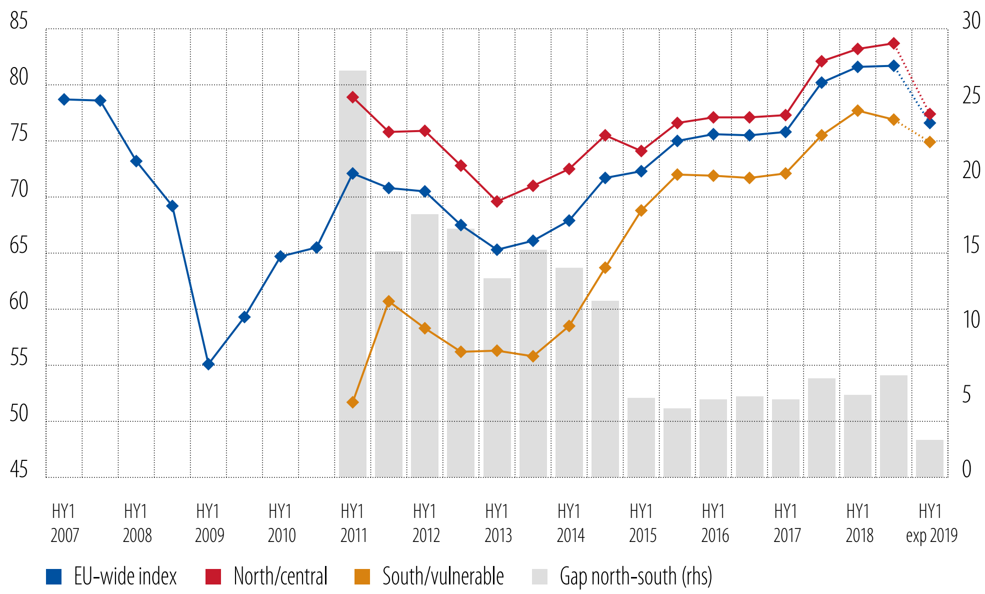
13 Large parts of this section are based on Kraemer-Eis et al. (2019), i.e. the latest issue of European Investment Fund's European Small Business Finance Outlook (ESBFO). The ESBFO is published twice per year (typically in June and December) by the Research and Market Analysis division of the European Investment Fund (EIF) and provides an overview of current small business financing in Europe.

The growing optimism of small businesses has waned as the economy has slowed. The EU-wide SMEunited business climate index, while still at its highest level since the beginning of the crisis, stagnated during the second half of 2018 and is projected to decline sharply during the first semester of 2019 (Figure 29). Declining sentiment among small businesses from Southern Europe drove the stagnation. At the same time, small businesses from Western and Northern Europe were able to maintain their optimism, although the index level is expected to decline in the first semester of 2019.

Bank products (loans and overdrafts) are by far the most popular financing instruments, followed by leasing and hire purchase (Figure 30). Equity and factoring, or selling accounts receivables, make up just a small fraction of small businesses' external financing needs. Unfortunately, the Survey on Access to Finance for Enterprises (SAFE) does not include alternative financing instruments, such as crowdfunding, even though they have gained popularity in small businesses' financing mix over the past few years.[14] In general, the financing composition of small firms does not vary strongly over time, although we did observe a decrease in the use of overdrafts, as well as a minor decrease in the use of bank loans and trade credit during the second half of 2018.

Figure 29

SMEunited Business Climate Index (%)

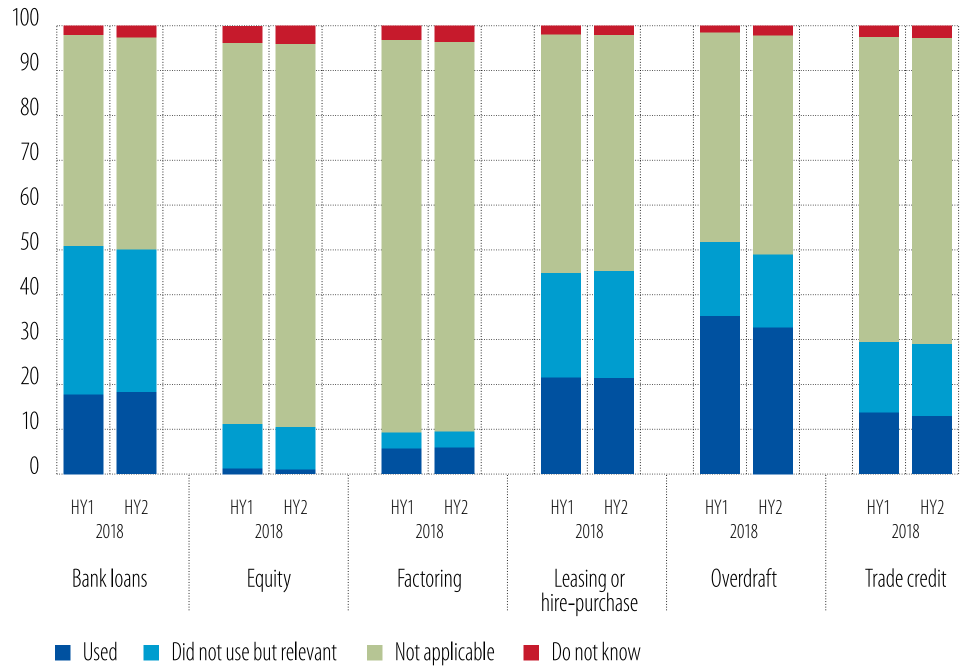


Source: ESBFO (Kraemer-Eis et al., 2019), based on the semi-annual EU Craft and SME Barometer (UPEAME).
Note: The index is calculated as the sum of positive and neutral answers with regard to the overall climate for business, averaged over the current climate and the expectations for the next period.

The role of large institutional investors, such as pension funds and insurance companies, in investment vehicles that provide alternative financing for small businesses is still relatively poorly developed in Europe. This is confirmed by the results of the EIF VC Survey 2018, a survey of European venture capital fund managers. Respondents cited the lack of involvement by pension funds as one of the factors in the underdevelopment of European venture capital (Kraemer-Eis et al., 2018).[15]

14 See Box B in Chapter 5 for a discussion of the growing importance of Fintechs and crowdfunding in European small business funding.
15 The main results of the venture capital survey are discussed in Chapter 5, Box C.

Figure 30
Sources of external financing of European small businesses (%)



Source: ESBFO (Kraemer-Eis et al., 2019), based on ECB SAFE (ECB, 2019b).

Demand, constraints and external financing gaps

External financing for EU small businesses is characterised by large disparities across countries.[16] To synthesise the various sources of information related to small firms' access to finance, the EIF's Research & Market Analysis division has established the EIF SME Access to Finance (ESAF) Index. The ESAF Index is a composite indicator that summarises access to finance for all Member States. It provides a convenient tool to benchmark the overall small business financing market in the European Union, as well as an instrument for specific sub-segments.[17] 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 main results for 2018 are presented in Figure 31. The updated version of the ESAF shows Sweden, Germany and Finland occupying the top three spots. Greece comes last in the ESAF ranking for the sixth consecutive year, preceded by Cyprus and Romania.

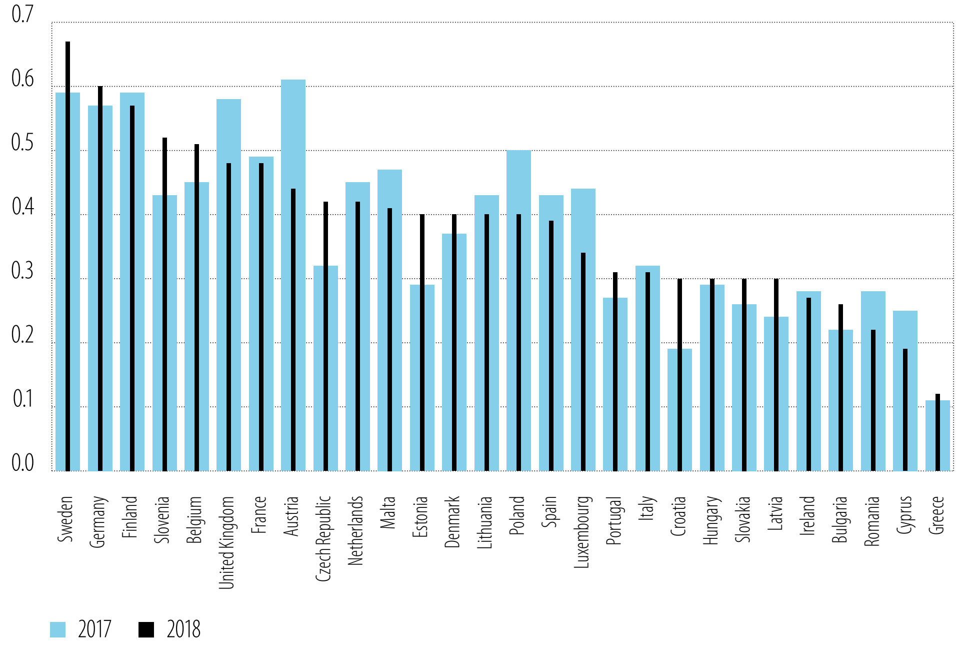
Euro area banks continued to ease credit standards in 2018, both for large and small firms. Figure 32 uses the ECB Bank Lending Survey (BLS)[18] to plot the quarterly net change in credit standards applied to the approval of corporate loans and credit lines. A positive value indicates tightening credit standards, whereas a negative value points to an easing. During the final quarter of 2018, the credit standards applied to small business lending eased for the seventh consecutive quarter.

16 Most of the assessments of small businesses access to external finance are based on survey data, as hard data disaggregated by firm size are rarely available. The sub-section presents evidence from the EU Craft and SME Barometer Survey as well as from the ECB SAFE. These two surveys provide information on the financial and financing conditions of small and medium-sized businesses since 2009.

17 The most recent update of the ESAF Index is elaborated upon in Torfs (2019).

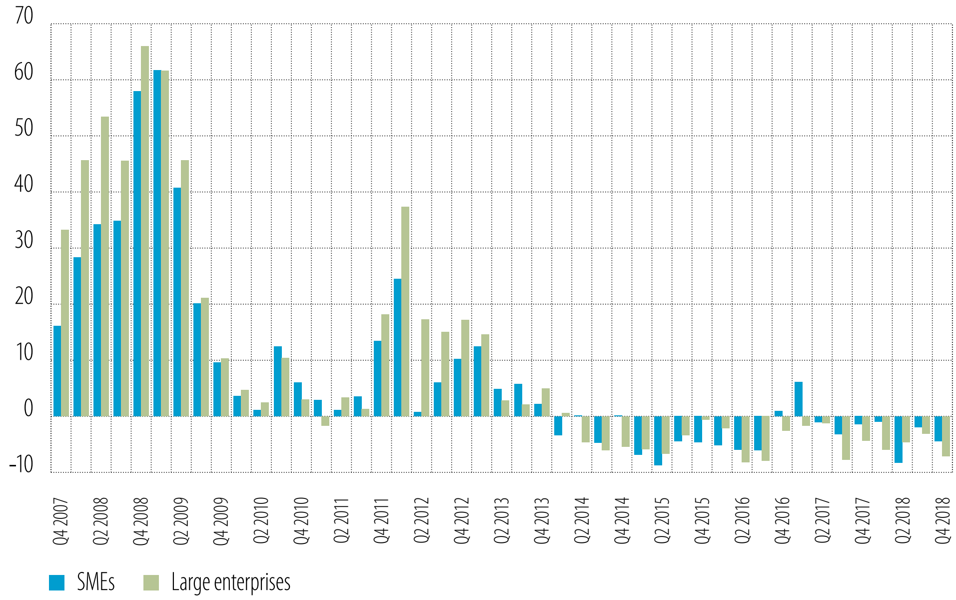
18 The ECB Bank Lending Survey (BLS) is a quarterly survey conducted by the ECB which provides information on the supply side determinants of bank lending (ECB, 2019a).

Figure 31
The EIF SME Access to Finance Index



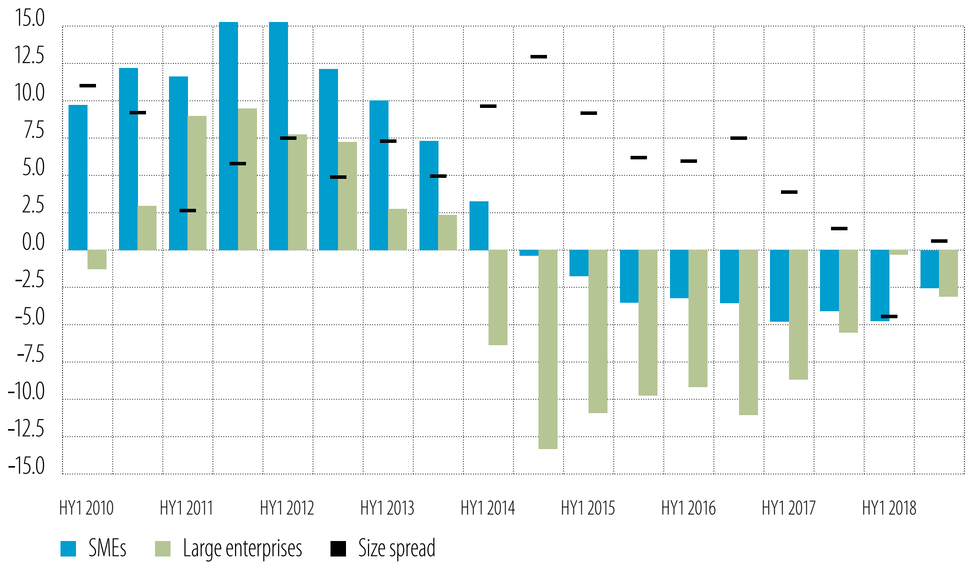
Source: *Torfs (2019).*

Figure 32
Net changes in credit standards applied to the approval of loans or credit lines to enterprises (%)



Source: *ESBFO (Kraemer-Eis et al., 2019), based on ECB BLS. Note: balance of answers between banks reporting an increase and banks reporting a decrease.*

Figure 33
Perceived change in the external financing gap (%)



Source: *ESBFO (Kraemer-Eis et al., 2019), based on ECB SAFE.*
Note: *Balance of answers between corporates reporting an increase and corporates reporting a decrease.*

Small businesses report that easing credit standards have reduced the financing gap. Figure 33 illustrates firms' perception of the external financing gap using a composite indicator constructed by the ECB, which is based on perceived changes in the needs and availability of external financing. Since 2014, the indicator has been negative for both classes of firm size (small and large enterprises), implying a shrinking financing gap. The financing gap shrank substantially faster for large firms in all but one quarter, indicating the disadvantaged position of small businesses on the external financing market.

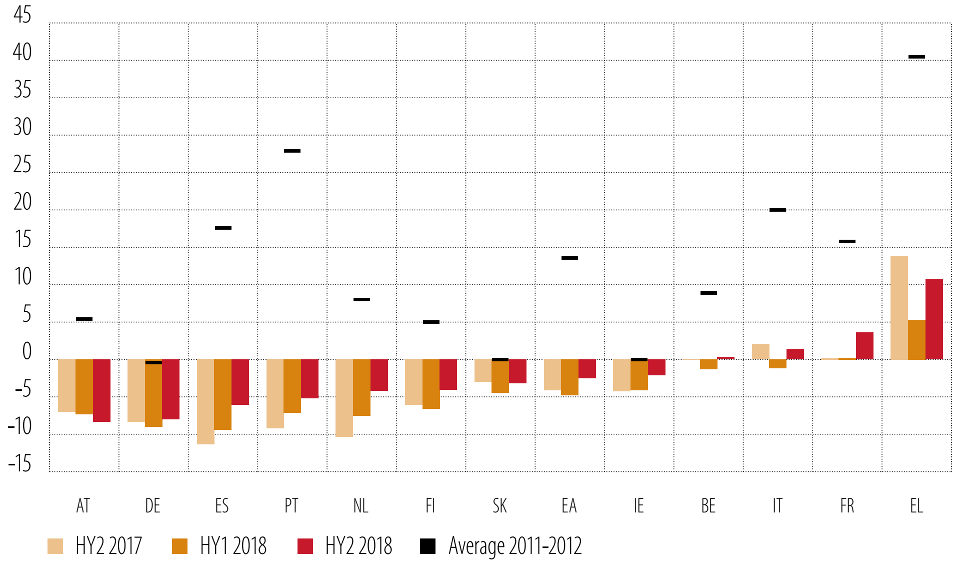
During the second semester of 2018, Greek, French and Italian small businesses reported a growing financing gap, while for Belgian small businesses the financing gap remained roughly constant. In all but three countries, small businesses reported improved access to finance, although those firms' perception of a funding gap has decreased in all countries but Austria. In all other countries for which data are available, SMEs believed the gap between the supply of and demand for external finance was decreasing (Figure 34).

Despite reported improvements in the external financing gap, a significant share of small businesses experience severe issues in accessing external financing. One in four small businesses continue to report severe difficulties in accessing finance, although the level is the lowest since 2012 (Figure 35). The difficulty in getting funds indicates significant credit market failures.

Access to finance differs widely between EU members (Figure 36). According to the SAFE, more than half of Greek small businesses experienced significant problems in finding suitable finance, a 5 percentage point rise compared to last semester. In Italy and Spain, more firms reported difficulties in accessing finance. In Finland, on the other hand, only 11.8% of small businesses reported finance issues, down from 12.2% a semester earlier.

Figure 34

Small businesses' perceived change in the external financing gap (country level, %)



Source: *ESBFO (Kraemer-Eis et al., 2019), based on ECB SAFE.*
Note: *The horizontal black marks denote the average level of the index in 2011–12, the period after the crisis when small businesses reported the highest values of the perceived change in the financing gap.*

Figure 35

SMEs listing access to finance to be a highly important issue, by year (%)

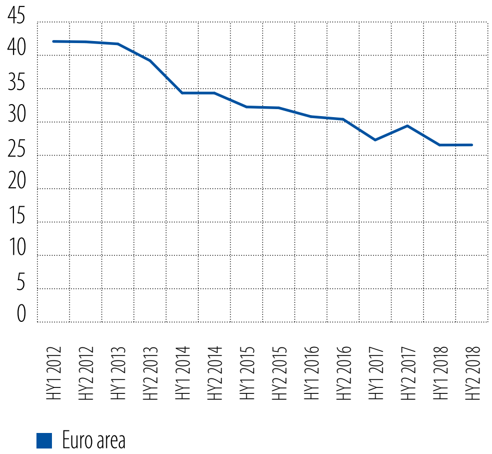
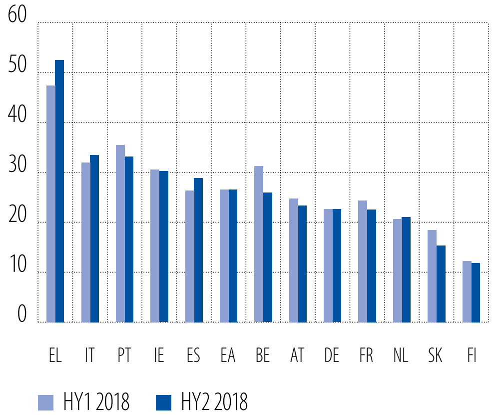


Figure 36

SMEs listing access to finance to be a highly important issue, by country (%)



Source: *ESBFO (Kraemer-Eis et al., 2019), based on ECB SAFE.*
Note: *Limited access to finance is assumed to be a highly important issue if it is rated 7 or more, on a scale of 1 (not important at all) to 10 (most important). This indicator is derived from survey item Q0b, urgency of problems that the firm is facing.*

Box A

Private debt funds[19]

Private debt funds have gained importance among investors in recent years, and are a growing source of financing for small businesses and mid-caps through direct lending funds. Similar to private equity, specialised loan funds operate through an alternative investment fund manager, which originates small business lending opportunities and provides debt rather than equity funding. These managers or alternative lenders are a diverse and expanding group that includes established and emerging asset managers, subsidiaries of larger financial institutions, and, more recently, marketplace or crowdfunding platforms.

Private debt has similarities and differences with bank financing. Commercial banks tend to operate on the low risk (low yield) end of the spectrum, while alternative lenders cover the entire spectrum. Private debt markets are better placed to deal with liquidity risks than banks, because of banks' exposure to deposit withdrawals in difficult market conditions. Private debt also deals better with funding risks, through the imposition of long-term funding commitments for investors or "lock-up periods," which restrict the redemption of invested funds. Firms tend to blend these two sources of finance, indicating that banks could use alternative lenders to meet customers' financing needs. Banks could in turn remain focused on less capital-intensive products and services, while retaining the client.

Private debt, which originally arose as a branch of private equity, is now a stand-alone market. Alternative lenders range from larger asset managers diversifying into alternative debt, to smaller funds set up by former investment professionals (Deloitte, 2019a). Several years after the start of private debt raising, the market split into three main alternative asset classes: (i) senior loans and unitranche, (ii) mezzanine/subordinated loans/hybrid debt-equity and (iii) venture debt. Some already well-established managers are also raising different funds, offering products with a varying levels of seniority (senior loans, unitranches, subordinated loans, etc.). Other products becoming more common are (i) managers targeting sponsored transactions (i.e. financing of a transaction with a financial or industrial equity sponsor) and (ii) managers targeting sponsorless transactions (i.e. financing of a transaction without an equity sponsor).

A large part of the private debt market still remains sponsored, meaning that the leverage component of a private equity operation contains both equity (provided by a private equity fund) and debt (provided, among others, by a private debt provider). Nevertheless, the share of European activity without a sponsor has been almost 20% since the end of 2017 (Deloitte, 2019a). Adopting a sponsorless investment approach could create a competitive advantage for smaller-sized debt funds.

In the last ten years, the global private debt market has almost quadrupled in size. From 2008 to 2018, the capital raised by the top 100 private debt fund managers around the world amounted to USD 626 billion (Preqin, 2018). Around one-third of this market consists of "dry powder," or unused capital commitments, meaning that substantial funds exist for new investments. Private debt has expanded steadily since 2006, with no visible slowdown during the crisis. Competition has become very aggressive on the pricing of sponsored unitranche issuances towards mid-market companies.

The most developed and largest private debt market is the United States, but Europe is growing the fastest. As of August 2018, funds focused on Europe accounted for 34% of the aggregated capital of private debt funds globally (Preqin, 2018). Moreover, in a survey among global institutional investors, 60% of respondents looking to invest in private debt funds said they wanted to invest in Europe (Preqin, 2019).

19 Sources: Kraemer-Eis, Botsari, Gvetadze, Lang, and Torfs (2019), OECD (2018), OECD (2019) and EIF market information.

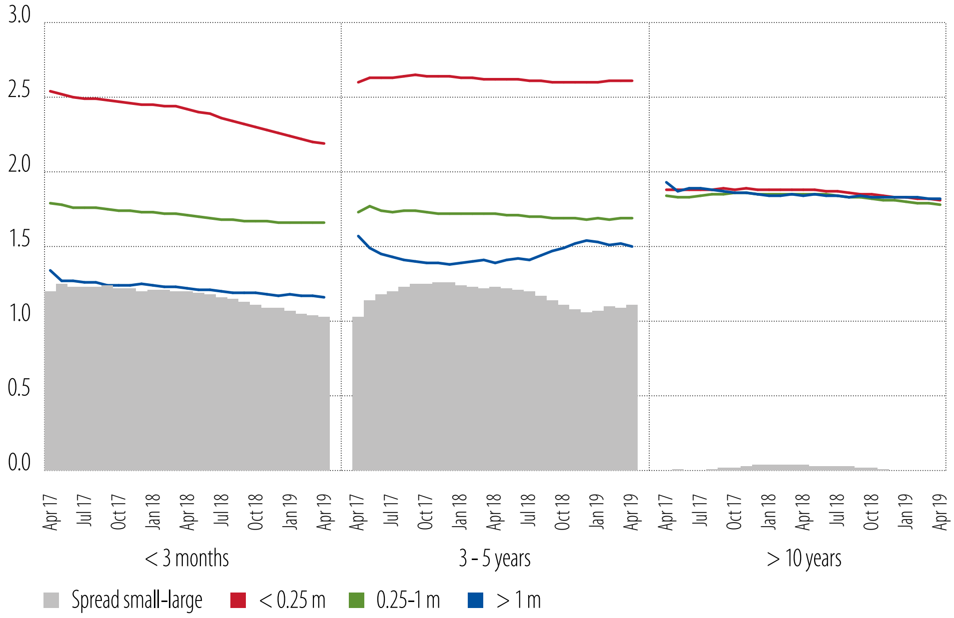
According to a recent survey, approximately half of the private debt committed globally is allocated to small businesses and mid-market borrowers. That figure is expected to rise as European private credit managers increasingly enter the fray. Smaller private credit managers allocate, on average, a higher share of their funds to small and medium-sized businesses (ACC, 2018). Within Europe, the UK attracts the largest amount of investment, but substantial funds also go to France and Germany. Italy and Spain appear to be growing as well, although the activity remains relatively sparse. The growth of this market has a bigger impact on the supply of capital to small businesses in Europe than in the United States, as several types of alternative debt are already operating in the United States.

Access to bank finance

Accommodative monetary policy in the euro area continued to trickle down to the corporate lending market. In 2018, the ECB's composite cost of borrowing indicator[20] hovered from 1.6% to 1.7%, a record low. However, Figure 37 illustrates that interest rates are not uniform across loan size or maturity classes.

Figure 37

Interest rates by loan size and maturity, and size spread (%)



Source: *ESBFO (Kraemer-Eis et al., 2019), based on ECB.*

Note: *The figure depicts the 12-month moving-average of floating interest rates charged by banks on loans to non-financial corporations (other than revolving loans and overdrafts).*

Small loans are generally burdened with higher interest rates. For short-term loans, the spread between the cost of borrowing for small and large lenders remains large.[21] Since small businesses are relatively more reliant on short-term credit, their competitive position relative to larger firms deteriorates. For long-term lending, borrowing costs for small and large lenders have converged.

20 The composite borrowing indicator is a volume-weighted average of the borrowing cost of loans from different maturities. For a detailed description of the methodology, see ECB (2013). It was constructed "to assess the effectiveness of the monetary policy pass-through across the euro area countries".

21 Interest rates are published for three distinct loan size categories: small loans (<EUR 0.25m), medium-sized loans (EUR 0.25m to EUR 1m) and large loans (>EUR 1m). Assuming smaller loans are predominantly used by smaller firms, we can draw conclusions on the different lending conditions faced by firms in different size classes.

Borrowing costs for small lenders differ significantly between countries. Lending conditions for small businesses were most favourable in Belgium, Luxembourg and France, while the most expensive lending environment is found in Ireland, Greece and Estonia. Compared to other European small businesses, Irish firms face the largest competitive disadvantage vis-à-vis large firms because loan spreads are large.

The Fintech market can also play an important role in enhancing finance for small businesses.[22] Fintech provides financial services through software or other technology, and those innovations give small business better information on lending conditions, reducing market asymmetries. Fintech is revolutionising financial business processes, such as payment or data-processing technologies, enabling small firms and start-ups to compete on an equal footing with larger players in the financial sector. Fintech also serves as a direct financing source for small business as varying sizes and growth prospects, through crowdfunding platforms that offer debt and equity financing.

Fintechs' impact are being felt across the entire spectrum of small business financing, most notably through crowdfunding. Established financiers, such as microfinance institutions, business angels and venture capitalists have recognised the power of crowdfunding and are joining up with retail investors through crowdfunding platforms. Also, mainstream banks are entering the Fintech space, using marketplace lenders as distribution channels and acting as counterparts in small business transactions.

Securitisation and policy actions targeting small firms

A host of organisations are working to support small businesses. Among them are various national promotional banks and international financial institutions, including the EIB Group (the European Investment Bank and its sub-holding, the European Investment Fund). Incentives have been set up to support small businesses' access to finance, including favourable lending conditions, credit guarantee schemes, guarantees on issuances of mini-bonds and various forms of incentivised venture capital and private equity funding. Initiatives developed under the Capital Markets Union (CMU) are trying to diversify the financing options for small firms. EIB research strongly confirms the beneficial impact of such interventions on small business investment (Box B).

Guarantees can improve access to finance. Credit guarantees are extensively used by financial institutions to alleviate the financial constraints placed on small businesses. National/regional guarantee institutions are the first line of small business credit guarantees, but multinational providers like the EIB Group can also play an important role.

A functioning securitisation market can transform illiquid loans to small firms into an asset class with adequate market liquidity. Securitisation (SMESec), which includes transactions backed by small business loans, leases and other products,[23] can improve the capital available for small firms. When analysing small business securitisation, 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 become less available for leasing companies since the crisis, securitisation could be a solution.

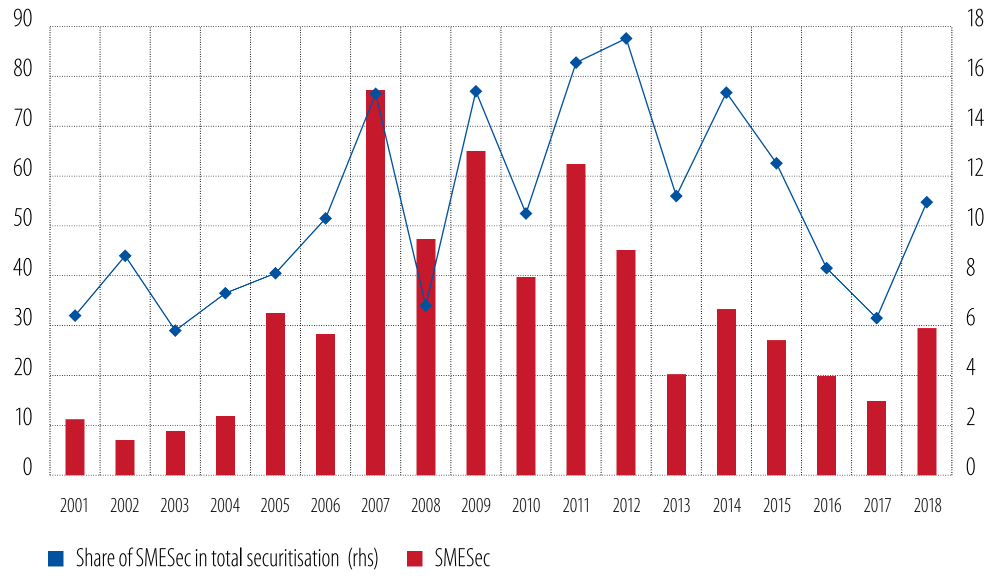
Small business securitisation issues remains at low levels and are still suffering from the crisis.[24] The European securitisation market grew steadily from the early 2000s until the outbreak of the global financial crisis. The overall issued (and visible) volume of small business deals in 2018 (EUR 29.5 billion) was almost double that of 2017 (EUR 14.9 billion, Figure 38). The market share of small business transactions in overall securitisation issuances rose (with some volatility) from 6% in 2001 to 18% (of total yearly issuance) in 2012, the highest level ever registered in Europe. From 2014 to 2017 the share of small business issuance in overall activity declined from 15% to 6.3%. However, in 2018 the share of small business securitisation

22 See Box B in Chapter 5 for an overview of Fintech.
23 For more information on the importance of leasing for small business finance, see Kraemer-Eis and Lang (2012).
24 The source for market activity data in this section is AFME (2019).

increased again to 11%, based on a strong fourth quarter (which accounted for EUR 22 billion of the total EUR 29.5 billion). Most of the issuance in 2018 occurred in Belgium (EUR 9.4 billion, or 33% of the total), Italy (EUR 8.5 billion, 29%) and Spain (EUR 7.8 billion, 27%). These three countries represented 89% of total European small business issuance.

Figure 38

SME securities issuance in Europe: volume and share of total securitisation
(EUR billion, lhs; and %, rhs)



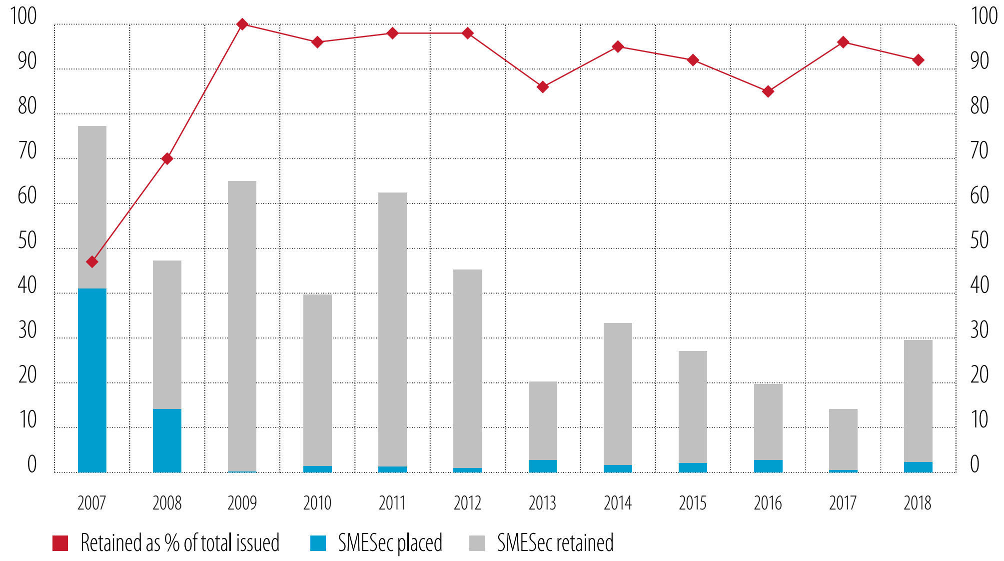
Source: *ESBFO (Kraemer-Eis et al., 2019), based on the Association for Financial Markets in Europe (AFME).*
Note: *SMESec: securitisation of transactions for small and medium-sized enterprises.*

The nature of the small business securitisation market changed during the crisis. It went from being a developing market pre-crisis (with most transactions placed in the primary market) to a purely retained/ECB repo-driven market during the crisis. Only a very small fraction of issuance is placed with investors (Figure 39).[25] The shift towards retained securitisation dried up liquidity in the ABS market during the crisis.[26] Consequently, ABS origination comes with higher costs. While enhancing credit, repos also include considerable haircuts, or reductions, to the face value of the securities.

Despite the financial and sovereign debt crisis and a prolonged negative economic cycle, the European securitisation market has generally performed well, with comparatively low default rates. However, as indicated, the European market has still not completely recovered from the crisis. Several indirect support measures aim to revive the market, such as important regulatory adjustments. New securitisation regulation will take effect in January for all EU members. The regulation will set rules for developing simple, transparent, and standardised securitisations.

25 Typical originators are not only large banks or banking groups, which can also be originators in several countries, as well as mid-sized banks.
26 The shift towards retained securitisation enables originating banks to repurchase the security in central banks' operations.

Figure 39
European SME securitisation by retention (EUR billion, lhs; and %, rhs)



Source: *ESBFO (Kraemer-Eis et al., 2019), based on the Association for Financial Markets in Europe (AFME).*
Note: *SMESec: securitisation of transactions for small and medium-sized enterprises.*

Box B
Does public support for small business lending make a difference?

Addressing the financing constraints of small businesses is an important part of the EIB Group's activities and constitutes a public policy goal. In 2018, 36% of the EIB's new lending was dedicated to small businesses and mid-caps. Small business and mid-cap funding typically takes the form of a multi-beneficiary intermediated loan (MBIL), whereby the EIB leverages the local expertise of banks across the European Union through an intermediated lending model involving private financial firms. The EIB provides funding to these intermediaries directly on favourable terms. In exchange, the intermediaries commit to use the funds to extend loans to small businesses, and to (partially) pass on the advantageous terms to firms.

It is important to determine whether EIB-supported lending makes a difference for the beneficiary firms.

We put under the microscope firms that received EIB-supported loans through the intermediated funding, measuring their corporate performance against otherwise identical firms that did not receive such loans. The analysis aims at assessing the impact of MBILs on the economic and financial performance of the beneficiary firms in 27 EU countries from 2008 to 2014. Our dataset includes 520 746 MBIL allocations to 403 788 individual companies.

The analytical framework used consisted of:

- Data merging: Data on individual loan allocations to firms are paired with Bureau van Dijk's Orbis database, which contains the information on the financial and economic characteristics of individual companies. This enables us to observe the performance of individual firms before and after the allocations.

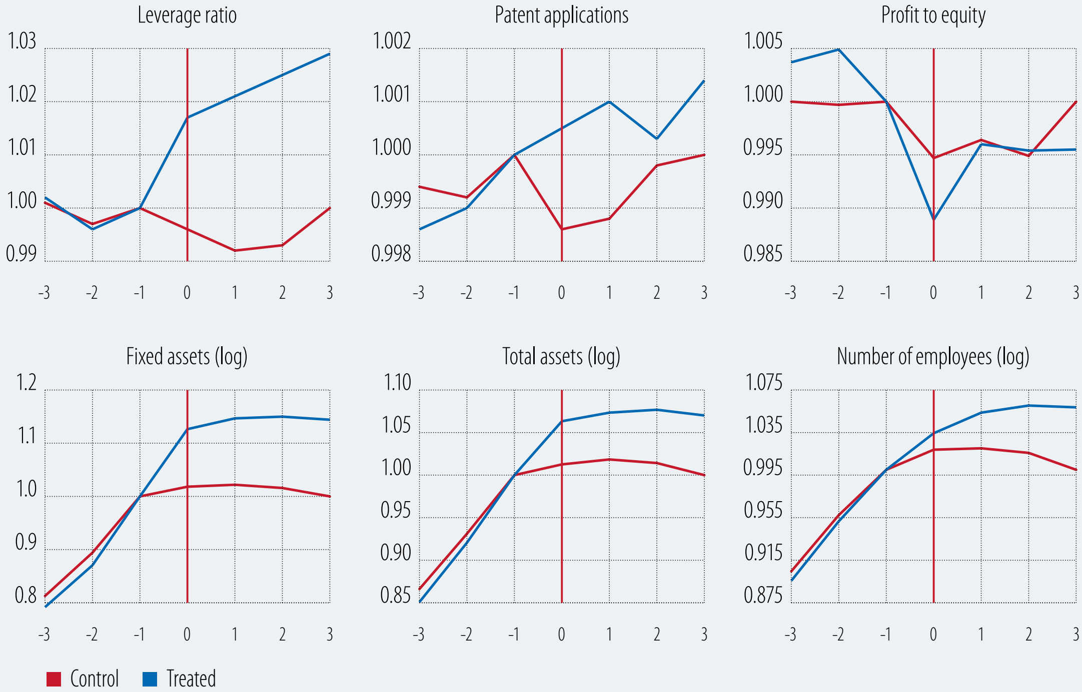
- Construction of a counterfactual sample: For each beneficiary we select a counterpart from the Orbis database: a similar firm that has not received an EIB loan. The objective is to create an alternative pool of companies (control group) that, given the available information, is as similar to the pool of EIB beneficiaries as possible – with the sole exception that it consists of companies that have not received EIB-funded loans. To ensure the similarity between pairs, we use propensity score matching.
- Performance comparison: Finally, we compare the performance of the group of beneficiaries in the period following the loan allocation to the performance of the firms in the control group. We do that by comparing average changes in quantitative performance indicators in the two groups using difference-in-differences. The indicators of interest measure employment, total assets, fixed assets, profitability, patent applications and leverage.

Figure B1 shows the average performance of EIB beneficiaries ("treated") vs the comparison group ("control") in the three years preceding and following the loan allocation, using various indicators. While the control and treatment group had similar dynamics beforehand, the loan allocation had a clear impact, and the behaviour of the two groups began to deviate afterwards. Besides the simple visual inspection of the data, the difference in performance is also confirmed by our econometric analysis.

Figure B.1

Performance of EIB beneficiaries ("treated") **vs the comparison group** ("control") **in the three years before and after the loan allocation**

((left axis) standardised to (t-1) = 1, (lower axis) treatment period)



Source: Gereben and Wolski (2019).

The analysis finds that there is a significant positive impact on employment in the three years following the loan. The positive results on employment suggest that that access to external funding improves the economic situation of beneficiaries to an extent that the firms are more likely to keep employees and/or hire new ones than firms without EIB funding. The size of the coefficient indicates that firms receiving EIB lending increased their employment by 4% to 6% more than the peer group of firms without EIB financing.

The results also indicate a significant and positive impact on the size of fixed assets, in the range of 8% to 14%. It shows that the beneficiaries typically used the loans disbursed to purchase investment goods. The impact of a higher level of investment goods is also reflected in the increase of the company size measured by total assets. While we experimented using various measures of profitability, it appears that in general the impact of a loan was not statistically significantly different from zero. There is an indication in the data, however, that EIB beneficiaries are more likely to be involved in patent applications and patent publishing. However, the overall effects are small in magnitude, as the total share of firms in the sample with patent information is very low.

In parallel, we observe a deterioration of 2 to 3 percentage points in the leverage ratios of the beneficiaries compared to the control group on average. This is driven by accounting methods. By definition, funding from the EIB increases the level of debt relative to equity financing. This has a negative impact on the leverage ratio compared to firms that do not receive funding.

The results suggest that, during the period under review, from 2008 to 2014, EIB lending to small businesses achieved its goal, alleviating credit constraints and enabling firms to grow. Conditional on data and methodological constraints, our results support the view that EIB funding fosters employment, investment and possibly also the innovative capacity of small businesses across the EU countries.[27]

27 We also find that the positive impact of EIB funding is larger in certain geographic regions. In this respect, EIB lending in Central and Eastern Europe has the highest impact, followed by Southern Europe. Beneficiaries in Western and Northern Europe still enjoy a significant positive impact, although the improvement over the control group is somewhat smaller than elsewhere.

Financing investment in specific types of assets

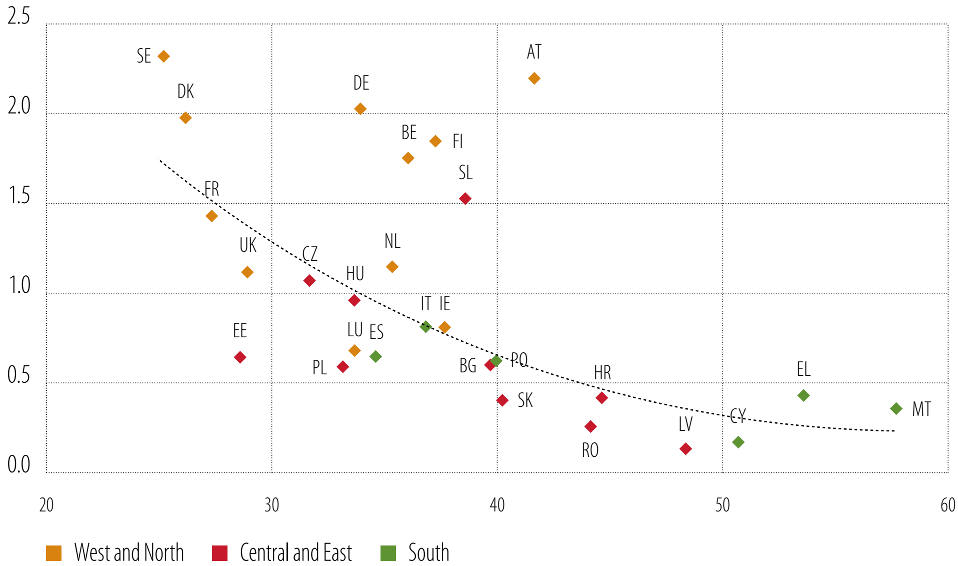
Financing investment in innovation

Chapter 3 expresses the view that the innovation machine is “broken” in the European Union, and that Europe lags far behind major competitors such as the United States and China. As shown in the chapter, productivity is higher for firms that invest in R&D. Consequently, the lack of financing for innovative firms is cause for concern as it could impede long-term economic growth in the European Union. We analyse the role of financing and its structure in explaining this sub-optimal level of intangible investment. We also illustrate the extent to which the underdevelopment of some products/market segments explain the disparities between countries.

Bank-based financial systems are associated with lower corporate R&D spending. Figure 40 plots the share of corporate R&D spending in the European Union against a measure of bank dependence, the share of corporate bank loans in the external financing of firms. The decreasing relationship suggests that banks may not be the most suitable institutions to finance R&D. This is also supported by the literature. For example, Allen and Gale (1999) show that bank-based systems can be associated with less lending to innovative companies due to the higher risk involved. However, the relationship can be mitigated by the fact that banks have a relative advantage in processing information more efficiently, an advantage accentuated when information costs become high.

Figure 40

Share of loans in external finance (x-axis, %) **and corporate R&D spending** (y-axis, as % of GDP)



Source: *EIB Economics department computations based on Eurostat and BIS.*
Note: *Both indicators are averaged over 2015-2017.*

Substantial empirical evidence illustrates that financing has an impact on economic growth (Levin, 2015). Moreover, this impact is at least partially channelled through the type of assets financed (Thum-Thysen et al., 2017). Besides the level, the type of investment also effects economic growth, as R&D investments are key to competitiveness. The question is whether investments in R&D assets (or R&D firms) face the same barriers and the same financial environment as firms overall (non-R&D firms). Generally, survey results shows that finance is less available for R&D firms, despite their higher profitability.

In the European Union, 76% of companies invest in intangible assets, which account for 37% of total investment (Table 1). Compared to other EU countries, businesses in Central and Eastern Europe invest significantly less in intangible assets, by around 10 percentage points. Among all intangible assets, R&D is the key ingredient for innovation and also recognised as the main driver of productivity and economic growth. Around 25% of companies invest in R&D, which accounts for 8% of total investment (around 5% in Central and Eastern Europe).

Table 1

Share of R&D and intangible investment in the EU and regions (%)

		EU	Central and East	South	West and North
% of firms with	R&D	25	20	29	25
	Intangibles	76	69	72	79
% of investments in	R&D	8	5	9	8
	Intangibles	37	27	37	38

Source: *EIBIS.*
Note: *Firms with R&D investments committed at least 0.1% of firm sales to R&D. Intangible investments include R&D, software and databases, employee training and organisational capital.*

Firms that invest in R&D face stronger investment barriers than those not investing in R&D (Figure 41). In particular, weak demand for products and uncertainty about the future are considered by R&D companies more often as impediments to investment. This might be due to the lack of market for their new products. Moreover, the capacity to innovate is linked to a firm's ability to access digital technology. Survey results show that R&D companies more often face constraints because of their limited access to digital infrastructure.

The lack of available staff with the right skills is more of a concern for R&D companies (Figure 41). These firms are often growing or even high-growth enterprises (HGEs) with strong hiring needs.[28] Moreover, such companies might need specialist skills and knowledge of new technology, and the supply of such labour might be scarce (Ferrando et al., 2019). The lack of available staff with the right skills is more constraining for innovative companies wanting to hire new employees, as successful innovation is often connected with a firm's expansion and growth, while new products might need faster skills adaptation and a knowledge of cutting-edge technology.

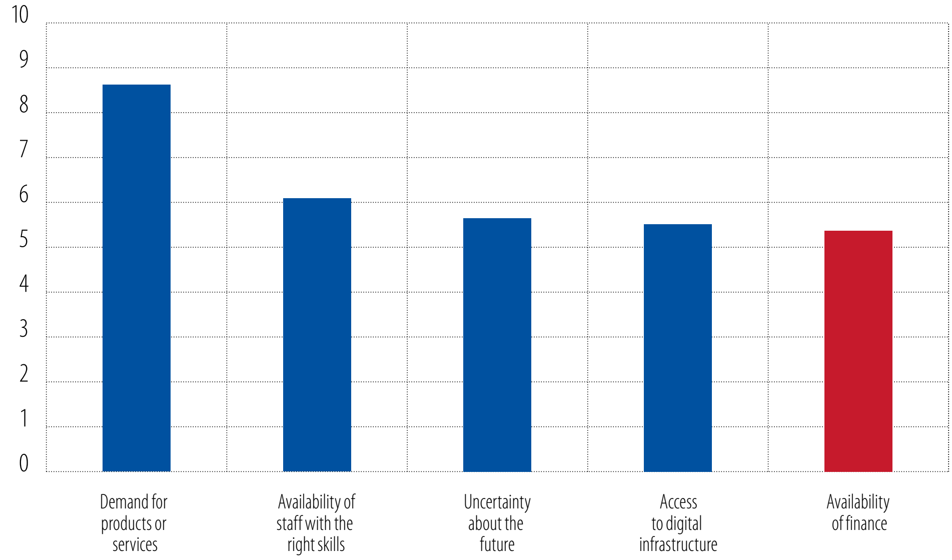
R&D firms are more finance constrained (Figure 42). Limited availability of finance is more constraining for companies that invest in R&D, despite their better productivity and profitability. There is a higher share of financially constrained firms among firms with R&D investment. More companies are financially constrained in Southern Europe, and the difference in access to finance between firms with and without R&D is the highest (11% vs 8%).

Financing constraints are associated with larger reported investment gaps, which are defined as a perceived lower level investment than what is economically beneficial (Figure 42). Around 32% of firms that are financially constrained and have R&D investment think they invested less than they should have.

Figure 41

Investment barriers for R&D vs non-R&D firms

(percentage point deviation between R&D-intensive and the others)

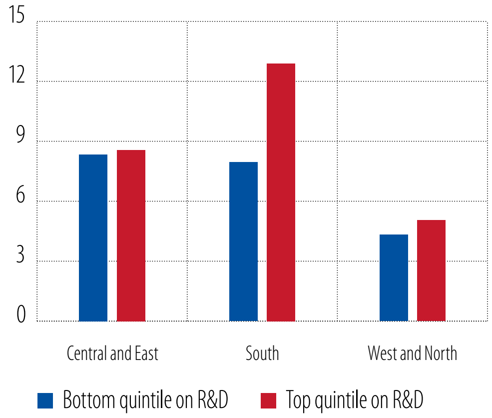


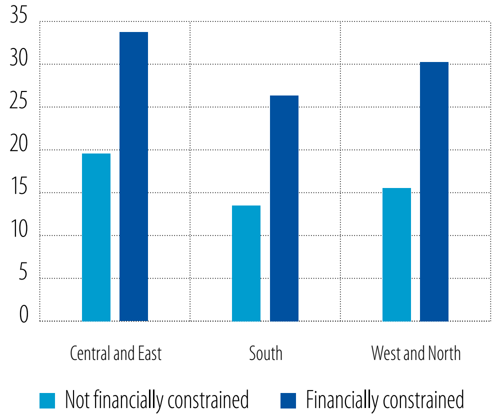
Source: EIBIS16, 17 and 18.

28 A high-growth enterprise is an enterprise with an average annual growth in the number of employees of more than 10% per year over a three-year period (t – 3 to t) and having at least ten employees at the beginning of the period (t – 3).

Figure 42

Specific characteristics of R&D-intensive firms and investment gap (%)



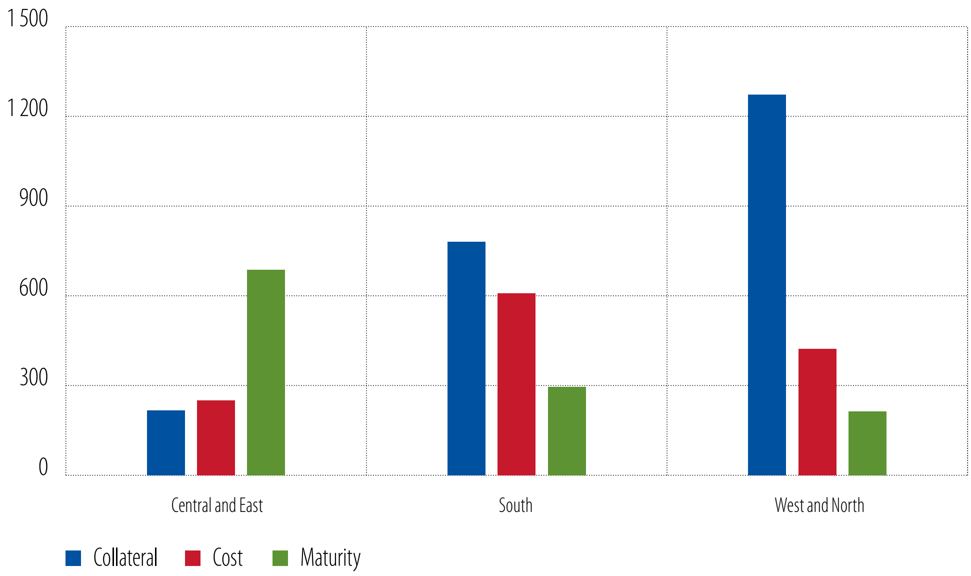


Source: *EIBIS16, 17 and 18.*

Figure 43

Dissatisfaction with external financing

(difference across intensity of intangible investment spending, percentage points)



Source: *EIBIS16, 17 and 18.*

Note: *Percentage share of firms: difference between the highest quintile versus lowest quintile of intangible spending.*

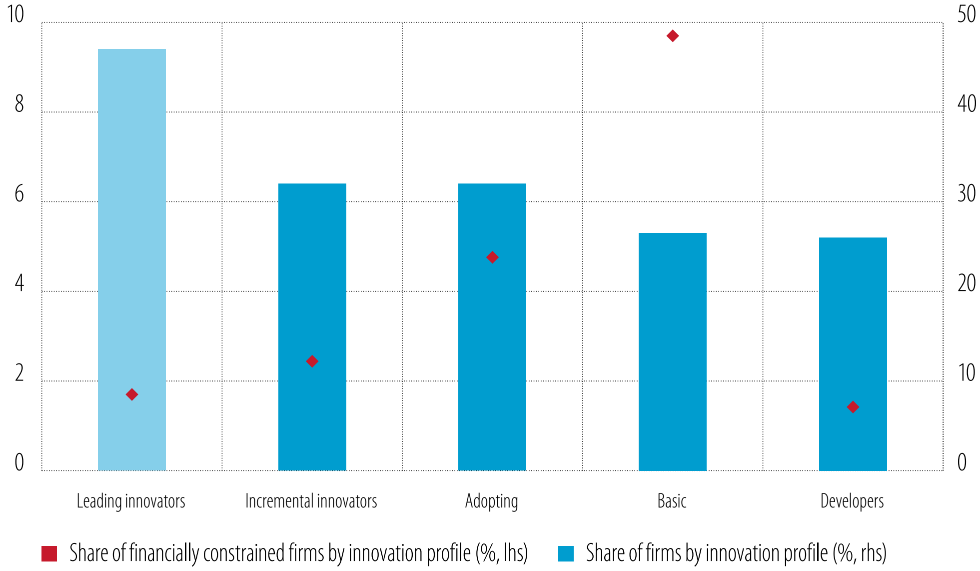
Firms´ dissatisfaction with the financial offering increases with the intensity of intangible investment (Figure 43). The top quintile (quintile 5) of firms are those that have an average of 95% of their total investment in intangible assets, while firms in quintile 4 have average intangible investment of 55%. Firms investing in intangible assets face financing constraints more often. In Southern Europe, firms investing in tangible assets are significantly less likely to be financially constrained than those with high intangible investments (6% vs 14%). The frustration of firms investing in intangibles is often related to a lack of collateral, while interest rates and loan maturities are also less favourable. For Central and Eastern Europe, firms investing in intangibles complain more about the tenure of the financing offered.

Turning to innovation, EIBIS results show a highly skewed innovation profile of businesses in the European Union. A large portion, 72%, of firms report no (substantial) investment in R&D and 56% did not introduce any innovation (Figure 44).[29] Moreover, focusing on new products, 8.5% of firms are leading innovators, 12.2% are incremental innovators, while the share of adopting companies is 23.8%. Figure 44 suggests that leading innovators face financial constraints more often and incremental innovators complain less than leading innovators about their financing constraints. Finally, firms that are adapting the new technology instead of developing it (without R&D investments) are less financially constrained.

We use treatment estimation techniques to infer the impact of the financial environment on the innovation profile.[30] The treated group is those firms that rely on a specific external financing form such as: bank financing, financing from family and friends, grants and new equity (private equity or newly issued shares), while the outcome variable is the innovation profile. The regression is used to estimate the innovation profile as a causal inference of the type of financing, after controlling for a set of conditioning factors specific to the firm.[31] Moreover, we include a dummy for the three regions. The results are summarised in Table 2.

Figure 44

Share of financially constrained firms by innovation profile (%, lhs) **and share of firms by innovation profile** (%, rhs)



Source: EIBIS16, 17 and 18.

29 See Chapter 3 or Veugelers et al. (2018) for more details on the innovation profile of a company. It is determined using two variables: 1) firms' investment in R&D and 2) introducing new products. R&D active firms report substantial R&D (i.e. at least 0.1% of firm turnover). Among R&D active firms, we distinguish three categories: leading innovators introduce new products for the country or globally; incremental innovators introduce products new to the company; and developers do not introduce any new products (yet) but invest substantially in R&D. Among R&D inactive firms, two different types can be distinguished: basic firms that are not introducing any new products; and adopting firms, which, although they do not invest in R&D, still introduce new products or processes developed by other firms.

30 A simple predictive comparison might not be enough to estimate the causal impact of obstacles as it might be driven by cofounding covariates, i.e. omitted predictors that can affect both type of financing and innovation profile. For example, a company with a very high cash flow is able to invest more in R&D, and consequently might be more attractive for investors (private equity); or firms with low leverage and good financial health are more likely to invest/innovate and also fulfil the credit eligibility criteria for a bank loan.

31 Cash flow to total assets, debt to total assets, size (as a dummy for micro, small, medium and large), age (as a dummy for age categories of less than 2 years, 2-5 years, 5-10 years, 10-20 years and above 20 years), technical intensity of the industry (as a dummy for the four groups: high-tech manufacturing, low-tech manufacturing, high-tech knowledge-intensive services, less knowledge-intensive services).

Firms financed with bank loans and credit lines are more often incremental innovators or adapting firms. The insignificant effect on leading innovators might be explained by the lower bankability of these firms due to the highly uncertain returns associated with the innovation profile and most likely also by the lack of collateral, especially for those in the high-tech and knowledge-intensive service industry (see Almeida et al., 2007 and Rampini et al. 2013). Given the lack of external financing opportunities, R&D firms often overcome this deficiency by spending their own cash (Brown et al., 2011 and Brown et al., 2012). The results also confirm that the availability of external bank finance not only reduces the rate of innovation, but also changes the trajectory of innovation from leading to incremental innovations (Nanda and Nicholas, 2014).

Financing from family and friends might serve as an alternative financing source for innovative firms. The results show that both leading and incremental innovators are relying relatively more heavily on this source of finance.

Table 2
Type of financing and innovation profile

		Leading innovator	Incremental innovator	Adopting firms
Bank loan and credit lines	ATET	0.003	0.039***	0.032**
	POmean	0.095	0.09	0.223
Family and friends	ATET	0.052**	0.078***	0.043
	POmean	0.083	0.096	0.245
Grants	ATET	0.101***	0.038**	0.006
	POmean	0.116	0.137	0.235
New equity	ATET	0.170***	-0.004	0.026
	POmean	0.095	0.121	0.229

Source: *EIB estimations based on EIBIS and Orbis. See Maurin and Pal (forthcoming).*
Note: *Number of observations: 5 404. The treatment is based on the dummy of obtaining the given type of financing or not. The potential outcomes are predicted for the whole sample including both treated and untreated units using the two regression lines. The Potential Outcome Mean (POmean) shows the share of firms of the given innovation profile if none of them receive the given financing. ATET is the average treatment effect in the sub-sample of those receiving the treatment, that is, the impact of obtaining the specific financing compared to the hypothetical counterfactual in which the company does not obtain that type of financing.*

Equity financing and grants have the strongest impact on R&D activity. Although very few firms report financing their projects through equity (1.3% of firms) and grants (10.6%) compared to other sources of financing, equity financing and grants have the strongest impact on leading innovation. The results emphasise the role of grants in maintaining or creating leading innovators. Grants provide financing mostly for leading innovators. The share of leading innovators doubles (up by 10 percentage points) among those that receive grants. Howell (2017) also finds also that an early-stage grant doubles the probability that a firm receives subsequent venture capital and has a large positive impact on patenting and revenue.

Among firms that use equity financing, after controlling, the estimation suggests that the share of leading innovators almost doubles. The results are in line with previous literature showing that the financial effects are strong enough to influence aggregate R&D activity. Brown et al. (2009) provided empirical evidence of the role of external equity financing in the R&D boom and bust in the United States during the 1990s. While young and innovative US firms, especially in high-tech industry, are able to rely on publicly issued shares, the European firms of this type can hardly access the capital market. Still, whenever it is possible to get the new equity (either in the form of issued shares or private equity), the EIBIS survey results show that leading innovators are strongly relying on this form of financing (the share of leading innovators increasing by 17 percentage points). Specific interventions helping to fill the equity gap in Europe support innovation (Box C).

Box C

The impact of venture capital investments supported by the EIF

Economists and policymakers widely acknowledge the role of young and innovative companies as net contributors to employment, innovation and productivity growth. Governments have a vested interest in supporting start-ups and promoting their success against the backdrop of market failures affecting new ventures' access to traditional financing (Colombo et al., 2014). The EIF, through its venture capital activity, fosters innovation and job creation throughout the European Union.

Through a series of working papers, EIF has documented its impact on the European venture capital ecosystem (Kraemer-Eis et al., 2016 for the introductory volume of the series). In volume 4 of this series, Signore and Torfs (2017) document the EIF's influence on venture capital-supported innovation by analysing the patenting activities of EIF-backed start-ups from 1996 to 2012. Patents supported by venture capital investments involving EIF participation grew at a strong pace prior to 2001 (Figure C1a).

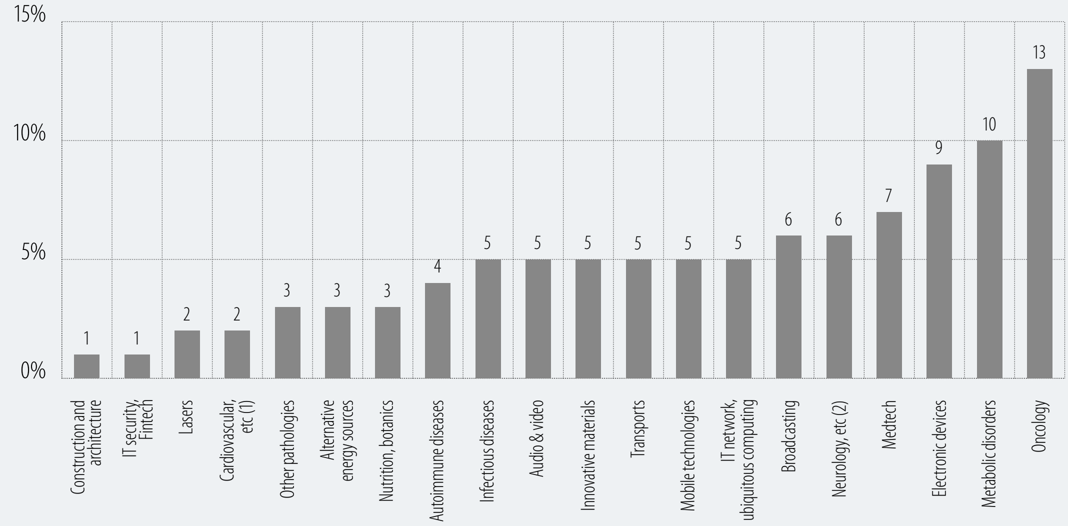
The crisis caused by the bursting of the dot-com bubble in 2000 led to a slowdown in patent growth. Later, in 2011, an increase in patent renewal fees at the European Patent Office further reduced start-ups' incentives to patent. Patent generation predominantly took place in the life science and IT sectors, which owned 95% of all EIF-supported patents. However, emerging fields like green technologies have been gradually gaining importance in recent years. Oncology emerged as the most patented field (see Figure C1b, for the complete distribution).

Figure C.1

Patenting activity of EIF-backed VC companies

a. Evolution

b. Technology field distribution (%)



Source: *Signore and Torfs (2017).*
Note: *(1) Cardiovascular, haematology, traumatology pathologies. (2) Neurology, psychiatry pathologies.*

In the latest volume, Pavlova and Signore (2019) aim to quantify the causal effect of venture capital investments supported by the EIF on the financial growth and performance of young and innovative firms. To measure the impact of the EIF's activity, Pavlova and Signore (2019) employ a novel dataset covering European start-ups supported by venture capital from 2007 to 2014, combining data provided by Invest Europe, EIF internal data, and financial accounts from the Orbis database. The authors generate a control group of firms not backed by venture capital through a combination of exact and propensity score matching, bringing in new ways and tools to study the notoriously opaque venture capital market.

The results in Pavlova and Signore (2019) confirm the positive effects of EIF-supported venture capital investments on start-up growth, as measured through numerous financial indicators. The authors observe faster growth (in terms of assets) of start-ups supported by EIF compared to firms that did not receive venture capital. Venture capital investment leads to higher capitalisation levels, higher revenues and higher job creation in the first five years following the investment. Moreover, the study finds higher investment and borrowing levels.

Start-ups backed with venture capital appear to trade off short-to-medium term profitability against achieving the desired scale of operations. However, the authors find no obvious cost inefficiencies brought by the venture capital financing itself. Venture capital investments merely enable treated firms to trade off higher levels of short-term profitability than they could have otherwise had, in exchange for faster growth. These findings, in line with current economic research, point to the effectiveness of EIF's policy instruments fostering small business access to venture capital.

Financing investment in energy efficiency

Energy efficiency investment is unevenly distributed in the European Union across countries, sectors and size classes (Chapter 4). Across EU regions, the share of investment in energy efficiency is very similar. It varies in a narrow range of around 10%, but a high proportion of firms do not invest in energy efficiency.

The firms which do not invest in energy efficiency tend to be relatively more finance constrained. Figure 45 reports the proportion of finance constrained firms separately for those investing in energy efficiency and those not. In the European Union overall, and especially in Southern and Central and Eastern Europe, firms investing in energy efficiency face more finance constraints. This relationship suggests that tight credit conditions explain why firms do not carry out energy efficiency investment.

Firms not investing in energy efficiency tend to be more dissatisfied with the financial offering. Figure 46 compares the dissatisfaction of firms with their financial offer. It depicts the difference between firms not investing and firms investing in energy efficiency for several indicators of financial offerings. For all indicators, especially cost and the collateral requirements, firms not investing in energy tend to be more dissatisfied. Hence, dissatisfaction with the financial offering may be a factor limiting investments in energy efficiency. The difference is especially pronounced in Southern Europe.

Figure 45
Proportion of finance constrained firms (%)

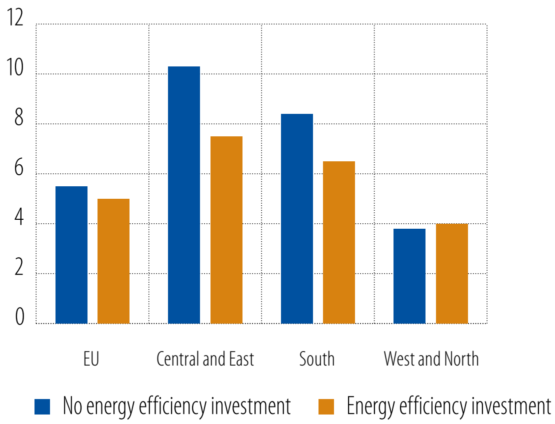
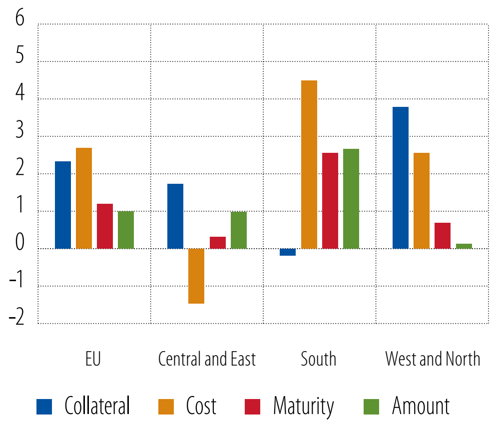


Figure 46
Difference in dissatisfaction between firms not investing in efficiency investment and those investing (percentage points)



Source: EIBIS 18 and 19.

Conclusion and policy implications

The EU corporate sector has strengthened its capacity to withstand a possible downturn. However, the stronger balance sheets witnessed over the last ten years have been more noticeable for stronger firms located in regions with more benign economic developments. Small businesses remain more exposed as the financial offering they receive is more restricted and the scope of their activity leaves less room for diversifying in response to specific shocks.

More resilience has partly come at the cost of lower corporate investment. This is a source of concern as periods of low investment tend to trigger a vicious circle. They tend to be followed by loss of competiveness, lower demand and therefore less capacity to finance capital expenditure. Special attention is therefore necessary at a time of massive investment required to ensure that corporates go digital and workers acquire the skills necessary for the future.

The financial environment is clearly more adverse for small businesses and enterprises innovating or investing in climate action. Public interventions are effective in addressing specific investment gaps in these areas. Evidence shows that targeted public intervention, through the provision of specific types of financial products, helps to foster corporate investment in public policy areas. Therefore, increasing public support and fine-tuning its calibration would be beneficial.

Policy actions can contribute to removing undue uncertainty. The relatively contained level of investment, given the relatively good performance of EU corporates, enables firms to accumulate cash and deposits. This preference for security and liquidity is at odds with the normal behaviour of risk-taking entrepreneurs. It reflects increased perceived uncertainty as well as some regulatory hurdles. Policy actions could help to revive investment.

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Removing frictions and allowing for a more efficient reallocation of labour and capital across firms **within the European Union** could increase productivity by **40%**

70%

of **EU firms** in the **lowest productivity group** remain stuck there for at least three years

The EU lags behind in business scale-ups:

EU scale-ups have **20%** **fewer employees than their US peers**, on average

The **productivity gap between leading firms and the rest** has increased **20%** since 2002

44%

of **EU scale-ups target a local market,** vs **23% in the United States**

77%

of **firms** say a **lack of staff** with the right skills holds back investment

Jobs at risk of automation range from **42%** to **52%** depending on the region

PART III

Competitiveness and inclusion

Chapter 7

Start-ups, scale-ups and business dynamics in the European Union and United States

Start-ups and scale-ups play an important economic role. These firms are drivers of investment activities, carriers of innovation, and an important source of labour demand. Start-ups and scale-ups also tend to increase competition and thereby drive market efficiency.

Europe lags behind the United States in terms of start-up and scale-up activities. Despite an increase in start-up creation in recent years, Europe still lags behind the United States in the number of young, innovative firms by a factor of three. This increases to a factor of four if we take into account the larger population size of Europe. In addition, we find qualitative differences increasing with firm age. While young firms with high growth ambitions (start-ups) in the European Union are still comparable in many respects to their US counterparts, as they grow older and become scale-ups, they increasingly start to lag behind.

The qualitative differences between EU and US scale-ups can to some extent be explained by structural factors. In particular, market size, access to top talent and a relatively weak venture capital market all pose obstacles to stronger growth in Europe. Our data, however, does not support the theory that differences in founder characteristics explain the weaker development of EU scale-ups.

A lack of past success stories perpetuates the structural weakness of the EU start-up and scale-up environment. Success stories play an enormous role when it comes to fuelling exit markets for new generations of start-ups, whether it be to encourage acquirers of start-ups or to improve market liquidity. This liquidity positively affects the chances of success of new generations of start-ups, for example by increasing the willingness of investors to support these firms from early on. The lack of past success stories puts Europe at a disadvantage compared to the United States.

To promote start-up and scale-up activities effectively, policymakers need to think backwards. In addition to addressing structural barriers that hamper growth, policymakers need to find ways to generate the same pull forces for new start-ups and scale-ups as Alphabet, Amazon or Facebook do when they act as acquirers of new firms, or when they pave the way to list on stock markets for new generations of firms. Policy options in this respect include:

- incentivising more corporate acquisitions of start-ups;
- making more use of innovation prizes to address big societal problems;
- working towards a harmonised European tech stock market;
- addressing regulatory bottlenecks in the use of stock options to incentivise top talent to work for start-ups and scale-ups.

Their economic importance notwithstanding, start-ups and scale-ups are drivers of geographic inequality. While they are a source of new opportunities (and a major driver of an efficient allocation of resources), policymakers need to be aware that start-up activities tend to often be highly geographically concentrated. The same dynamics that make new start-ups and scale-ups flourish in close proximity to past start-up success stories often entail tendencies towards the concentration of economic activity, which drive up prices and wages within start-up clusters while fuelling differences with other regions.

Introduction

Why does Europe have so few unicorns? Although Europe has a large number of leading multinational companies, it exhibits a poor track record when it comes to forming start-ups and scaling up young firms with high growth ambitions, in particular when compared to the United States and China. While it is not clear whether the lack of unicorns (i.e. young firms with a market valuation of USD 1 billion or more) is a problem per se, it is remarkable that the most successful business ventures in recent years have come from outside the European Union. This is particularly notable as Europe's economy is comparable in size to that of the United States and bigger than China's.

What do young firms need to scale up their business? Little is known about the success factors of young firms with high growth ambitions, despite their broader economic role. Bartelsman and Dhrymes (1998), Henderson (1993), and Tushman and Anderson (1986) show that young, high-growth firms contribute substantially to productivity growth. Haltiwanger et al. (2013) and Decker et al. (2014) highlight the importance of these firms for job creation. Acemoglu et al. (2013) argue that young firms have the greatest propensity to make major innovations. Schneider and Veugelers (2010), as well as Czarnitzki and Delanote (2013), confirm this idea.

By analysing what helps young firms to achieve their growth ambitions, this chapter aims to contribute to our understanding of economic dynamism and provide reasons for the recent lack thereof (Breschi et al., 2018).

So far, data limitations have made it difficult to tackle these questions. Most firm-level data focus on established firms. These data sources tend to under-represent young firms, making them generally ill-suited to studying the success factors of these firms (Coad et al., 2016). Data sets dedicated to young firms help to address the issue in part. However, their main limitation is that not all young firms have the ambition to grow. Gompers et al. (2005), as well as Schoar (2010), show, for example, that a large part of firms are created by subsistence entrepreneurs, who aim strictly at supporting themselves and their families. In the absence of information on entrepreneurs' goals, this limits how much we can learn from such data about the drivers and constraints of young firms with high growth ambitions.

In this chapter, we introduce a novel dataset of young firms with high growth ambitions. The starting point of our data collection effort is the Crunchbase database, an online platform where young firms around the world can present their businesses and their current financing needs. The main incentive for firms to be listed in this database is to attract risk capital. The phenomenal growth of Crunchbase in recent years means that it accounts today for close to the entire universe of young firms with high growth ambitions (see Box A for more details), making it a unique data source for studying such firms.

To complement the data available on Crunchbase, we invited a sample of firms listed in Crunchbase to take part in a 20-minute telephone interview. The selected firms were all younger than ten years old and registered in either the EU27, United Kingdom or United States. The aim of the interview was to ask young firms with high growth ambitions about their objectives, business activities and what hampers their growth (if anything).[1] For more details on the survey, see Data Annex.

This chapter reviews a series of hypotheses for the differences in start-up and scale-up activities in the European Union vs the United States. This includes differences in motivation, ambition and risk taking, as well as differences in firm characteristics and business models. We also examine the relative importance of framework conditions – such as market size, access to skills as well as availability of growth financing – for the differences in start-up and scale-up activities between the European Union and the United States. Our main argument is that, when focusing on these factors, Europe mainly has a gap when it comes to later-stage ventures.

1 Additionally, we conducted several face-to-face interviews to obtain a more qualitative understanding of start-up and scale-up activities before looking at the survey data. We would like to thank our interview partners in Lisbon, Luxembourg and Berlin for their time and insights.

We show that there is a strong geographical link between past start-up success and future success. We argue that the structural deficits identified for European firms, such as the absence of a truly integrated market and an under-developed venture capital market, are accentuated by a lack of past success stories. Venture capital markets strengthen exit channels for investors in start-ups and contribute to a favourable start-up ecosystem more generally. If EU policymakers want to create more successful start-ups and scale-ups, they therefore need to break through the negative cycle of low start-up activities feeding into low future start-up activities.

Our analysis has important implications for how to foster start-up activities in the European Union, but also flags potential costs associated with this. Our findings suggest that policymakers should strengthen policies that aim to complete the European Single Market and work actively to improve access-to-finance conditions in particular for later-stage start-ups. To be truly successful, we argue that it will be essential to complement these initiatives with policies that emulate the role of past start-up success stories in the United States. The policies can include stronger incentives to foster the dialogue between corporations and start-ups as well as working towards a common European stock exchange.

Start-ups and scale-ups tend to exacerbate ongoing conglomeration trends in economic activity. The positive economic and social role of start-ups and scale-ups notwithstanding, policymakers need to anticipate that pursuing policies to foster more start-up and scale-up activities in Europe will most certainly come with tendencies to concentrate economic activities which can, if not addressed early, fuel inflationary pressures in start-up clusters while widening inequalities vis-à-vis the rest of the country/region.

This chapter is organised as follows: We first review why start-ups and scale-ups matter. In the second section, we look at where we stand in terms of start-up and scale-up activities in the European Union. The third section points out a gap in later-stage start-up (or scale-up) activities. The fourth, fifth and sixth sections review a series of possible explanations for the gap vis-à-vis the United States. We conclude the chapter with a discussion of policy measures that can, in our view, help boost start-up formation and scale-up success in Europe.

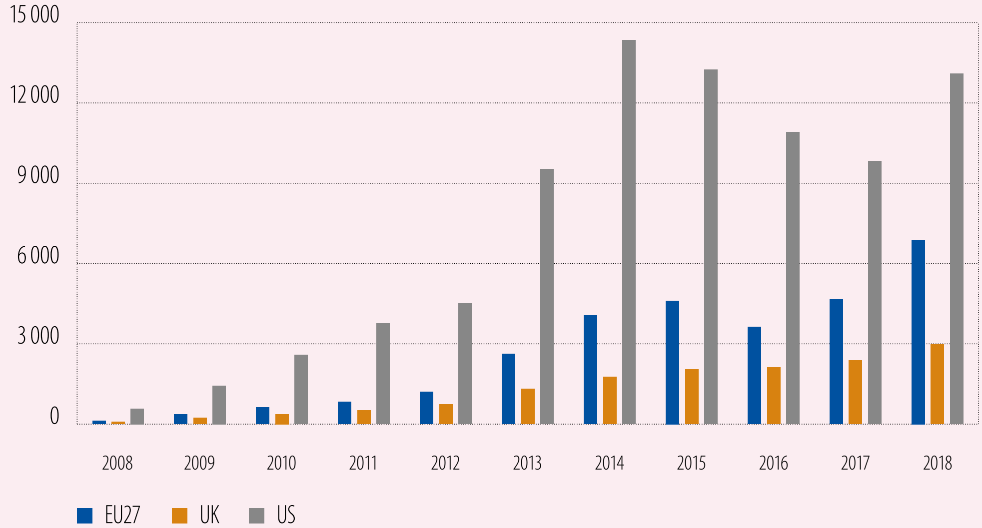
Box A

Crunchbase

Crunchbase is a commercial database of innovative start-ups and scale-ups and the people behind them, maintained by Crunchbase Inc. Crunchbase Inc. is a start-up itself, based in the United States and founded in 2007. One of the main strengths of the Crunchbase database is the data it contains on both companies and people, i.e. founders, employees and investors, resulting in a wide variety of profile pages. A further advantage is that the data are sourced through two main channels: on the one hand, a large network of global investment firms, and on the other, executives, entrepreneurs and investors who update and revise the company profile pages.

In the last ten years, Crunchbase has grown rapidly. In the version used for this chapter, downloaded in January 2019, the database contained information on more than 720 000 different firms operating in 185 countries. Of those firms, about 250 000 reported being founded from 2008 to 2018. For every company, the database reports both the foundation year and when the firm first registered on Crunchbase. For firms founded from 2008 to 2018, Figure A.1 shows when the record was added separately for firms in the EU27, the United Kingdom and the United States.

Figure A.1
Number of firms by record entry

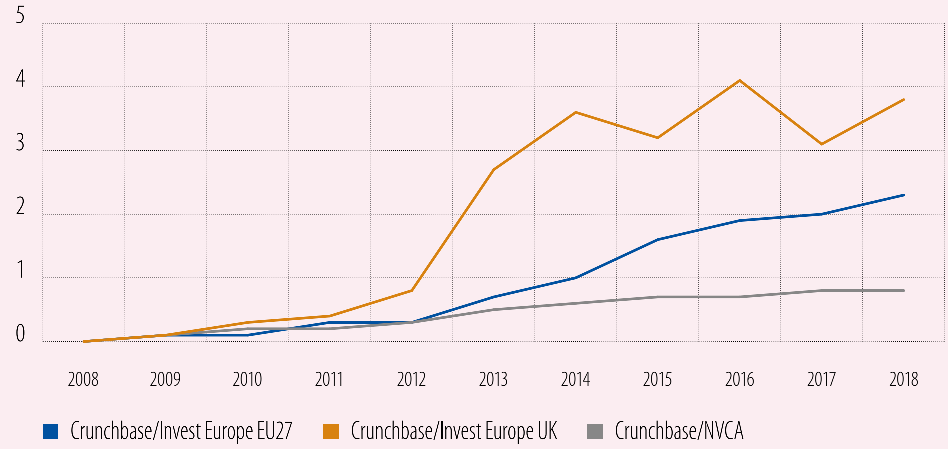


Source: *Crunchbase, authors' calculation.*
Base: *Firms founded 2008-2018 that are still active.*

Crunchbase is increasingly used by the venture capital industry as a data source. Given its importance it is plausible to assume that ambitious start-ups that seek funding have a strong incentive to register on Crunchbase and to keep their information updated. If we benchmark the venture capital investments recorded on Crunchbase against those compiled by Invest Europe and the National Venture Capital Association, we find a very high level of overlap (Figure A.2).

In the same vein, Dalle et al. (2017) provide evidence that Crunchbase has a comprehensive coverage in comparison with other sources at micro level, such as VentureXpert or PricewaterhouseCoopers.

Figure A.2
Crunchbase coverage in the EU27, UK and US (Ratio total funding)



Source: *Crunchbase, InvestEurope, National Venture Captial Association (NVCA), authors' calculation.*
Base: *Crunchbase sample is limited to firms funded after 2007 that received formal funding. Crunchbase includes all types of formal venture capital whereas data from venture capital associations generally do not.*

Why do we care about start-ups and scale-ups?

The literature defines start-ups as young firms with high growth ambitions. This excludes young businesses that never intend to grow beyond their solo founder, have employees, or reach a wider geographical market (Katila et al., 2012). The main preoccupation of start-ups is to identify a repeatable and scalable business model.

Once firms have solved this problem, the main challenge becomes to scale market position, join forces with established collaborators and identify opportunities for ongoing expansion. Businesses in this later stage are typically referred to as scale-ups. In this chapter, we refer to young firms with high growth ambitions as either start-ups or scale-ups depending on their own assessment on where they stand.

Start-up and scale-up activities are a driver of GDP per capita (Figure 1). A large body of research has shown the positive effect of young, high growth firms on economic activity (Calvino et al., 2016, provide a review of the relevant literature). Our data enables us to add to this by illustrating some of the key channels through which start-ups and scale-ups contribute to growth.

Start-ups and scale-ups are drivers of aggregate investment activities, in particular investment in intangible assets. Start-ups and scale-ups tend to invest a lot more per employee than more mature firms do (Figure 2a). For the asset types that these firms target with their investment activities, we find a significantly stronger focus on intangible assets among start-ups and scale-ups compared to their more mature counterparts (Figure 2b).

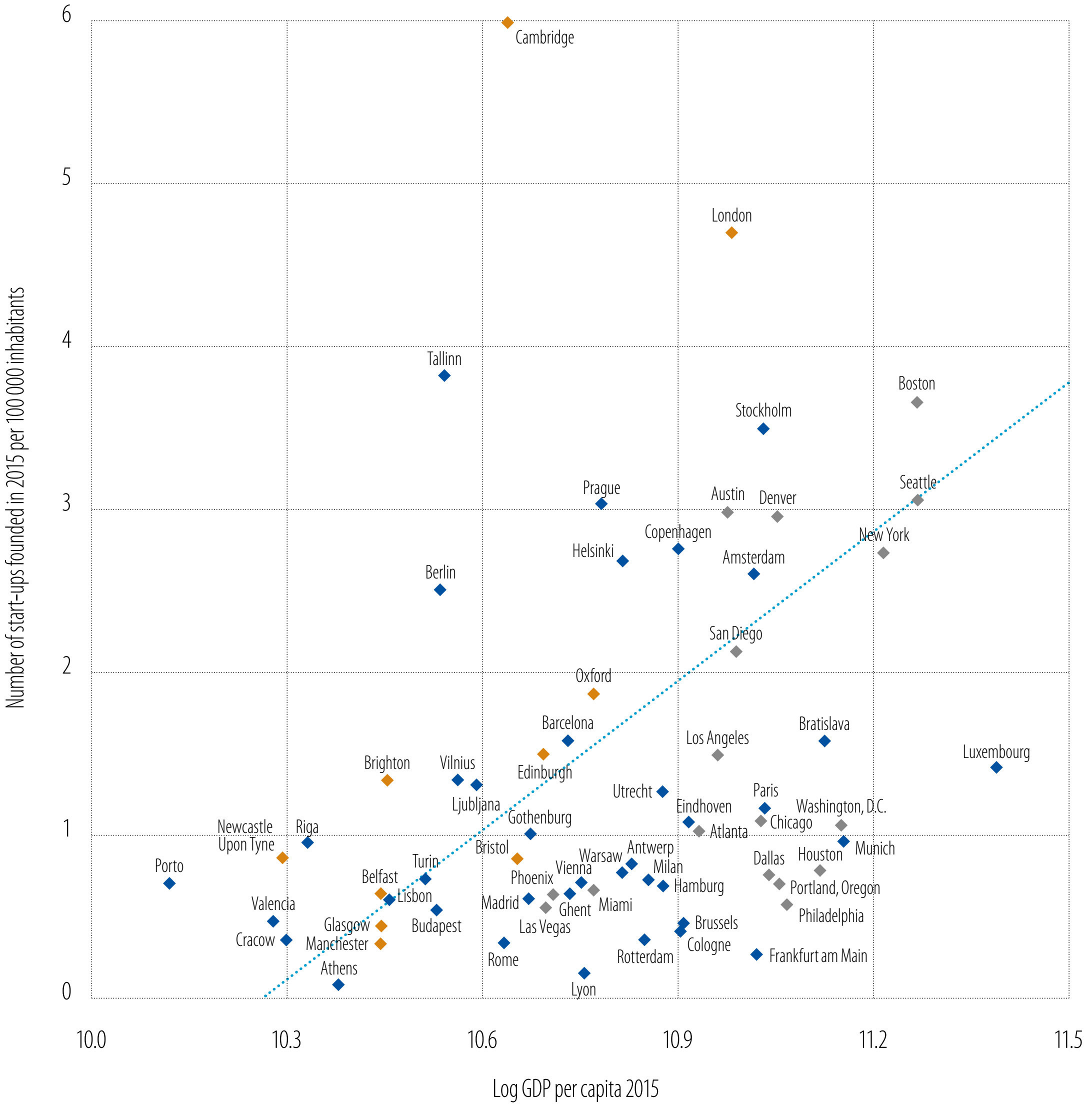
Throughout the chapter, we use the firms' own assessment of the current phase of their business[2] to label them as either start-ups or scale-ups.

Start-ups and scale-ups are also carriers of innovation. About 95% of start-ups and scale-ups state that their business is based on a new idea. This can be either with respect to the product or service that they offer, the delivery mode via which this product or service is provided or the organisation of the supply chain/technology that the firm uses. Apart from these well-known types of innovation, we find that start-ups are also often carriers of innovation when it comes to how they earn money with the products or services that they offer as well as the way that they brand or advertise them (Figure 3a).

The new ideas incorporated into start-ups and scale-ups are in many cases highly novel. About 75% of start-ups and 55% of scale-ups report that the most novel aspect of their firm is "new to the world" and thus a fundamental innovation. For about 15-20% of firms, it is novel to the country/state in which they operate and for 15-25% novel to the local context (Figure 3b).

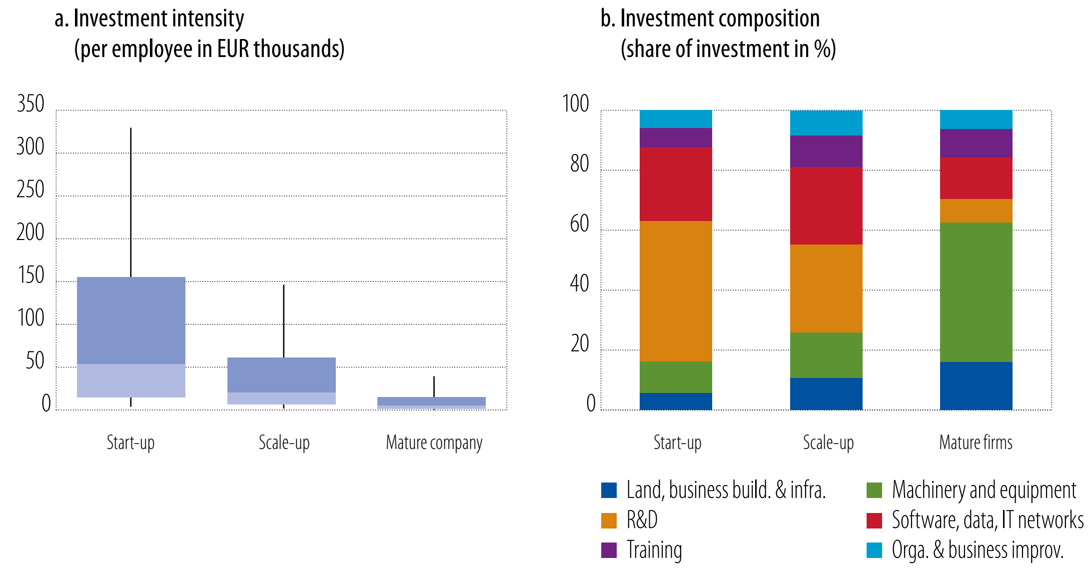
2 We asked companies: "Which of the following best describes the current stage of your business? Early stage, launch/early revenue phase, growing revenue/scale-up, maturity/consolidation." We label firms that fall into the first two categories as start-ups, whereas firms in the last two categories are labelled scale-ups.

Figure 1
Firm creation and GDP per capita



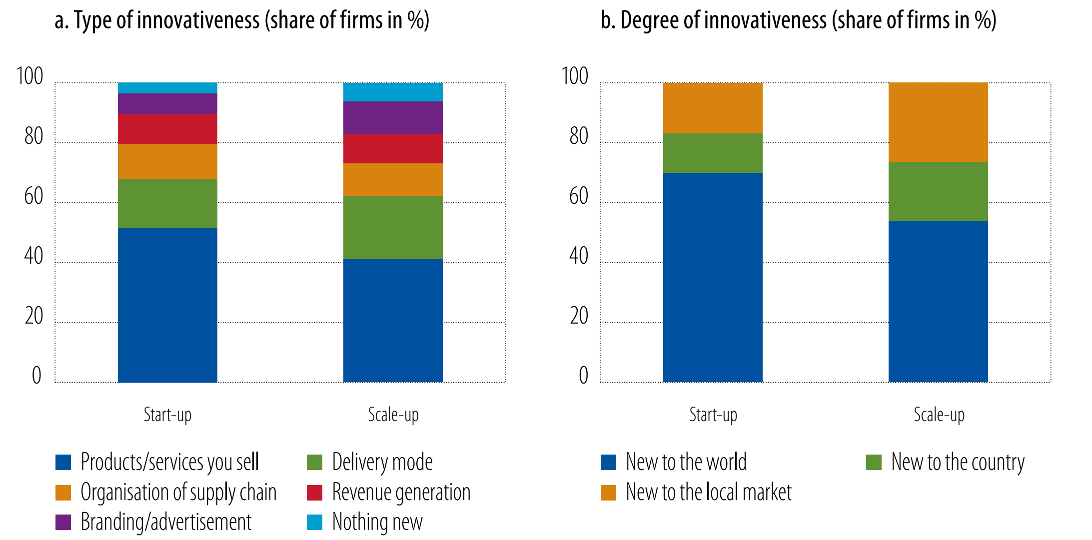
Source: *Crunchbase, OECD Metropolitan Data, authors' calculation.*
Base: *Firms founded in 2015 that are still active and received formal funding.*
Note: *We included cities with more than 500 firms listed on Crunchbase founded from 2008 to 2018 that are active in the United States. The corresponding number in the EU27 and United Kingdom is 100 firms. Also, cities needed to be included in the OECD Metropolitan Data.*

Figure 2
Investment spending



Source: *EIBIS Start-up and Scale-up Survey 2019, EIBIS 2019.*
Base: *All firms (EIBIS Start-up and Scale-up Survey 2019), all firms older than ten years (EIBIS 2019).*
Note: *Investment intensity is measured as investment spending per employee. Box plots report 10th, 25th, median, 75th and 90th percentiles of investment intensity.*
Question: *How much has your business invested in each of the following with the intention of maintaining or increasing your company's future earnings?*

Figure 3
Most innovative aspect of business



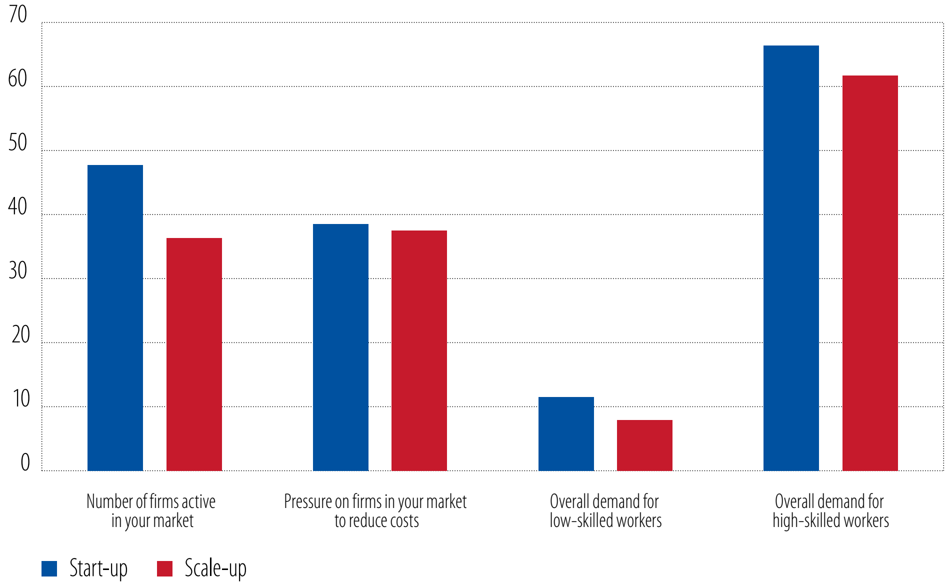
Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Question: *Which of the following, if any, is the most innovative aspect of your business?*

Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms that reported an innovative aspect.*
Question: *How new is it? Is it …?*

Start-ups and scale-ups are also important for labour demand and competition. They expect to have a (net) positive impact on overall demand for workers in their market, in particular, with regard to high-skilled staff. Firms also report a positive effect on the cost structure and the number of competitors active in their market (Figure 4). This is in line with a large body of literature showing the important role of young firms in employment growth as well as in their impact on competition (see Wong et al., 2005 and Gornall and Strebulaev, 2015, for a review).

Figure 4

Expected effect of impact (net balance, share of firms in %)



Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Note: *Net balance shows the difference between the share of firms expecting an increase and firms expecting a decrease.*
Question: *Looking ahead to the next three years, do you think that your business will lead to an increase, a decrease or have no impact on each of the following in your market …?*

Where do we stand in terms of start-up and scale-up activities in Europe?

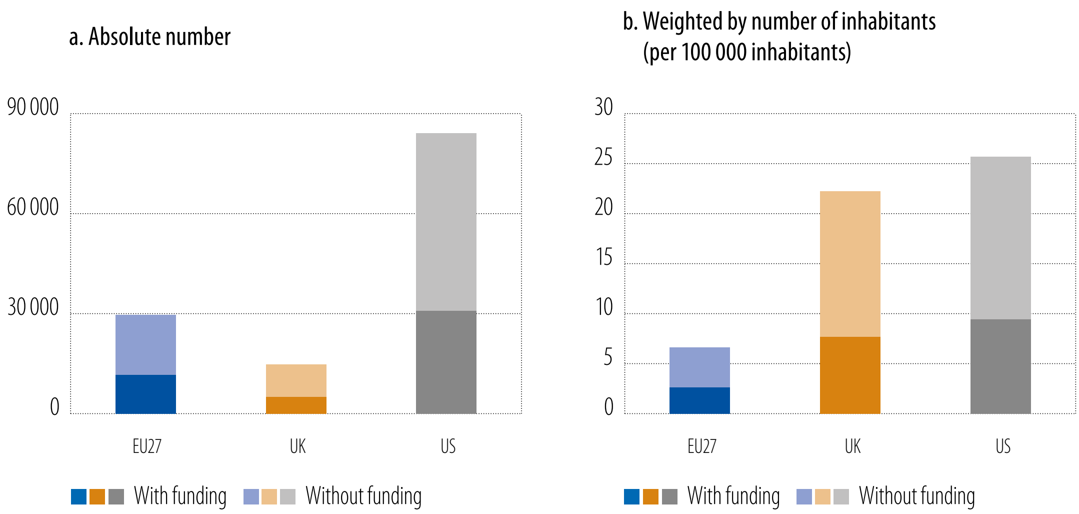
Number of start-ups and scale-ups

The EU27 has a relatively low number of start-ups and scale-ups. This is true in absolute numbers (Figure 5a) and as a share of the total population (Figure 5b). The EU27 has managed to reduce the difference vis-à-vis the United States to some extent in recent years (The State of European Tech, 2018). Nevertheless, the gap remains large, with the EU27 having only about one-quarter to one-third the number of young, high growth firms of the United States.

Only some European countries have a higher start-up and scale-up density than the United States. Even in these countries (Ireland, Estonia and Luxembourg), however, the number of start-ups and scale-ups (per 100 000 inhabitants) is only about half that of the leading US states (Figure 6). Interestingly, the US states with the lowest start-up and scale-up densities are not very different from the weakest EU countries, suggesting a geographically diverse start-up and scale-up scene within the United States.

Figure 5

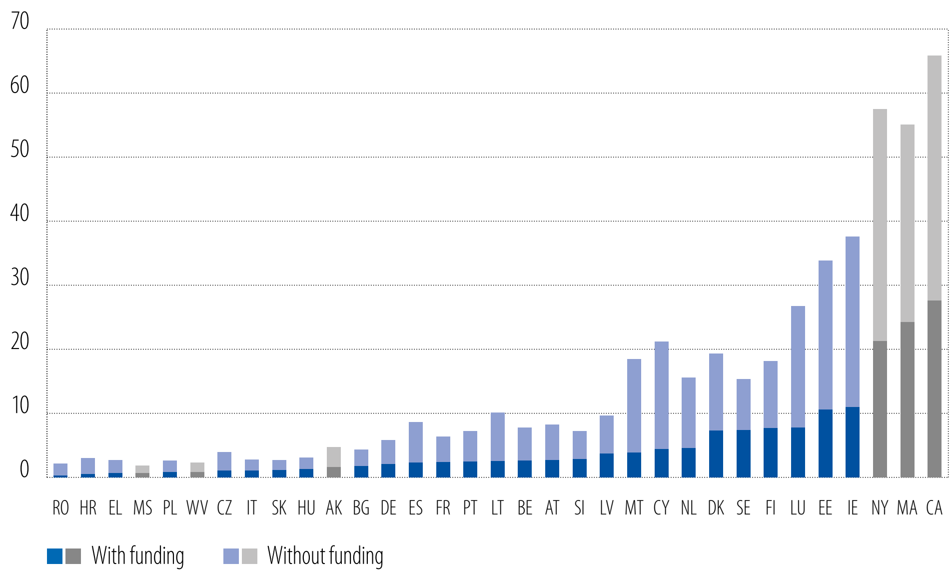
Number of firms with and without funding in the EU27, US and UK



Source: *Crunchbase, authors' calculation.*
Base: *Firms founded 2008-2018 that are still active.*
Note: *Crunchbase lists firms that have already received some form of formal funding (with funding) as well as firms that have not received formal funding yet (without funding).*

Figure 6

Number of companies per 100 000 inhabitants in the EU27 and US



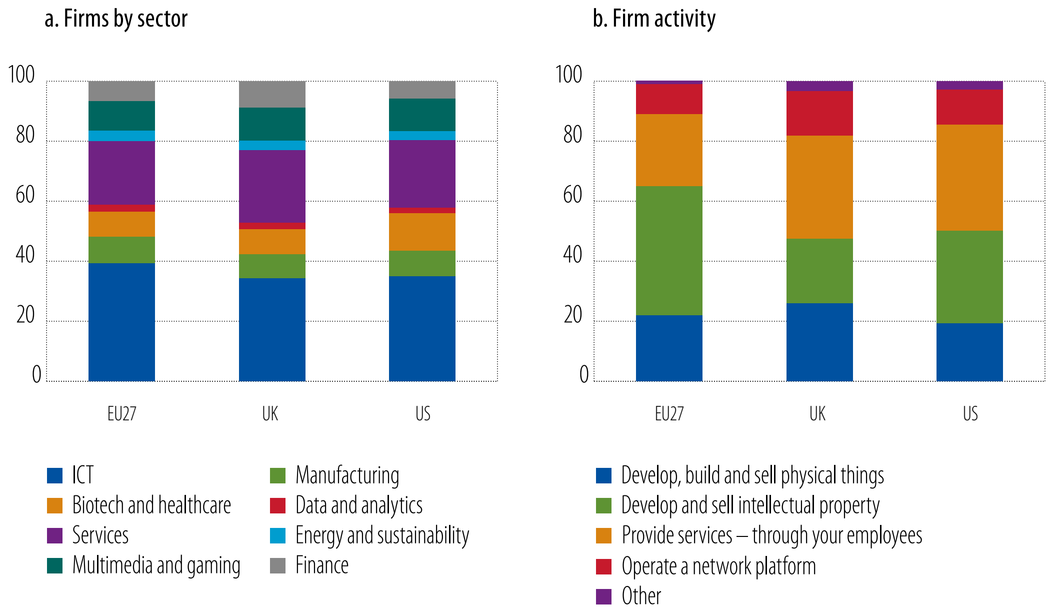
Source: *Crunchbase, Eurostat, US Census Bureau, authors' calculation.*
Base: *Firms founded 2008-2018 that are still active.*
Note: *Crunchbase lists firms that have already received some form of formal funding (with funding) as well as firms that have not received formal funding yet (without funding). MS: Mississippi, WV: West Virginia, AK: Alaska, NY: New York, MA: Massachusetts, CA: California.*

Firm characteristics

Most start-ups and scale-ups in Europe are active in the information and communication technologies (ICT) sector, followed by the services sector (Figure 7). In terms of business activities, most EU start-ups and scale-ups develop and sell intellectual property, followed by the development and commercialisation of physical things and the provision of services though employees (Figure 7). Compared to the United States, we find a slightly stronger focus of EU start-ups and scale-ups on intellectual property and a slightly lower focus on the provision of services.[3]

Figure 7

Sectorial split (share of firms in %)



Source: *Crunchbase, authors' calculation.*
Base: *All firms founded after 2007, still active or with an initial public offering (IPO).*
Note: *Sectors were constructed as follows: each firm on Crunchbase is tagged with different categories of activities. Some firms have up to 22 main tags that can be further split into sub-categories. Based on these categories, we defined the sectors listed in the figure. We assigned sectors based on dominance. In the case of multiple sectors with equal importance, we assigned probability weights.*

Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Question: *What is the main activity of your firm?*

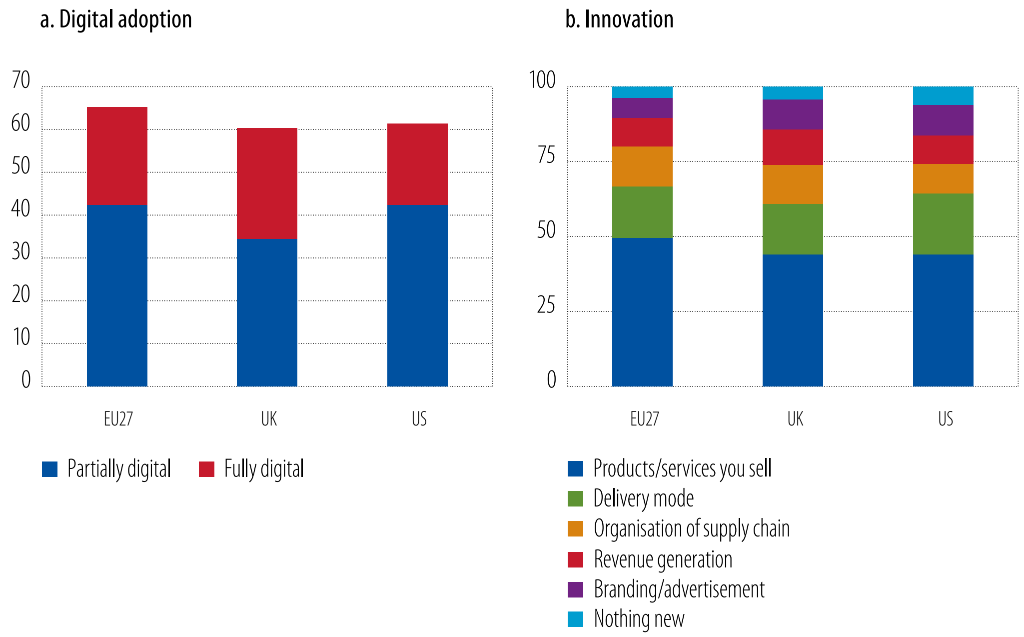
About one in five young firms with high growth ambitions in Europe is fully digital, i.e. has organised their entire business around one or more digital technologies. Another 40% of start-ups and scale-ups implemented digital technologies only in parts of their business. The share of digital firms is comparable to that in the United States (Figure 8a). Cognitive technologies (such as artificial intelligence) and internet of things applications are most frequently used by start-ups and scale-ups on both sides of the continent.

3 Instead, we would argue that the relatively high share of service start-ups in the United States is a result of the boom in gig economy start-ups (including Uber, Airbnb and Instacart) from a decade ago.

Half of EU firms are about new products or services. Another third is about the way that these products and services are produced and/or delivered. Less than 10% of young firms with high growth ambitions consider their business model or the way they brand their products/services to be the most innovative aspect of their business in the European Union (see Figure 8b). In comparison with the United States, EU firms tend to be more about novel products or services and slightly less about finding new ways to deliver them, which is consistent with the experience that many "on demand" innovations (such as Uber, Instacart, Airbnb) come from the United States.

Figure 8

Digital adoption and innovation (share of firms in %)



Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Question: *Can you tell me for each of the following 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? Cognitive technologies, blockchain, internet of things.*

Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Question: *Which of the following, if any, is the most innovative aspect of your business?*

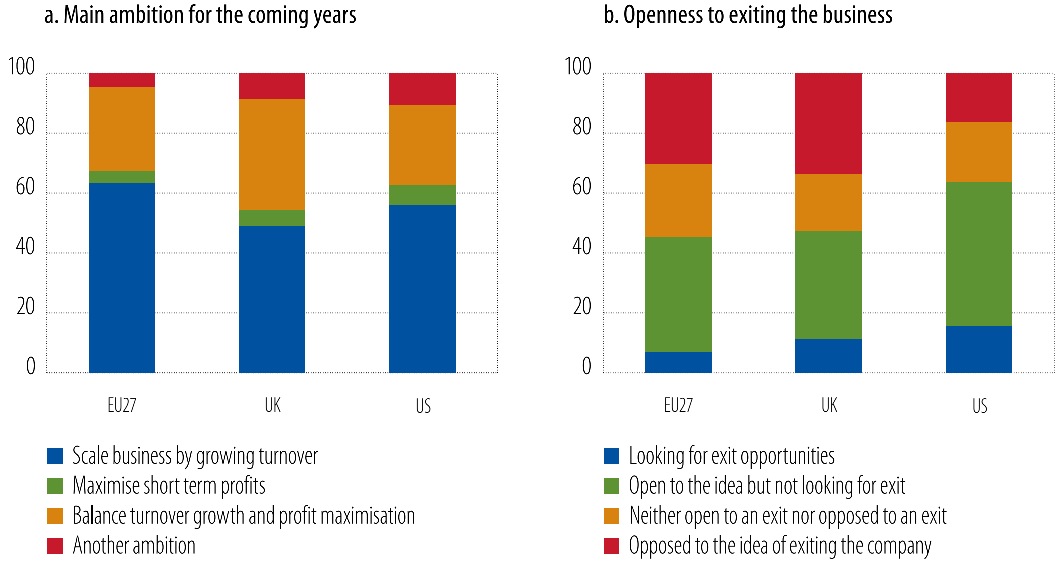
Founder characteristics

The main preoccupation of EU founders is to scale their business. That is, to maximise sales even if it comes at the expense of short-term profits. EU and US start-ups and scale-ups are very similar in this respect (Figure 9a), which is in conflict with the often heard prejudice that EU start-ups are too short-term oriented compared to their US peers. In the same vein, Figure 9b shows that European entrepreneurs are much more determined than their US peers to continue to grow their business rather than seeking an early exit.

The willingness to take risk is only slightly higher in the United States. To understand the link between risk perception and entrepreneurship, we combined the Crunchbase dataset with the Global Preference Survey (Falk et al., 2016, 2018). The Global Preference Survey is an experimentally validated dataset of preferences from 80 000 people in nearly 80 countries. It measures among other things people's risk preferences. Figure 10 highlights the fact that risk perception and the number of start-ups are linked: countries where individuals are more prone to risk taking see more start-ups relative to the number of inhabitants. The correlation is, however, relatively weak.

Figure 9

Main ambition and exit openness (share of firms in %)

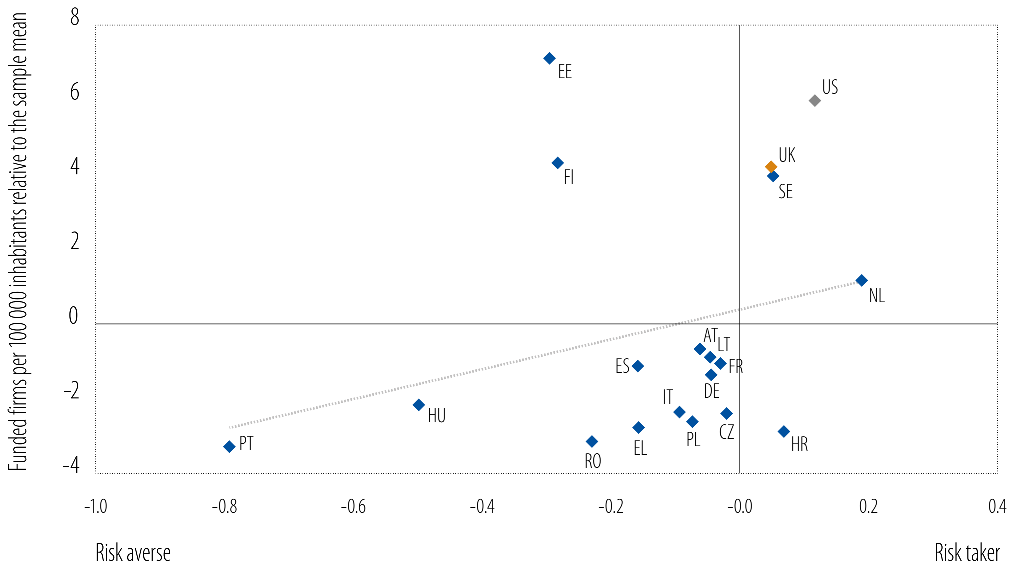


Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Question: *Looking ahead to the next three years, which of the following best describes your company's main ambition?*

Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms where founder holds controlling share.*
Question: *How prepared would you say the controlling owners are to exit the company in the next three years?*

Figure 10

Risk perception and number of start-ups

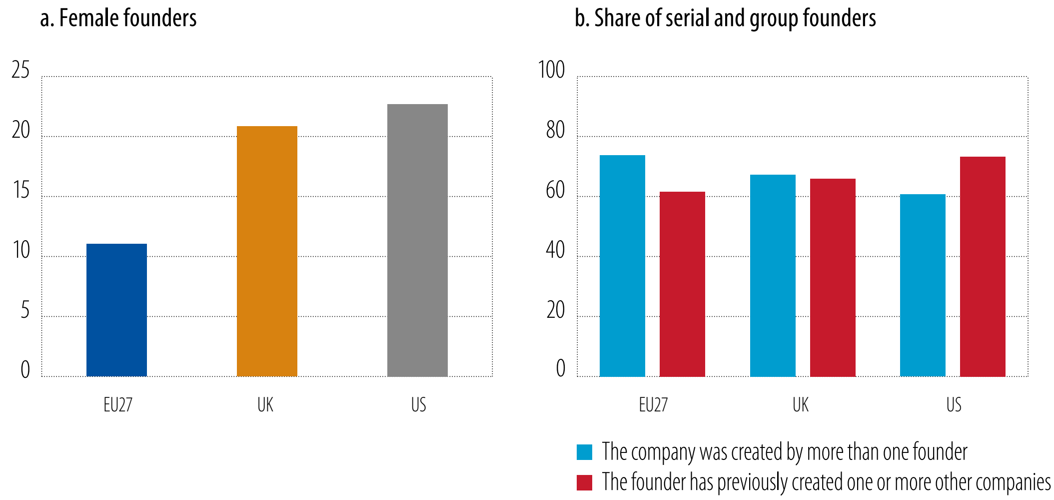


Source: *Global Preference Survey and Crunchbase, authors' calculation.*
Base: *Firms founded 2008-2018 that are still active and received formal funding.*

Women entrepreneurs and serial entrepreneurs are under-represented in Europe. Only about one in ten start-ups and scale-ups have a majority of female founders (see Box B for a longer discussion of this issue). While more than 60% of founders are serial entrepreneurs, this share is much lower in the EU27 than in the United States with nearly 75% of founders having previously created one or more other companies. European firms are, on the other hand, more likely to have been created by more than one founder, which is often considered to be a determinant of start-up success (Figure 11).

Figure 11

Founders (share of firms in %)



Source: EIBIS Start-up and Scale-up Survey, EIBIS 2019.
Base: All firms.
Question: Are at least half of the founders women?

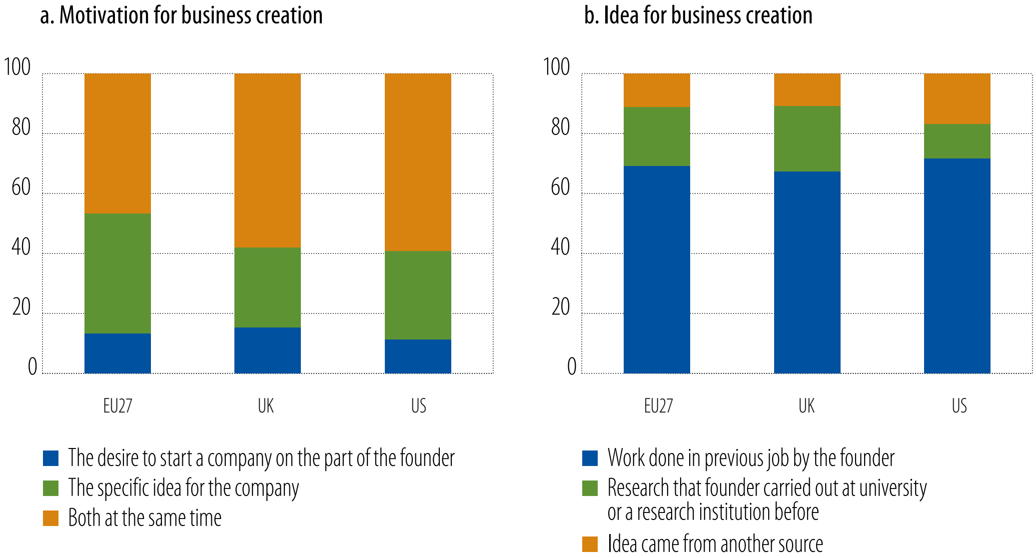
Source: EIBIS Start-up and Scale-up Survey 2019.
Base: All firms.
Question: Which, if any, of the following apply?

Most founders in the European Union were motivated by a specific idea to start their business rather than by a desire to become an entrepreneur. For about 45% of founders, the idea to start a business came first; for 40% it came at the same time as the desire to start a business. Only about 15% of founders had the desire to start a business before they had an idea of what they wanted to do. Having a specific idea as the sole motivation to start a business is stronger in Europe than in the United States (Figure 12a).

The main source of the idea to start a business is previous work experience. About 70% of the firms interviewed report this as the origin of the idea to start a business. Of start-ups, 20% are created based on previous research that one or more of the founders pursued at a university or research centre. Interestingly, in contrast with the view that European higher education facilities lag behind their US peers when it comes to cultivating entrepreneurship, the EU share of start-ups based on previous research is almost twice as high as in the United States (Figure 12b).

Figure 12

Motivation and idea for business creation (share of firms in %)



Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Question: *Can you tell me which of the following came first in the case of your company?*

Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Question: *Can you tell me how the idea for your company arose? Was it in relation to …?*

Box B

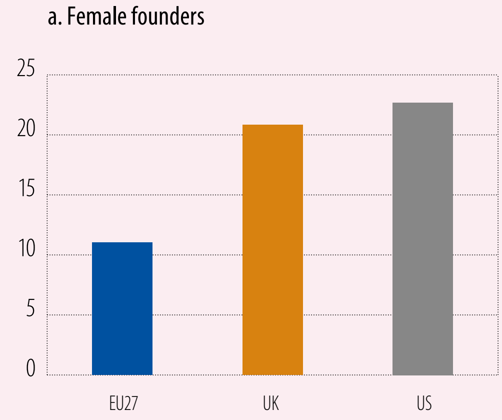
Women

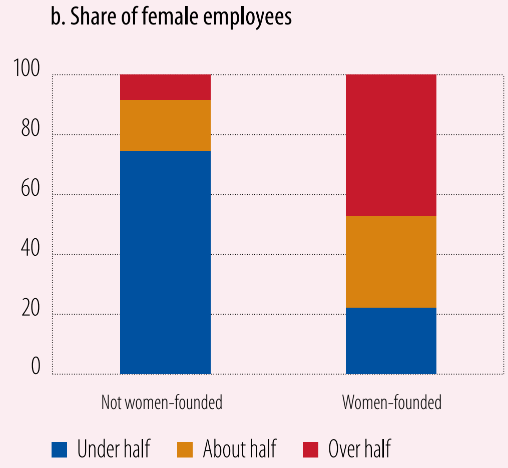
Female founders are severely underrepresented in European start-ups and scale-ups. The share of start-ups that have a female founder(s) is 23% in the United States, 20% in the United Kingdom and 11% in the European Union (Figure B.1a).

The low share of women-led start-ups and scale-ups has knock-on effects for female employment. Female-founded companies tend to employ a lot more women than do male-founded companies (Figure B.1b).

Access to finance is often named as a key barrier for women entrepreneurs. There is a growing body of literature on this subject (see OECD (2016), Alesina et al. (2008), Jung (2010), and European Parliament (2015) for a review). At first sight, our data confirm the idea of that female entrepreneurs struggle to find finance. We find that women-led start-ups and scale-ups rely more on informal sources of finance and tend to finance their activities more with debt and less with equity. In addition, the equity that women-led firms receive is more likely to come from themselves, family or friends (Figure B.2c). All of this suggests worse access-to-finance conditions. Public sources of support do not seem to address this issue yet (Figure B.2d).

Figure B.1
Female founders and employees (share of firms in %)

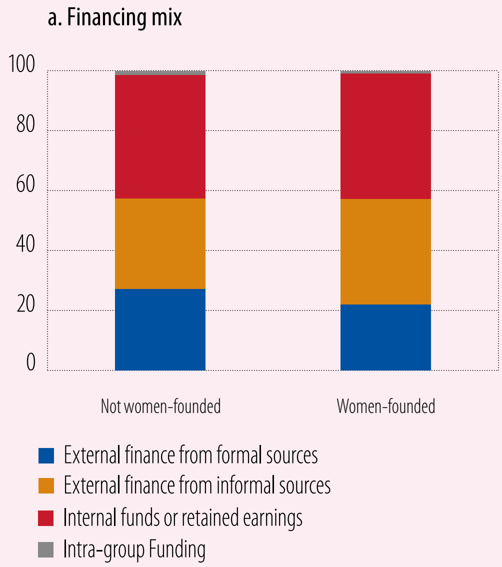


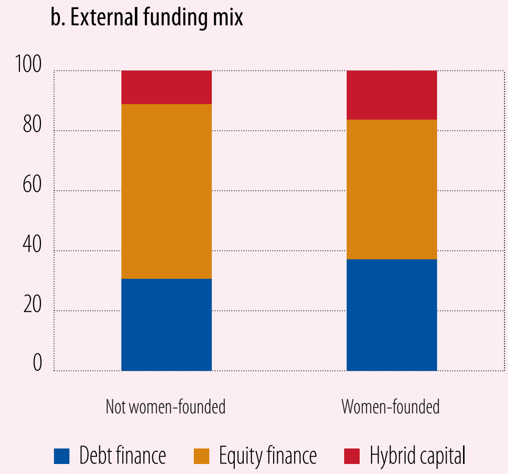


Source: *EIBIS Start-up and Scale-up Survey, EIBIS 2019.*
Base: *All firms.*
Question: *Are at least half of the founders women?*

Source: *EIBIS Start-up and Scale-up Survey, EIBIS 2019.*
Base: *All firms.*
Question: *Are at least half of the founders women? Roughly what is the proportion of women in your company?*

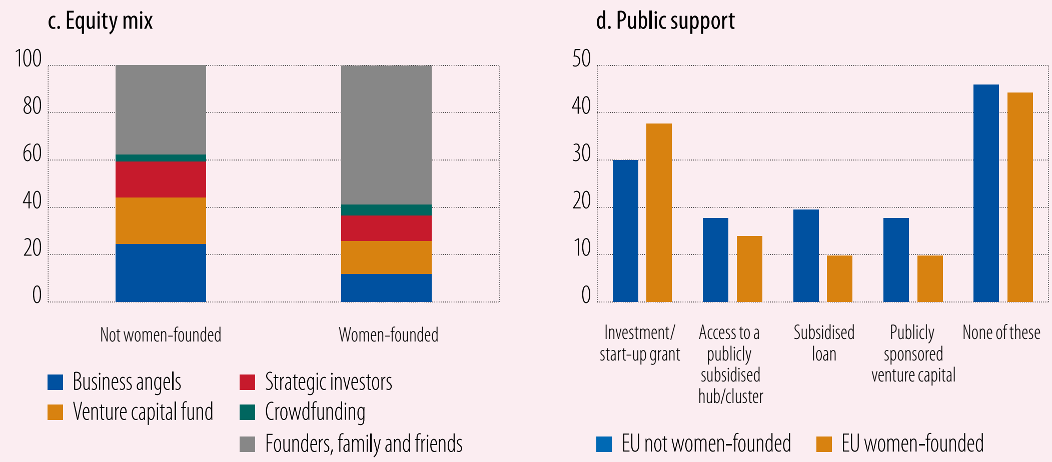
Figure B.2
Financing mix (share of firms in %)





Source: *EIBIS Start-up and Scale-up Survey, EIBIS 2019.*
Base: *All firms.*
Questions: *Are at least half of the founders women? Approximately what proportion of your business activities have been financed by each of the following?*

Source: *EIBIS Start-up and Scale-up Survey, EIBIS 2019.*
Base: *All firms that used external finance.*
Questions: *Are at least half of the founders women? What proportion of the external finance was in the form of …?*

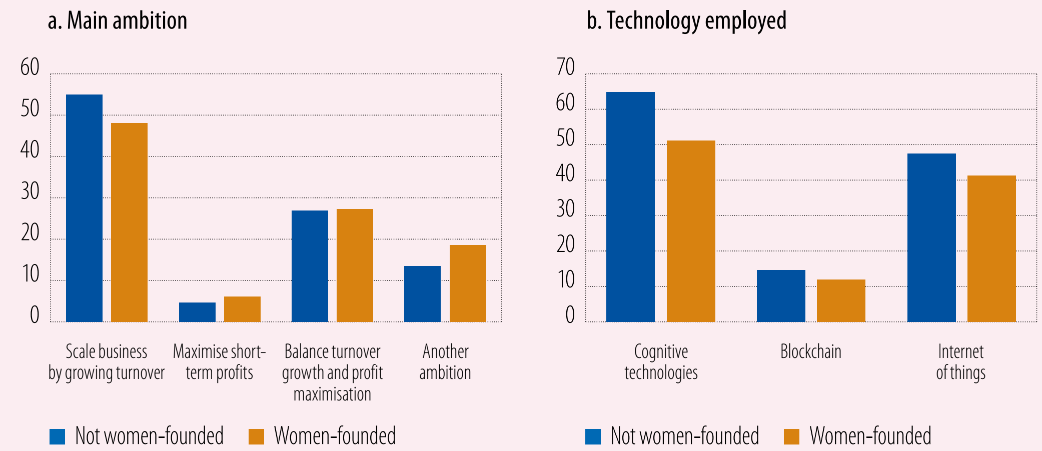


Source: *EIBIS Start-up and Scale-up Survey, EIBIS 2019.*
Base: *All firms that used equity finance.*
Questions: *Are at least half of the founders women? Who provided you with the largest share of equity finance for your business activities?*

Source: *EIBIS Start-up and Scale-up Survey, EIBIS 2019.*
Base: *All firms based in EU27.*
Questions: *Are at least half of the founders women? Since the start of your business, has it, at any point, benefited from any of the following types of public support schemes?*

Differences in ambitions and business activities could be confounding factors. Our survey data show that female founders tend to focus slightly less on scaling up than their male peers. Their businesses also tend to rely slightly less on digital technologies and the development of intellectual property as opposed to providing a service through its employees. Finally, we find that women-led firms often have a stronger local focus than men-led firms, even though that may be a consequence of their weaker access-to-finance conditions rather than a cause of it (Figure B.3d).

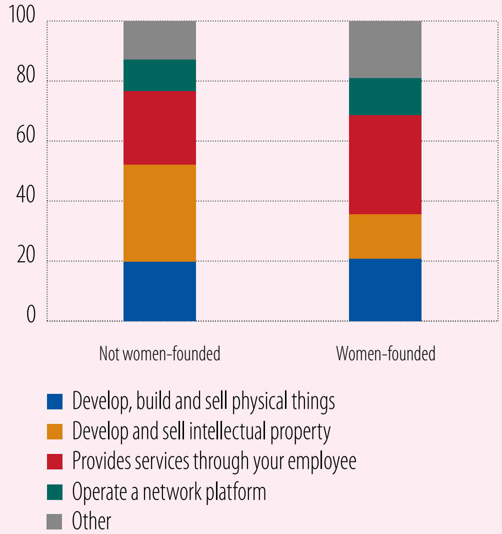
Figure B.3
Activities and digitalisation status (share of firms in %)



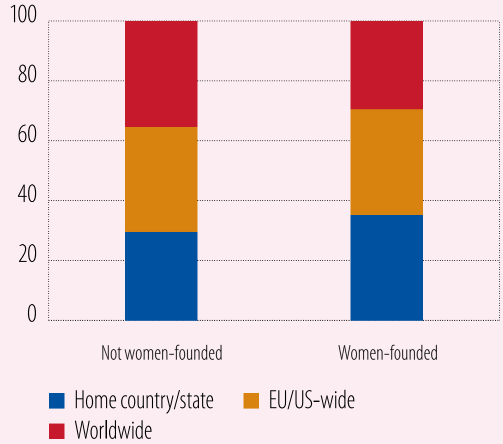
Source: *EIBIS Start-up and Scale-up Survey, EIBIS 2019.*
Base: *All firms.*
Questions: *Are at least half of the founders women? Looking ahead to the next three years, which of the following best describes your company's main ambition?*

Source: *EIBIS Start-up and Scale-up Survey, EIBIS 2019.*
Base: *All firms (EIBIS Start-up and Scale-up Survey).*
Questions: *Are at least half of the founders women? Can you tell me for each of the following 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?*

c . Firm activity



d. Geographical reach



Source: *EIBIS Start-up and Scale-up Survey, EIBIS 2019.*
Base: *All firms (EIBIS Start-up and Scale-up Survey).*
Questions: *Are at least half of the founders women? What is the main activity of your firm?*

Source: *EIBIS Start-up and Scale-up Survey, EIBIS 2019.*
Base: *All firms.*
Questions: *Are at least half of the founders women? In which geographical markets do you primarily operate?*

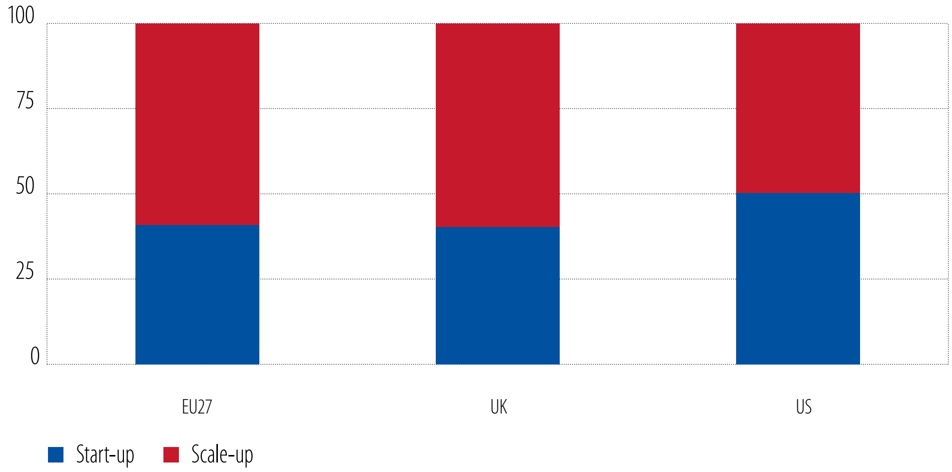
Accounting for differences in ambitions and business activities, the financing gap between male and female entrepreneurs remains. To see if women are at a disadvantage when it comes to access to finance – or whether the differences that we observe in funding conditions is simply due to differences in ambitions/firm characteristics – we use a regression framework. We compare for women-led and men-led firms that are similar, the share of funding that comes from informal sources, the equity share in firms' external financing mix and the share of equity that comes from founders, family and friends.

What find that, even after controlling for possible confounding factors, women-led firms have a 5 percentage point higher funding share from informal external sources; an 11 percentage point lower equity share in their external funding mix; and an 18 percentage point higher share of equity funding from founders, family and friends. This suggests that the differences in financing conditions are not only due to differences in ambition, activities, or innovation behaviour, but also reflect more difficulties in accessing finance.

Where is the gap in Europe in terms of start-up and scale-up activities?

Europe has a particular deficit in the scale-up phase. The lower number of start-ups and scale-ups in Europe is not driven by a deficit in either start-ups or scale-ups in particular (Figure 13). We argue, however, that a big part of the overall gap in start-up activities can be explained by lower scale-up success in Europe. The logic is that if chances to scale a business are low, entrepreneurs are less willing to start a business in the first place. This affects start-up activities.

Figure 13
Relative share of start-ups and scale-ups (share of firms in %)



Source: EIBIS Start-up and Scale-up Survey 2019.
Base: All firms.
Question: Which of the following would you say best describes the current stage of your business?

In the following, we illustrate the scale-up gap in two ways:

- First, we show that while there are no big qualitative differences between start-ups in the European Union and the United States, a clear gap arises as firms age.
- Second, we show that the main bottlenecks to growth appear at the later stages. That is, while start-ups in the European Union face similar challenges to their US peers, these bottlenecks become more constraining for EU firms as they develop.

We will discuss both pieces of evidence in turn, starting with qualitative differences between EU and US start-ups and scale-ups.

While EU and US start-ups are, on average, relatively similar in size, US scale-ups tend to grow much bigger than their EU peers (Figure 14a). Related to this, we find that EU scale-ups are more likely to limit their business activities to their local/national markets compared to US scale-ups (Figure 14b), although the share of start-ups and scale-ups that operate worldwide is comparable in the EU27 and United States.

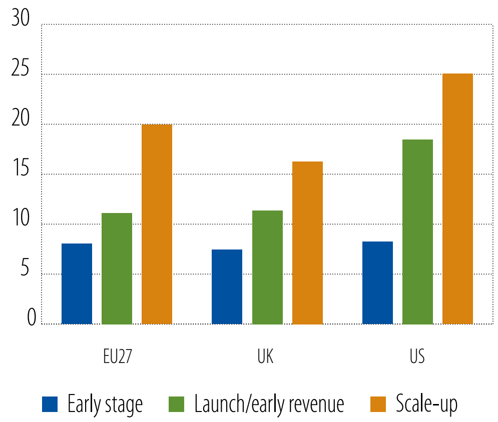
In the same vein, we find that EU firms raise less funding as they grow older. Figure 15a shows the amount of funding young firms with growth ambitions raise by the firm's age. While initially the differences between the European Union and the United States are modest, as firms develop the gap between the two increases. The same phenomenon can be observed for firm valuations (not shown) which, in turn, helps to explain the disproportionately larger share of unicorns – i.e. scale-ups with a firm valuation of USD 1 billion or more – in the United States than in the European Union. While the United

States has three times as many start-ups and scale-ups as the European Union, it has almost nine times as many unicorns (Figure 15b).[4]

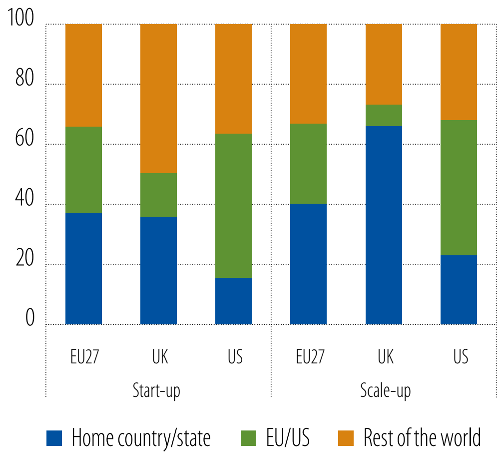
Figure 14

Size and target markets

a. Size by region (mean number of employees)



b. Target market (share of firms in %)



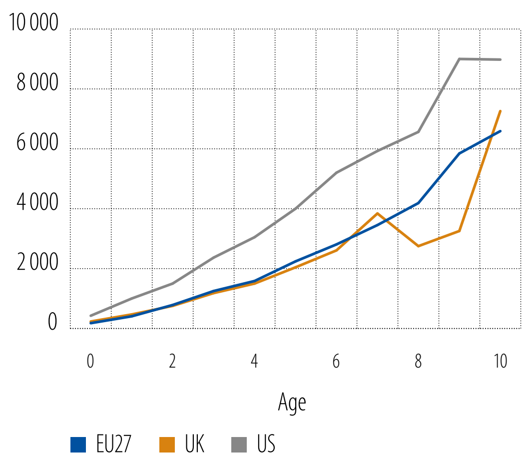
Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms that are not in at the maturity/ consolidation stage.*
Questions: *How many people does your company employ at all its locations? Which of the following best describes the current stage of your business?*

Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Question: *In which geographical markets do you primarily operate?*

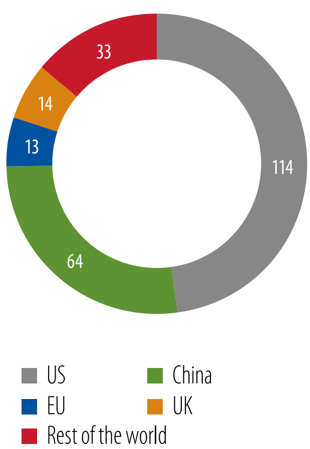
Figure 15

Venture capital funding and number of unicorns

a. Venture capital funding per firm (median funding of firm in USD thousands)



b. Unicorns



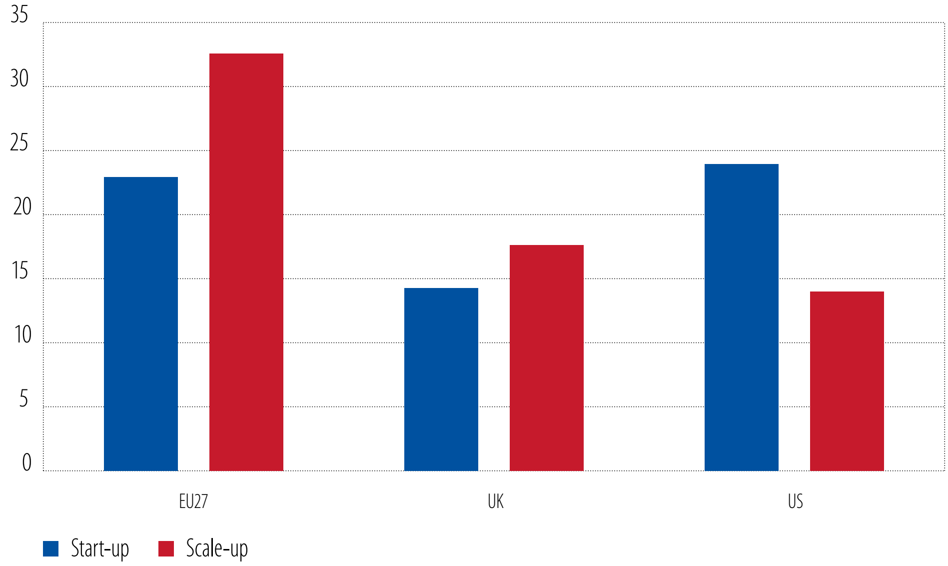
Source: *Crunchbase, authors' calculation.*
Base: *Firms founded 2008-2018 that are still active and received formal funding.*

Source: *Crunchbase Unicron Leaderboard.*

4 A similar argument could be made for mega IPOs or corporate acquisitions.

The qualitative differences between EU and US scale-ups is made worse by the migration patterns of firms. Often, the most successful EU firms move to the United States, e.g. Zendesk or HackerOne. We can see this pattern play out if we compare how sensitive EU firms are to adverse changes in framework conditions. We find that scale-ups in the European Union are more likely than their US counterparts to react heavily to adverse changes (Figure 16). There is no similar difference for start-ups.

Figure 16
Reaction to adverse changes (share of firms very likely to move or to close, in %)



Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms that react to at least one of the adverse changes.*
Question: *Thinking about your current main location, how likely would a deterioration of each of the following make you consider moving or closing your business?*
Note: *The figures represent the firms that indicate for at least half of these adverse effects mentioned that they would be very likely to move or close their business.*

This raises the question: what is causing the scale-up gap? The next section discusses several hypotheses.

Structural barriers

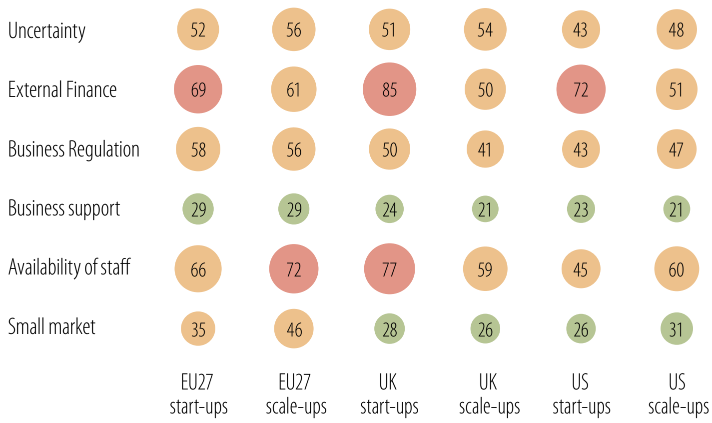
A possible explanation for the weak start-up and scale-up activities in the European Union is the fact that the bloc faces more structural barriers. European start-ups and, in particular, scale-ups are often held back by fragmented markets, lack of staff with the right skills and insufficient access to risk capital. Also, regulatory barriers matter but often seem to be a more severe constraint at early phases of start-up activities than later ones.

Market fragmentation

An often named argument for the weak start-up and scale-up activities in the European Union is fragmented markets. While in sheer size Europe may have the biggest market in the world, in many ways it is actually not one market. The different countries of the European Union have different languages, cultures, laws, histories, lifestyles, etc. As a consequence, what works in Germany might not work in France and vice versa. To target the entire European Union, entrepreneurs have to find a winning formula that works for most of the countries in the Union, unlike the United States which has a more unified market. This might explain why many start-ups and scale-ups in the EU27 operate solely in their home country.

The absence of a truly single market is particularly an issue for firms in the EU27 at later stages. One in two scale-ups in the EU27 report that market size is holding back their growth compared with 31% in the United States; this is a 15 percentage point difference for start-ups (Figure 17). Market size is even more of an issue for start-ups active in smaller EU countries. And it is an issue for scale-ups providing services through their employees, consistent with particularly high barriers to penetrating other markets in the service sector. We find no evidence that the numerous mentions of small market size are related to weak demand (see Box C for a discussion).

Figure 17
Obstacles (share of firms in %)



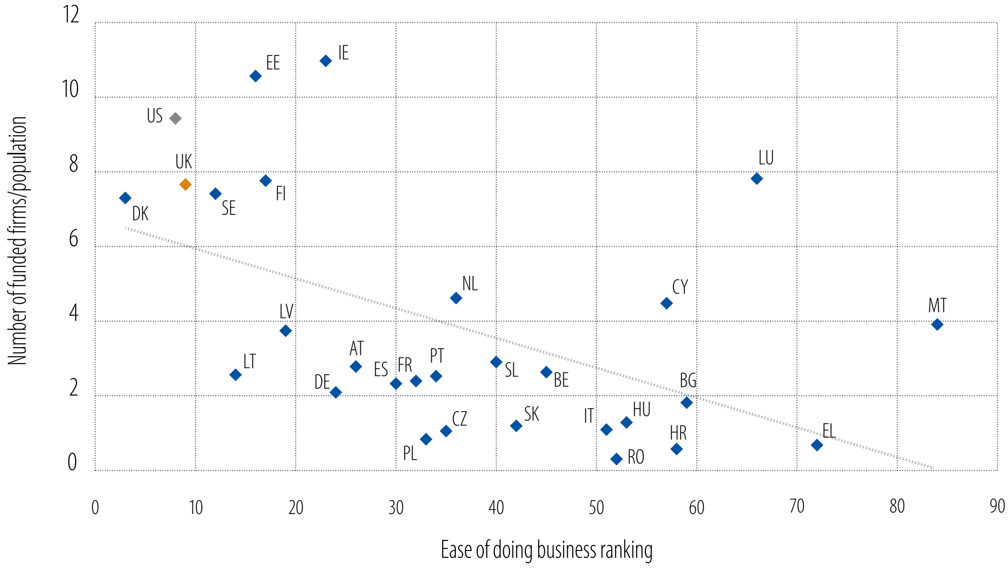
Source: EIBIS Start-up and Scale-up Survey 2019.
Base: All firms.
Question: To what extent is each of the following an obstacle to the success of your business?

Regulation

One possible driver of market fragmentation is regulation. In many respects, the regulatory environment in Europe is not harmonised, making it difficult for young firms with limited resources to access new markets. A simple way to illustrate the fragmentation of regulatory rules is by plotting the World Bank's Ease of Doing Business indicator by country (Figure 18). It not only shows that most countries in Europe rank worse than the United States, but also reveals huge differences across EU countries, pointing to very idiosyncratic approaches to business regulation.

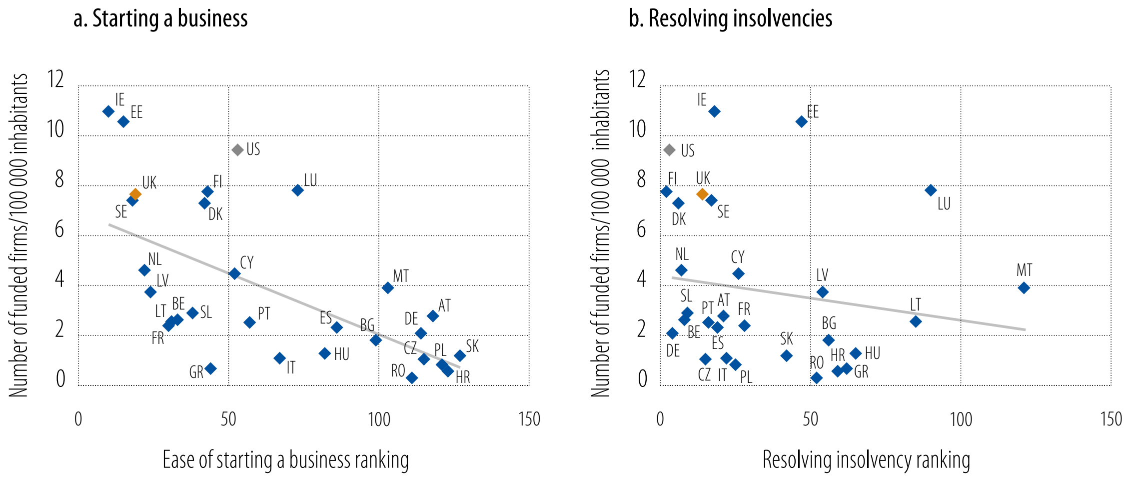
In addition, start-ups in Europe consider regulation to be a barrier to growth. About 57% of young firms report business regulation as an obstacle to realising growth ambitions. This is about 10 percentage points higher than in the United States. Matching our survey data with information from the World Bank's Ease of Doing Business indicator, we find a clear link between regulatory burdens and start-up and scale-up activities, in the sense that a more rigid regulatory environment is typically associated with lower start-up and scale-up activities. In particular regulation related to the ease of starting a business and regulation related to the ease of resolving insolvencies are strongly correlated with start-up and scale-up activities (Figure 19).

Figure 18
Ease of doing business



Source: *World Bank, Doing Business database 2018 and Crunchbase, authors' calculation.*
Base: *Firms founded 2008-2018 that are still active and received formal funding.*

Figure 19
Ease of starting a business and resolving insolvencies



Source: *World Bank, Doing Business database 2018 and Crunchbase, authors' calculation.*
Base: *Firms founded 2008-2018 that are still active and received formal funding.*

Box C
Start-up activities and business dynamics

An important caveat for our study is that it focuses on a cross section of firms. The literature – e.g. Campbell (1998), Lee and Mukoyama (2015), Pugsley and Sahin (2018) – suggests that the number of start-ups being created varies in line with the business cycle. This means that some of the differences that we find between the European Union and the United States, or within the European Union, may simply be due to the differences in dynamics over the relevant time horizon.

The relationship between start-up formation and the business cycle is reflected in our data. Figure C.1 shows that in cities where GDP per capita increased or decreased markedly, more start-ups have been created in recent years relative to 2008-2009. In cities where GDP per capita increased only slightly, on the other hand, the number of start-ups created 2016-2018 is comparable to 2008-2009.

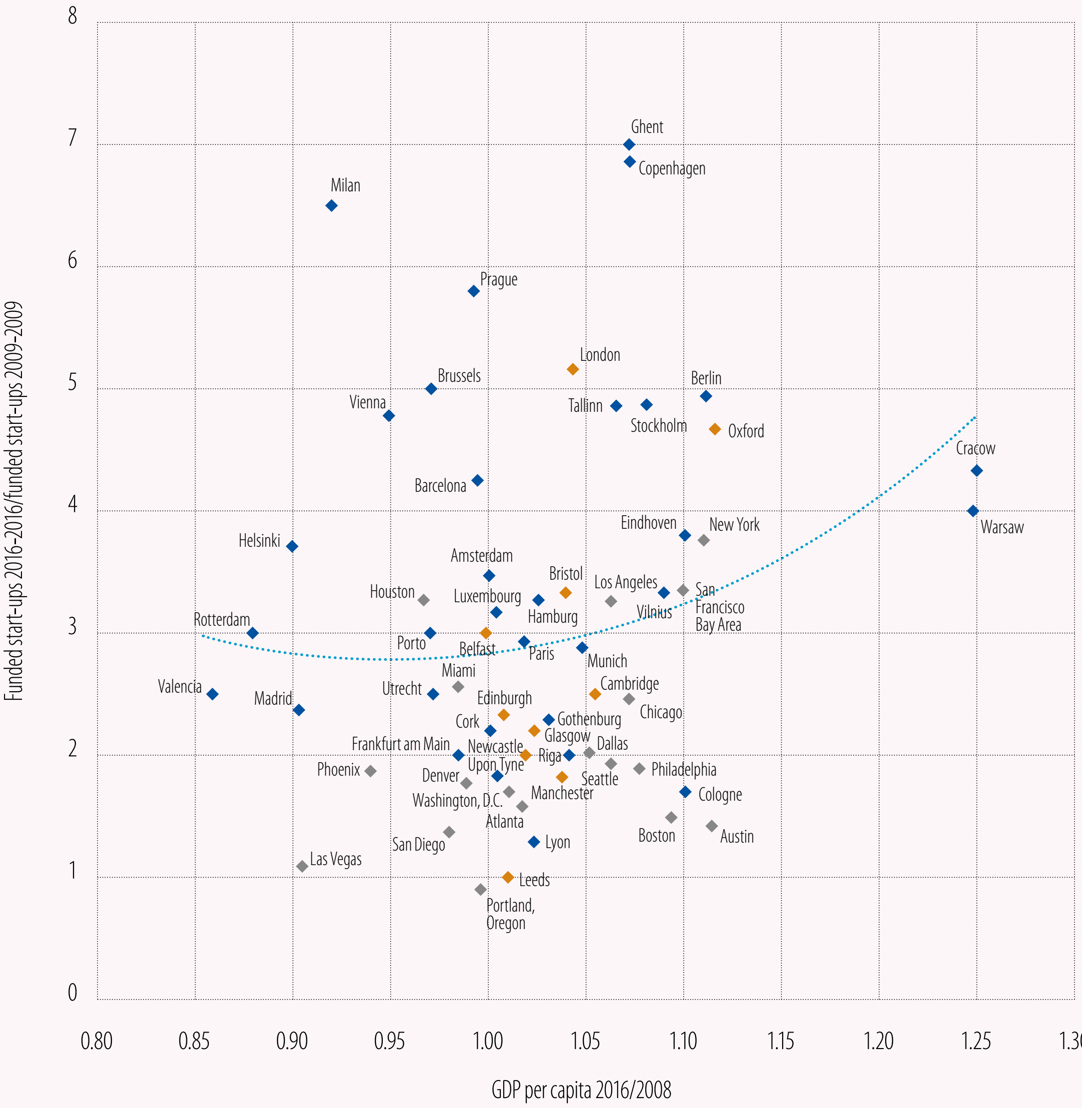
The higher start-up formation at low and high growth rates can be explained by necessity vs opportunity-driven business formation, where the necessity drives firm creation in times of crisis and the opportunity drives firm creation in times of booms (Thompson, 2011).

The business cycle is also correlated with the quality of start-ups/scale-ups. The literature suggests that firms born in recession start on a smaller scale and remain small over their lifecycle (Sedlacek and Sterk, 2017 and Moreira, 2015). The authors explain this phenomenon with demand-side constraints. We can show that start-ups that were created in 2011 in cities with low unemployment rates are today bigger on average than start-ups that were created in cities with high unemployment rates (Figure C.2).

While we cannot control for the fact that some of our results are driven by differences in the business cycle, we do not believe that they can account for our puzzle. First of all, the differences in start-up and scale-up activities are a long-standing phenomenon. Dubocage and Rivaud-Danset (2002) report a marked gap in venture capital funding between the European Union and the United States as early as in the late 1990s. Secondly, despite the link between the business cycle and start-up formation, the established correlations are way too low to account for a substantial part of the start-up gap between the European Union and the United States.

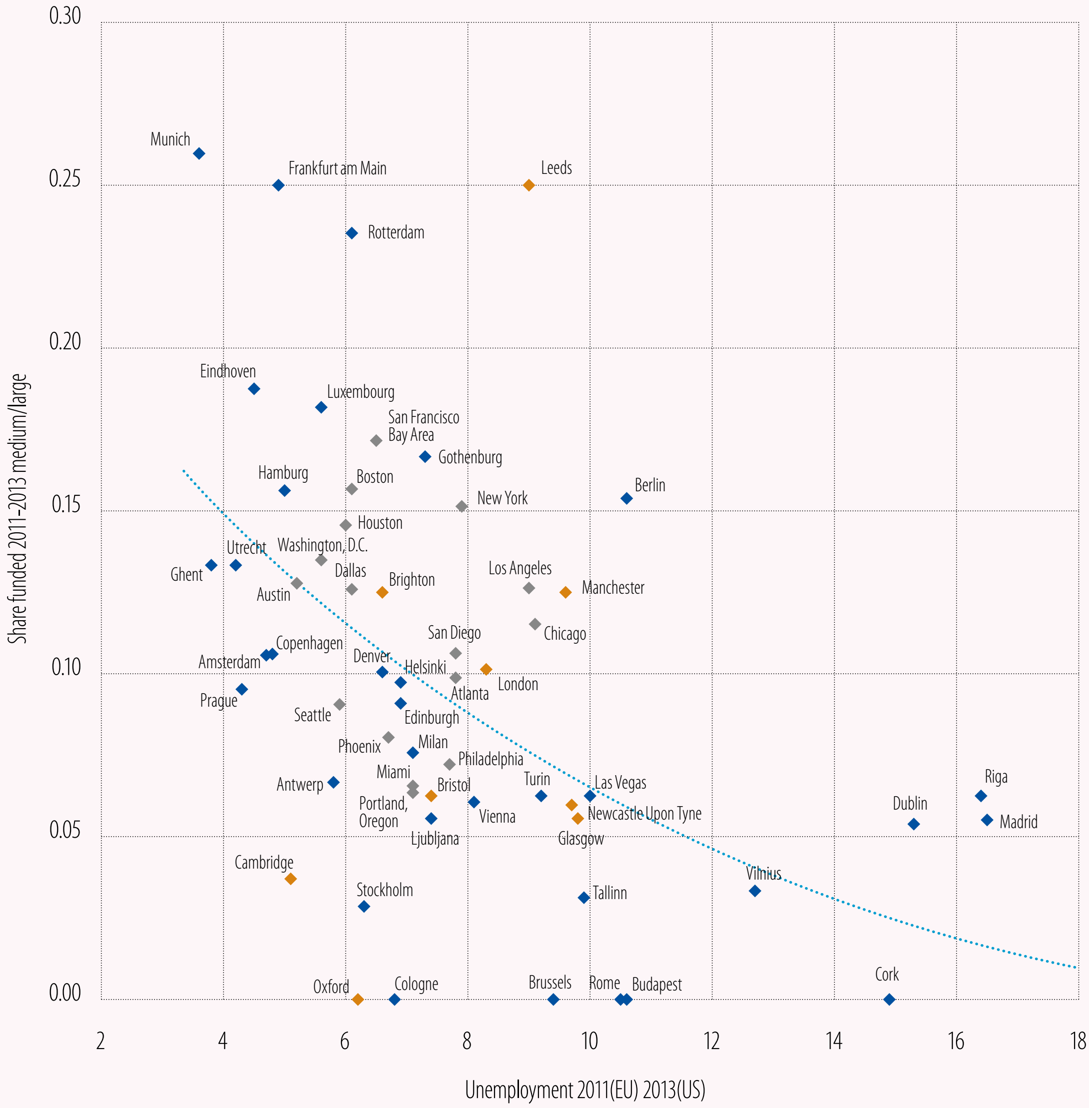
Finally, if the difference in start-up and scale-up activities between the European Union and the United States were primarily due to differences in the business cycle, we would expect this to be shown in firms' answer pattern when it comes to the motivation to start a business and the barriers to growth. Specifically, we would have expected a much higher share of founders to say that the desire to start a business preceded the specific idea for the business as well as a higher share of businesses to complain about a too small market size.

Figure C.1
Firm creation and growth performance



Source: *Crunchbase, OECD Metropolitan Data, authors' calculation.*
Base: *Firms founded between 2008-2018 that are still active and received formal funding.*

Figure C.2
Unemployment and company size

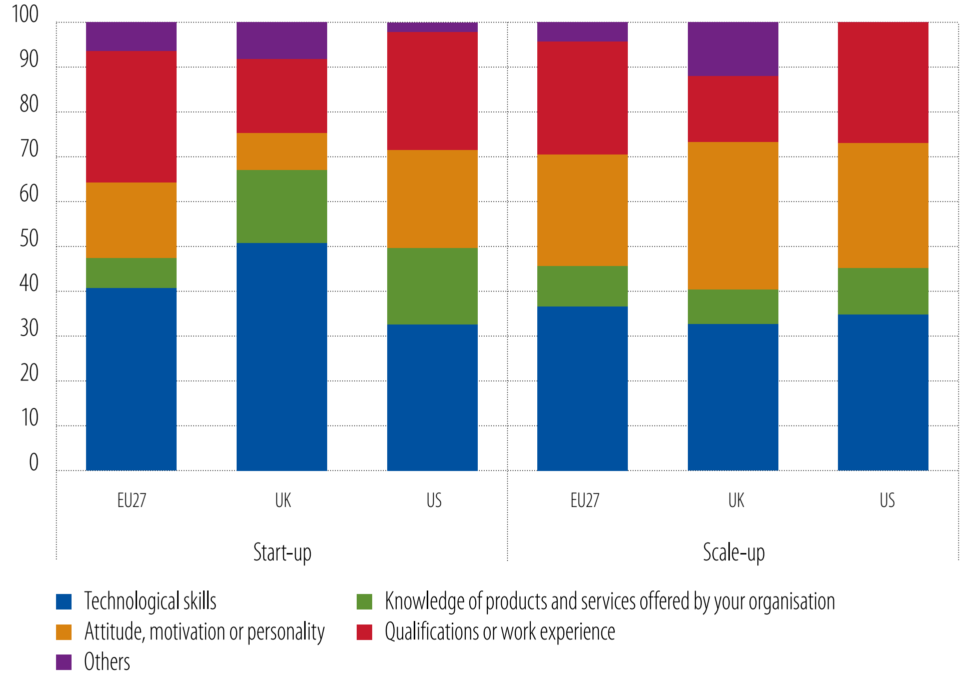


Source: *Crunchbase, OECD Metropolitan Data, authors' calculation.*
Base: *Firms founded 2008-2018 that are still active and received formal funding.*

Skills

Lack of staff with the right skills is another important obstacle to growth among scale-ups. A majority of firms, 66% of start-ups and 72% of scale-ups, report this as an issue in the EU27. Given the importance of talent for start-up and scale-up success (Bolton and Johnson, 2013) a lack of skills is likely to be a drag on the development of start-ups and scale-ups in Europe. For the types of skills missing, EU27 firms primarily report technological skills to be in short supply, slightly more than their US peers. Also, work experience and relevant qualifications are often sparse (Figure 20).

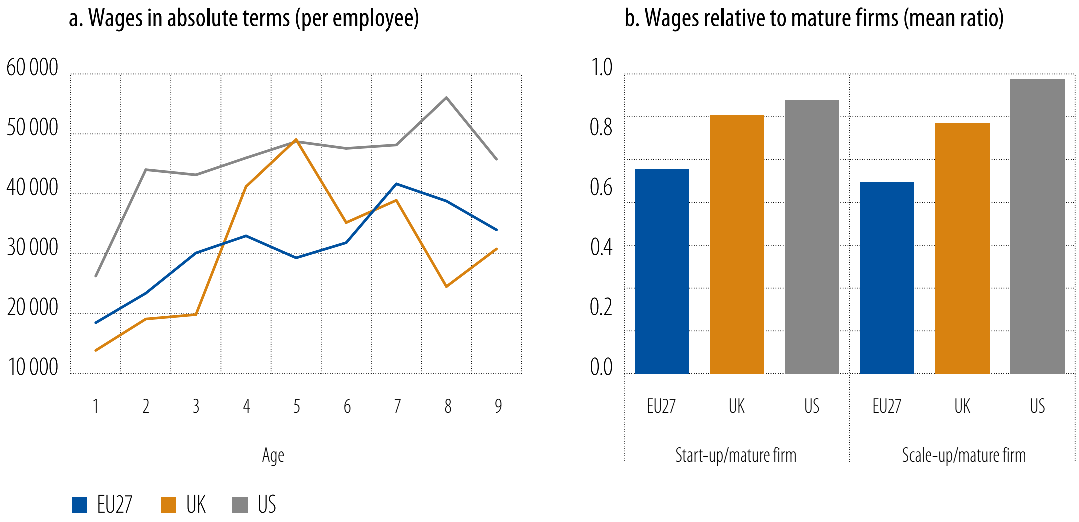
Figure 20
Availability of staff with the rights skills as a constraint (share of firms in %)



Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Question: *And thinking about the availability of staff with the required fit, which of the following is the main obstacle?*

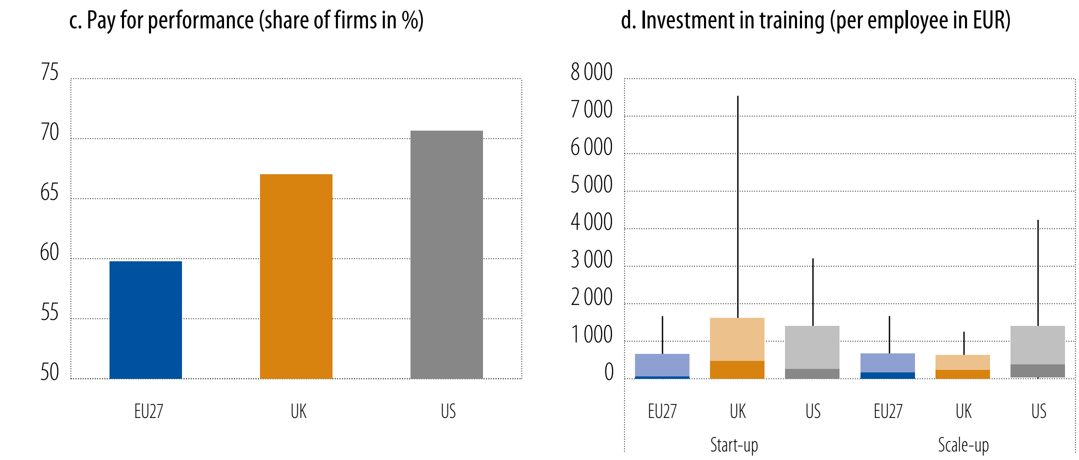
The lack of employer attractiveness makes it particularly difficult for European Union firms to attract top talent. EU start-ups and scale-ups pay, for example, significantly lower wages than their US peers. That is true both in absolute terms (Figure 21a) as well as in the share of pay by larger firms. Lower pay likely makes it even more difficult for EU firms to attract the right talent. Whereas in the EU start-ups and scale-ups pay on average about 66% of what their mature peers pay, the corresponding share in the United States is around 94% (Figure 21b). Firms in the European Union are also less likely to reward good performance, which might be helpful in particular in attracting high-flying employees (Figure 21c), and invest less in the skills of their workforce (Figure 21d).

Figure 21
Attractiveness of employers



Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Questions: *How many years has the company been operating? How many people does your company employ at all its locations, including yourself? How much did the company spend on wages in 2018?*

Source: *EIBIS Start-up and Scale-up Survey, EIBIS 2019.*
Base: *All firms (EIBIS Start-up and Scale-up Survey), firms older than ten years (EIBIS2019).*
Question: *How many people does your company employ at all its locations, including yourself? How much did the company spend on wages in 2018?*



Source: *EIBIS Start-up and Scale-up Survey, EIBIS 2019.*
Base: *All firms that used equity finance.*
Questions: *Are at least half of the founders women? Who provided you with the largest share of equity finance for your business activities?*

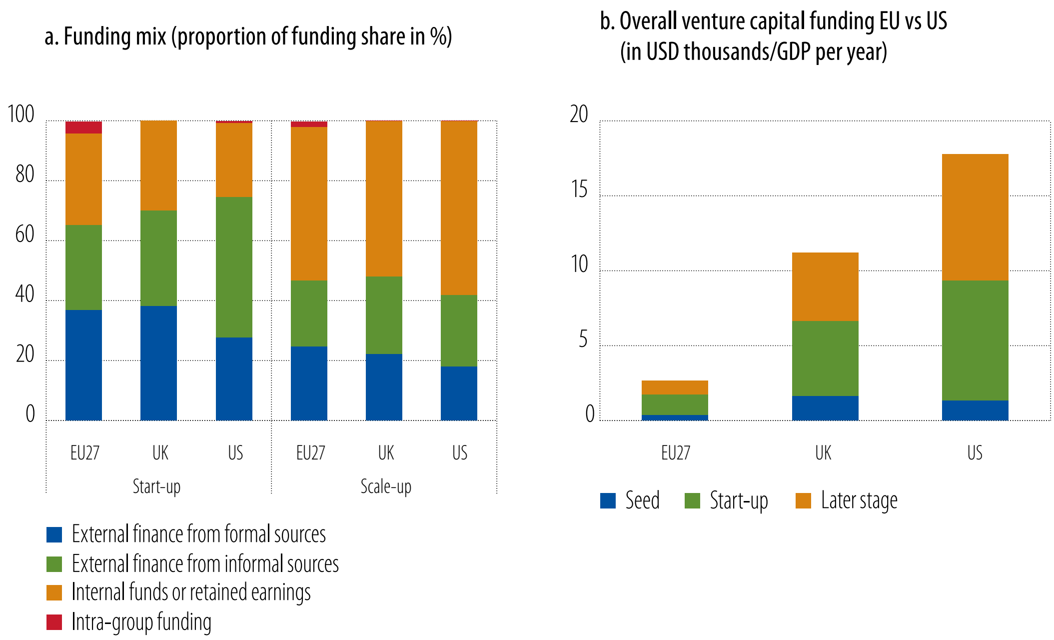
Source: *EIBIS Start-up and Scale-up Survey, EIBIS 2019.*
Base: *All firms based in EU27.*
Note: *Box pots report 10th, 25th, median, 75th and 90th percentile of investment intensity in training.*
Questions: *Are at least half of the founders women? Since the start of your business, has it, at any point, benefited from any of the following types of public support schemes?*

Access to finance

Limited availability of finance is another barrier to growth for scale-ups in the European Union. More than 60% of start-ups and scale-ups report this as an obstacle. While the share of firms reporting a lack of access to finance as an obstacle is comparable between the European Union and the United States, EU scale-ups are significantly more likely to report this as an issue compared to their US peers (61% vs 51%).

The more difficult access to finance reported by EU scale-ups is consistent with a higher reliance on internal funds among these firms, as well as a relatively under-developed venture capital market in Europe (Figure 22).

Figure 22
Venture capital funding

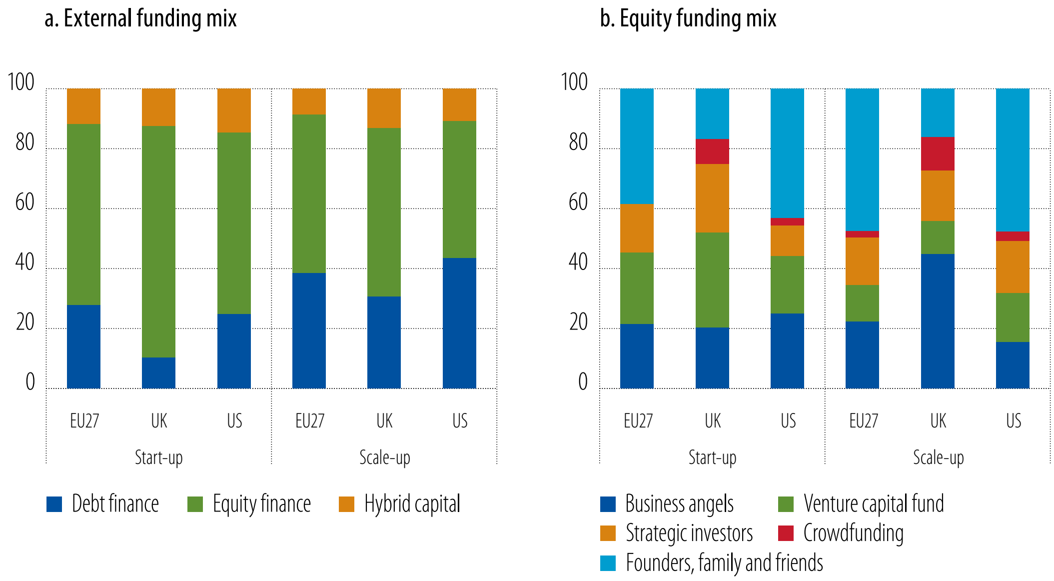


Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Question: *Approximately what proportion of your business activities has been financed by each of the following?*

Source: *Crunchbase, authors' calculation.*
Base: *Firms founded 2008-2018 that are still active and received formal funding.*

In addition to funding volumes, there are differences in firms' funding mix between the European Union and the United States. An important one is the reliance on business angels, which tends to be higher among scale-ups in the European Union than in the United States (Figure 23b). This points towards a structural weakness in the venture capital market because business angels can typically only take relatively small equity stakes in firms, which tend to be inadequate during the later stage (see EBAN (2017) or AFME (2017) for a discussion). Another interesting difference is the slightly lower reliance on debt funding among later-stage firms in Europe vis-à-vis the United States (Figure 23a). At first sight, this is surprising given the strong bank-based financial system in the European Union, which would have suggested the opposite pattern. Nevertheless, it is in line with the literature showing a lack of venture debt funding in the European Union (AFME, 2017).

Figure 23
External financing mix (in %)



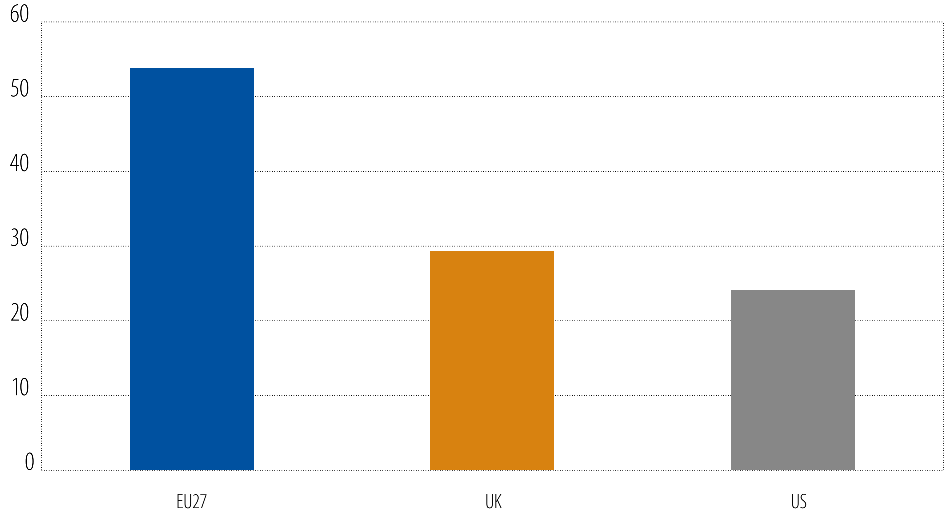
Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms that used external finance.*
Question: *What proportion of the external finance was in the form of …?*

Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms that used equity finance.*
Question: *Who provided you with the largest share of equity finance for your business activities?*

Linking the government's presence to previously mentioned funding constraints suggests that public support has been quite effective in closing the early-stage funding gap, but has done little to help firms to scale up (once their project is ready).

While EU policymakers are already making a great effort to close the funding gap, more attention should be given to later stages. A study by Brigl and Liechtstein (2015) from the Boston Consulting Group estimates that the government share of all European venture capital investments amounts to a whopping 35%. Our survey results support this and show the marked contrast with the United States. Whereas in the European Union 54% of start-ups or scale-ups received some type of public subsidy, the corresponding share in the United States was only 24% (Figure 24).

Figure 24
Public support measures (share of firms in %)



Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Question: *Since the start of your business, has it, at any point, benefited from any of the following types of public support schemes?*

The importance of past start-up and scale-up success

Lack of past success is likely to accentuate existing structural barriers. In the following, we argue that past success has a great impact on the chances of current generations of start-ups and scale-ups, accentuating some of the identified structural barriers. Lower success rates make it more difficult to fill the later-stage funding gap and to convince top talent to join EU start-ups and scale-ups.

The United States has a stronger history of start-up and scale-up success than the European Union. Dubocage and Rivaud-Danset (2002) report a strong gap between EU and US start-up activities as early as in the 1990s. Another metric is firm age. While the median age of EU firms listed with S&P Global Ratings is 102, in the United States it is 63. Finally, the much higher number of unicorns registered over the past decade in the United States (as reported earlier) and higher number of mega initial public offerings (IPOs) point towards a stronger history of start-up and scale-up success in the United States.

The importance of past success also helps to explain the big differences in start-up and scale-up activities within the United States. To the extent that the effect of past success on current and future generations of start-ups and scale-ups is strongly bound geographically, our hypothesis is consistent with the fact that, even within the United States, start-up and scale-up activities are quite heterogeneous. California, Massachusetts and New York play in an entirely different league when it comes to start-up and scale-up activities than Arkansas, Mississippi, and West Virginia.

Past success pulls in new start-ups and scale-ups

One way in which past success stories affect success among new start-ups is their impact on exits. The most common types of exits for investors – other than secondary sales to other financial investors – are acquisitions and IPOs. Acquisitions account for about 89% of exits, while IPOs account for 11%, when looking at firms that have been founded after 2008. Past start-up success stories play a major role in boosting both of these exit channels.

Successful start-ups often act as acquirers of new start-ups and scale-ups. If we look at the top five acquirers of start-ups worldwide, we find, without exception, start-up success stories from the recent past: Google, Cisco, IBM, Microsoft, and Oracle.[5]

While these firms have broadened their geographical focus in recent years, they overwhelmingly acquire start-ups from their immediate vicinity, thereby generating an enormous local demand for new start-ups and scale-ups. Mind the Bridge (2016) shows a correlation of 95% between the home state of the acquirer and that of the acquiree in the United States. The EIF (2017) shows that from 2003 to 2015, an average of 44% of firms that were backed by EIF-supported venture capital were acquired by non-European buyers, particularly from the United States.

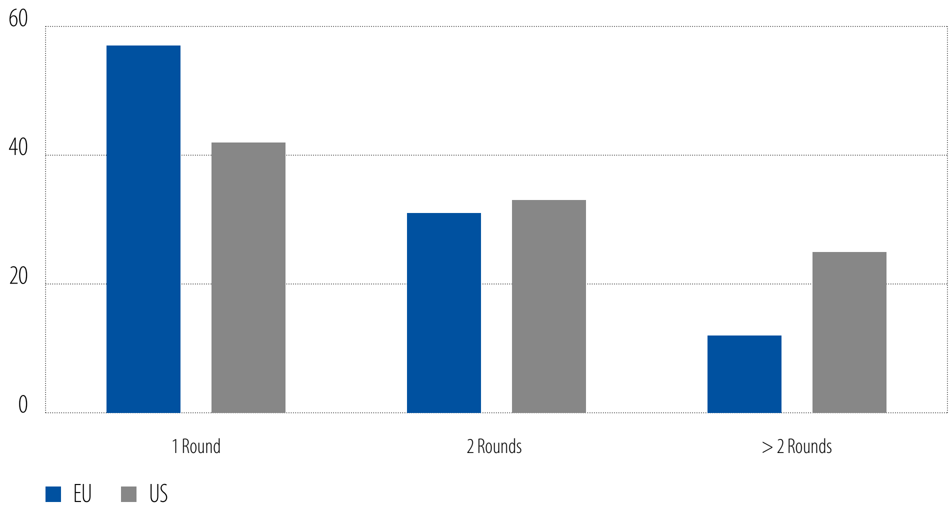
The lower number of past success stories in Europe is likely to put the continent at a disadvantage. The difference in the acquisition activities of start-ups and scale-ups between the European Union and the United States is striking. Since 2012, US corporates have spent about EUR 500 billion on such acquisitions; their EU counterparts have spent about just one-tenth of this amount (i.e. EUR 50 billion).

The difference in acquisition volumes matters. A strong acquisition demand directly translates into a strong incentive for investors to support high growth firms from an early stage on. It also increases their willingness to invest large amounts in these firms – explaining the earlier finding that investment amounts tend to be higher in the United States than in the European Union – and to invest more patiently. Figure 25 illustrates this patience by showing the average number of funding rounds in the same firm for EU and US firms.

Knowing that there is a good chance that start-up and scale-ups will be acquired by a deep-pocketed company eventually, investors are reassured that they will be able to successfully exit the firms (EIF, 2019).

Figure 25

Evolution of venture funds (% of investments)



Source: Duruflé et al. (2016).

5 Top acquirers in terms of amount of prices paid.

The positive effect of strong corporate demand for acquisitions extends to entrepreneurs' willingness to start new ventures. Even if a corporate acquisition is not what many entrepreneurs envision when they start their business, the higher willingness of investors to fund their endeavours in an environment with high acquisition demand means higher valuations of their ideas and, thus, more means to put these ideas into practice and/or a greater compensation for entrepreneurial effort.

Past success also drives IPOs and therefore explains at least part of the larger number of IPO activities in the United States. Stock markets benefit from spill-over effects, where more buyers attract more sellers, and vice versa (Wilson, 2015). There are also important economies of scale for analyst coverage that suggest markets become more liquid when there is a critical mass of listed companies with a common investment theme (Duruflé et al., 2016). Past success in the form of more past IPOs, therefore, constitutes a clear competitive advantage. While an IPO is the exception both in the United States and the European Union, we find a significantly higher number of initial public offerings among US firms than EU firms. Also the average size of IPOs in the United States is much higher than in the European Union, with the median US deal size being about 1.5 times that of the European Union (Ernst and Young, 2018).

The positive dynamics of past success stories are probably also at the core of why even the few European firms that seek a public listing do so in the United States. For 2018, Ernst and Young report 17 European firms listing their IPOs outside of the European Union, and only seven outside IPOs coming into the European Union. For the United States, the corresponding numbers are 57 inbound and nine outbound IPOs.

Past success creates a start-up ecosystem

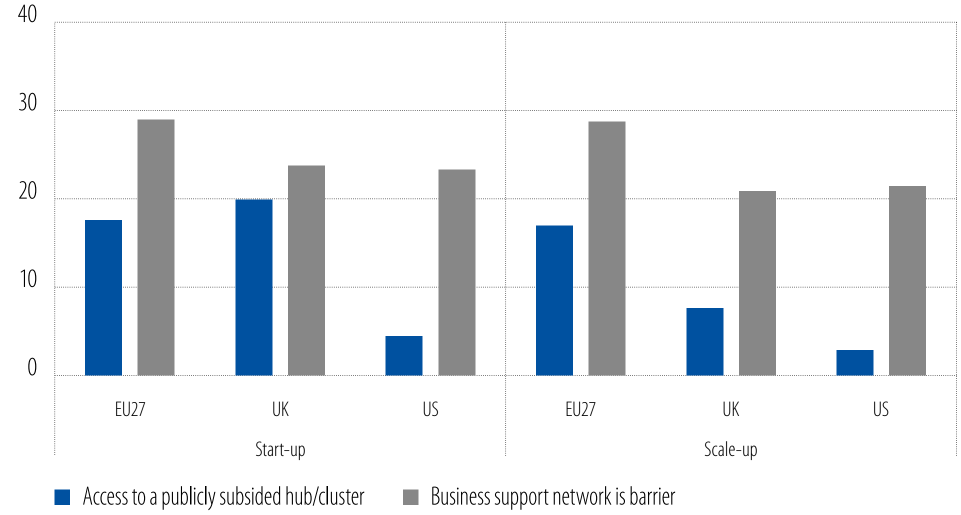
Past success stories also play a key role for start-up ecosystems. Mapping start-up activities in three emerging start-up hubs, Rottenberg and Bierly (2015) show that nearly 80% of start-ups trace their roots to one or more of the initial success stories in these hubs. They argue that first-generation entrepreneurs often have a major impact on the start-up ecosystem by acting not only as acquirers or investors in new start-ups but also as role models, mentors and by giving access to critical support networks during the scaling up phase.

Past and current start-ups have many areas of common interest. One such area is a lack of access to talented employees, one of the main barriers reported by start-ups and scale-ups (Figure 17). It is likely to be a lot easier for a start-up or scale-up in Silicon Valley with sufficient funding to hire someone who has been working for Google or Facebook than a start-up in Madrid. This gives start-ups located close to past success stories a clear advantage. Closely related to this, working amid a good talent pool increases the availability of crucial industry information. For example, should you continue using ASP.NET or move to Ajax? Or, what are the benefits of using HTML5? Answers to these questions can make or break a start-up. Operating in an environment employing the best engineers will make it easier to get timely access to this kind of information.

Past success stories also allow start-ups to benefit from access to a plethora of support resources. This includes a big pool of lawyers specialised in intellectual property, common service providers for employee benefits (such as for food or transport) or lobbying networks to increase the cap on foreign employee visas, or dedicated transport facilities from a nearby suburb. All of these resources reinforce the higher chances of success of start-ups when they co-exist with past success stories. Figure 26 illustrates the difference in support networks between the European Union and the United States. It shows that while EU firms are more likely to have access to publicly sponsored clusters and networks, they are at the same time more likely to report a deficit in the ecosystem of support than their US peers.

Figure 26

Regional use of public support measures (share of firms in %)



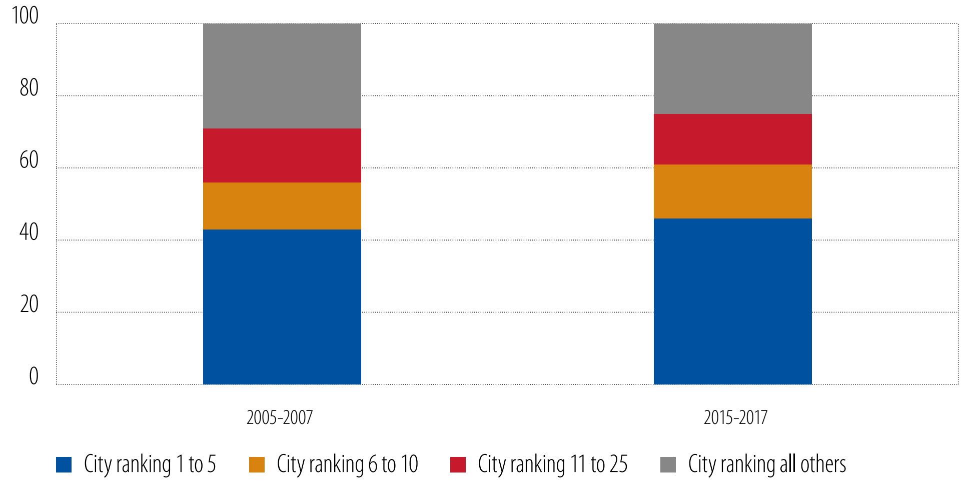
Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Question: *Since its start, has your business, at any point, benefited from any of the following types of public support schemes? To what extent is the business support network an obstacle to the success of your business?*

Three illustrations of past success fuelling current and future success

One way to illustrate the power of past success is to look at venture capital concentration. Venture capital investments are highly concentrated geographically. The top five cities account for nearly half of the global total, and the top 26 for more than three-quarters of global venture capital investment (Figure 27). Research by Florida and King (2016) shows that even within cities, venture capital activity tends to be concentrated among just a few postal codes. This finding is confirmed for the European Union by the EIF (2018).

Figure 27

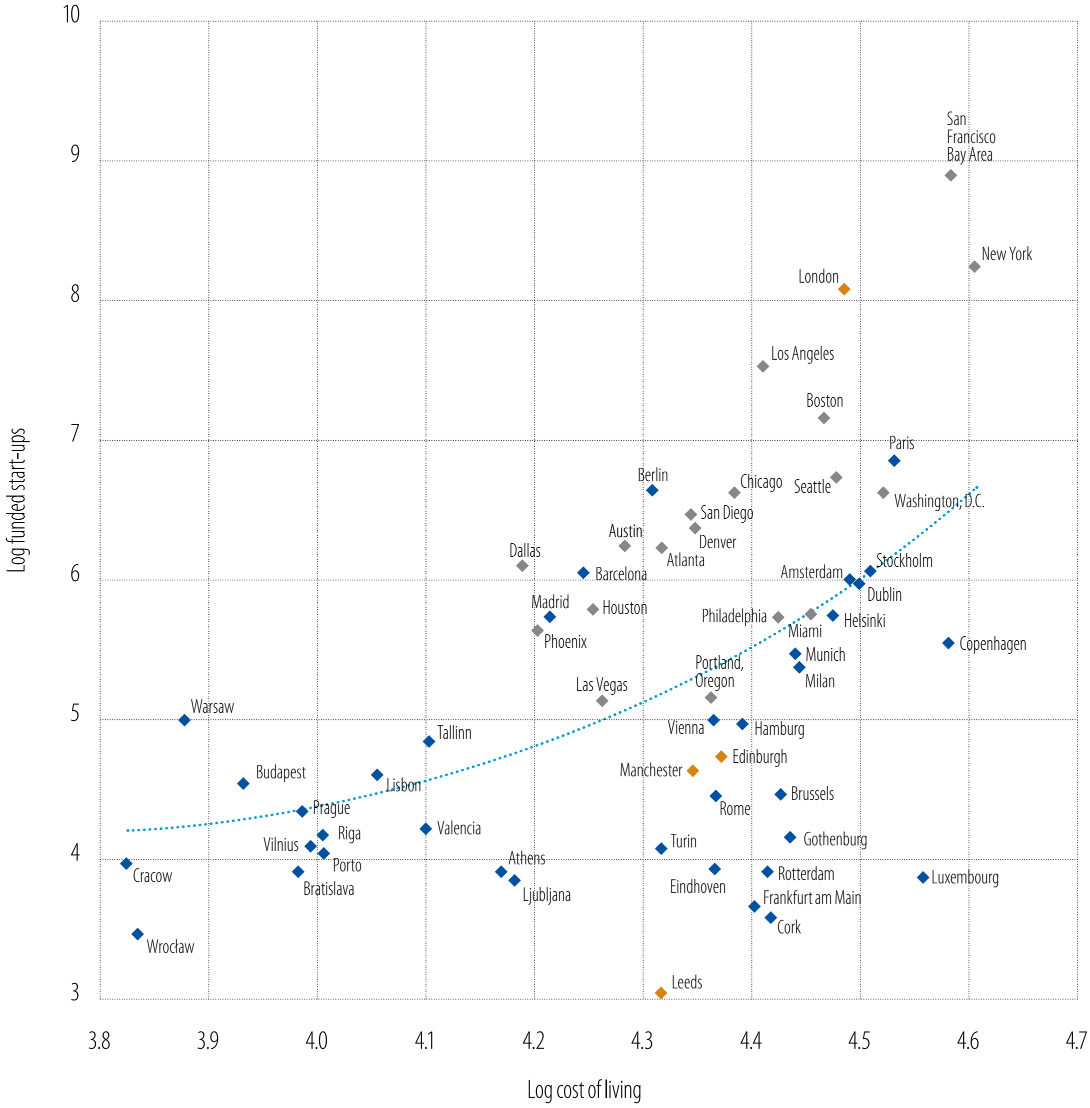
Venture capital investment in the US by city ranking (in %)



Source: *Florida and Hathaway (2018).*

The geographic concentration of venture capital has increased over the last decade. This concentration is particularly true at the very top, where the top ten cities now account for 61% of venture activity worldwide, up from 56% a decade ago (Figure 28). Given the large amount of underlying activity, even small percentage point changes represent meaningful shifts in concentration. What is interesting is that the increased concentration takes place despite an explosion in the cost of many top locations for housing and employee expenses. The concentration suggests clear conglomeration benefits in line with those described above, with past success being a key ingredient for current and future success.

Figure 28
Living costs



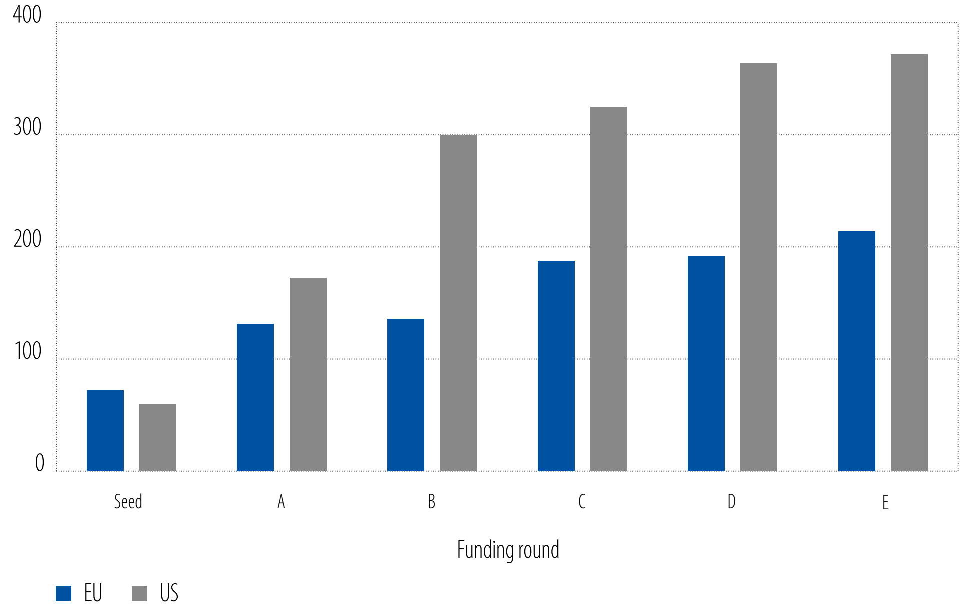
Source: Crunchbase, Numbeo, authors' calculation.
Base: Firms founded 2008-2018 that are still active and received formal funding.

Another way to illustrate our hypothesis is to look at the evolution of fund sizes from one period to the next. Later-stage investors funding scale-up activities need deep pockets. While the amounts of funding at the start-up stage are typically fairly modest, scale-ups require substantially larger funding rounds.

To satisfy this need, a scale-up either needs an investor that can make a large investment, or several investors that can collectively fund a large round. If we compare fund sizes between the European Union and the United States, we find relatively little difference at the start-up stage, but much bigger funds at the scale-up phase in the United States than in the European Union (Figure 29). While the literature puts forward several possible explanations for this, such as a lack of willingness of institutional investors in the European Union to invest in venture capital funds (EVCA, 2014; AFME, 2017), it is interesting to see that the difference in fund sizes between the European Union and the United States is more pronounced in later-stage funding than for initial funds.

Figure 29

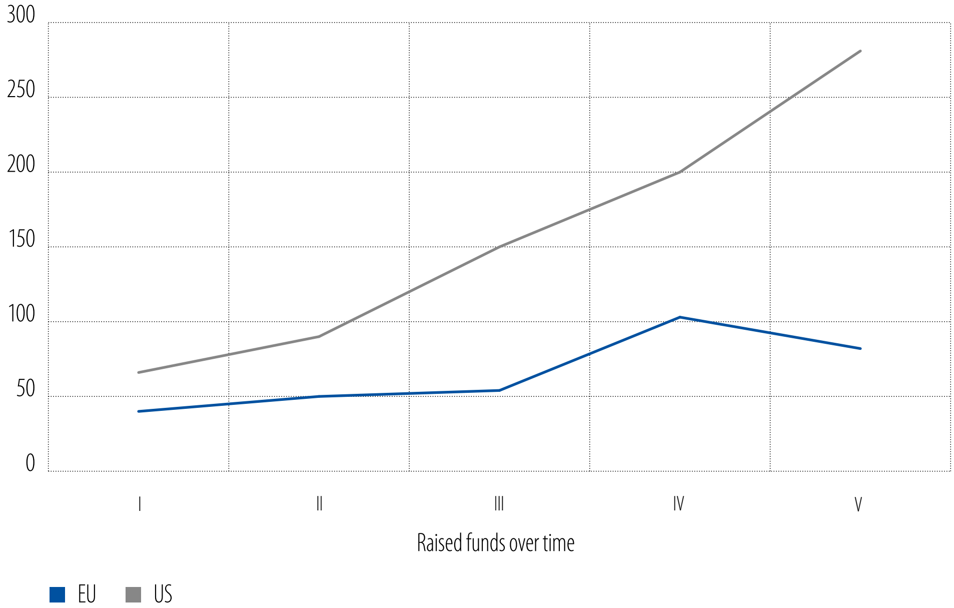
Fund sizes by round (median, in USD millions)



Source: Durflé et al. (2016).

US funds are larger at each round of fundraising, with the differences growing over time. Figure 30 examines the evolution of fund sizes as the same venture capital firms proceed from one fund to another. After their second fund, the median fund size is two to three times as large in the United States as in Europe. This suggests that potential providers of capital (also called limited partners) are as reluctant in the United States as they are in the European Union when a fund raises capital for the first time. However, with every additional round of fundraising, this reluctance declines, consistent with the idea that past success drives current and future success.

Figure 30
Evolution of fund sizes (median, in USD millions)

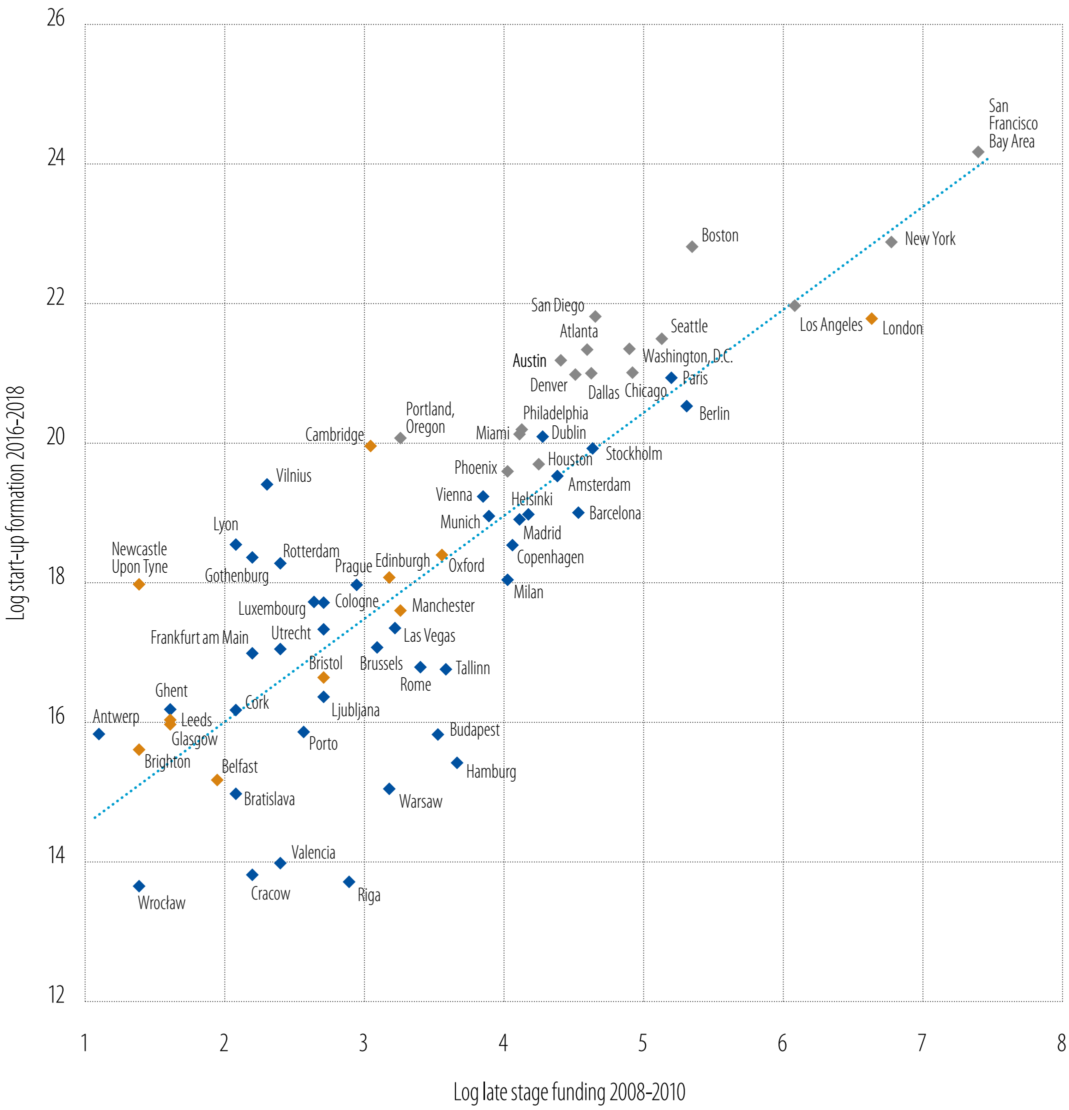


Source: Durflé et al. (2016).

To confirm this, when looking at which venture capital firms raised the biggest funds in 2018, we find that behind each and every one are some of the biggest start-up success stories in recent years. Bessemer Venture Partners, which raised USD 1.85 billion, were early investors in LinkedIn, Skype and Pinterest; Sequoia Capital, which raised USD 1.375 billion, was an early investor in Apple, Google, Oracle, PayPal, YouTube, Instagram, Yahoo! and WhatsApp; and General Catalyst, which raised USD 1.65 billion, invested in Snapchat, Neverware, Stripe, Airbnb and Deliveroo.

A third way to illustrate the power of past success is by tracking start-up formation in the years following a scale-up success. A simple correlation between the volume of later-stage funding from 2008 to 2010 and start-up formation from 2016 to 2018 shows a positive link between past investment volumes in later-stage firms and current start-up activities (Figure 31). While it is difficult to draw any conclusions about the causal effect of past success on current start-up activities, the correlation becomes apparent.

Figure 31
Start-up activities and later-stage funding



Source: *Crunchbase, authors' calculation.*
Base: *Firms founded 2008-2018 that are still active and received formal funding.*

One way to get closer to a causal link between past success and current start-up activities is by focusing on individual instances of high (later-stage) funding volumes and start-up activities in subsequent years. To do so, we identified for each city in our sample, "lighthouse investments", which we define as investments that are ten times the average funding volume in that city.

In a second step, we then monitored what happens to early-stage funding activities in the same city the year after such lighthouse investments take place, using a regression framework. We find is that while normally high funding activities in one year are followed by lower funding activities in the next year (in other words a reversion to the mean effect), lighthouse investments are systematically followed by much higher than average early-stage funding activities.

The positive association between lighthouse investments and future early-stage funding activities is largely limited to the same sector. If a firm in the health sector is subject to an exceptionally large funding round, early-stage funding will be higher in the following year first and foremost for other health firms (but not manufacturing, software, etc.). We check this by running the same analysis sector by sector within cities.

Our results are statistically significant and robust with the inclusion of a series of control variables, including city and year fixed effects. Interestingly, our results also hold if we include a control variable for very high overall funding volumes in a city and year. The control variable suggests that it is not high funding volumes per se that drive future investment activities – in fact, we find a negative coefficient on this variable – but exceptionally high individual investments.

Our results are also robust when we include the number of acquisitions in a city and year as an additional control variable (see column 2, Table 1). In line with our hypothesis, we find a strongly positive correlation between acquisition activities in one year and funding volumes in the subsequent years. Given the short time horizon of our analysis, the positive coefficient on both lighthouse investments and acquisition activities is likely to be due to signalling effects, which reassure early-stage investors that they will be able to divest from their own investments, in turn increasing their willingness to invest in new projects.

Table 1

Interaction between early-stage funding over time

Outcome variable: Early-stage funding in time *t*	(1)	(2)
Early-stage funding in time *t-1*	-0.0432	-0.0582
Lighthouse investment in time *t-1*	28.39***	72.69**
Very high overall investment volume in *t-1*	-124.2**	-92.76**
Acquisition activities in *t-1*		34.41**
Constant		
Year FE	Yes	Yes
City FE	Yes	Yes
Observations	643	301
Number of metropolitan areas	70	38
R^2	0.581	0.494

Source: *Crunchbase, authors' calculation.*

Note: *The dependent variable is early-stage investment in time t and city i (measured as early-stage investment in a year relative to its average value). The time period of the analysis is 2008-2018. Lighthouse investments are individual investment rounds that are ten times larger than the average investment size in a city with a minimum volume of USD 25 million. "Very high investment volumes" are defined as overall investment volumes in a city that exceed the city's average by a factor of two. "Acquisition activities" is a count variable of the number of acquisitions in a city and year.* (t) *denotes the time period "*t*",* (t-1) *denotes time period "*t-1*". All models include city fixed effects and year fixed effects. Columns 1 and 2 report estimated coefficients. *, ** and *** denote statistical significance at the 10%, 5% and 1% confidence levels, respectively.*

What can policy do?

Fostering innovative start-ups should be a policy priority. In line with previous research, our data show that new and young firms contribute to job creation. In addition, they are important drivers of investment, in particular in intangible assets, and innovation. Innovation is critical not only for productivity growth but also when it comes to addressing some of the major challenges of our time, such as climate change and an ageing society. However, start-up formation is subject to a series of market failures (for a detailed discussion, see Boadway and Tremblay, 2005).

Our research suggests that the European Union lags behind the United States in start-up and scale-up activities with a particular deficiency in the later stages of firm development. To address this issue, policymakers should work on addressing key structural bottlenecks such as the completion of the EU Single Market, and the under-developed venture capital and venture debt markets (in particular at the later stages). In addition, remaining regulatory barriers for starting a business should be resolved.

To be effective, we argue that policies aimed at removing structural constraints should be complemented by initiatives aimed at strengthening demand for start-ups and scale-ups. In this chapter, we argue that the success of other firms is key to the success of start-ups. Specifically, we argue that the poorer history of past success stories accentuates the structural barriers holding back start-ups and scale-ups in the European Union and can therefore explain the big difference in start-up and scale-up activities between the European Union and the United States.

Past success stories, we argued, have a strong effect on the success of current and future start-ups by acting as a pull factor for new firms and also by putting in place a favourable local ecosystem. If EU policymakers want to emulate the success of the United States, they must complement the policies put in place to address structural bottlenecks with policies that foster demand for new start-ups and scale-ups.

Incentivising companies to invest more in start-ups would foster the development of new start-ups and scale-ups. The most common outcome for successful start-ups in the United States is to be acquired by another company. European corporates are ten times less likely to invest in start-ups and scale-ups than their US peers. While part of the difference is due to the disproportionate role of tech firms in acquiring start-ups and scale-ups – the European Union has fewer than the United States – the gap is still unduly large relative to the size of the EU corporate sector.

To overcome this problem, interaction between start-ups and corporates should be strengthened. Promoting initiatives aimed at matching start-ups and large corporates, such as the Start-Ups Europe Partnership, and educating established companies to integrate start-ups and innovation are consistent with this goal. In addition, incentives should be created for corporates to invest in high-risk companies. Targeted tax breaks and/or subsidised lending for relevant merger and acquisition deals could foster of start-ups and scale-ups by established firms. All of this, of course, has to be done in a way that conforms with competition policy and aimed solely at providing more capital for innovation. For a discussion of start-ups and market structure, see Box D.

A second policy option is for the government to act as a source of start-up demand itself. The government could compensate for part of the lack of pull forces, for example, by means of more innovation prizes. The basic idea of an innovation prize is that the government defines a broad problem to be solved, a reward for solving it and the terms of the contest, and then leaves it to innovators to compete for the prize. Innovation prizes have been used extensively in the past and led to some important inventions (Brunt et al., 2012). However, innovation prizes like the Archon Genomics X Prize, for the first firm to sequence one hundred human genomes in ten days, are relatively rare these days.

A third policy option is to create a true European tech stock market. Stock markets benefit from positive market externalities, where more buyers attract more sellers, and vice versa. It is hard to see how any one European country could achieve such a critical mass on its own. We therefore suggest creating a pan-European stock market or at least inter-listing or networking mechanisms among European tech stock markets. Implementing such an initiative remains challenging, but the benefits for the scale-up ecosystem would be substantial (Wilson and Silva, 2013).

To close the later-stage funding gap, policymakers must resist the temptation of scattered support that only focuses on domestic firms. We showed that young firms with high growth ambitions are often constrained by financing, in particular at the scale-up phase. One reason is a lack of large venture capital funds that are able to shoulder large investment rounds and can stick with the same firm for multiple rounds. Policymakers may be tempted to please everyone, spreading public funding as widely and equally as possible. While a similar approach could cause problems at the start-up stage, at the scale-up stage a distributed funding approach is definitely problematic, as it prevents the most promising firms from accessing the funding they need.

Policymakers could also try to get the best venture capital funds in the world to come to Europe. Putting more public money into the market is important, in particular for the later stages of firm growth, but is unlikely to be sufficient. The academic literature established the importance of venture capitalists' expertise in particular in the later stage (Hochberg et al., 2007). Beyond financial engineering, successful venture capitalists have knowledge of specific sectors, general business expertise, and years of experience scaling up firms. While this kind of expertise is not completely absent in Europe, several papers argue that it is harder to come by than in the United States. One possible way of overcoming this bottleneck is to consider attracting the best international talent to set up venture capital operations in Europe.

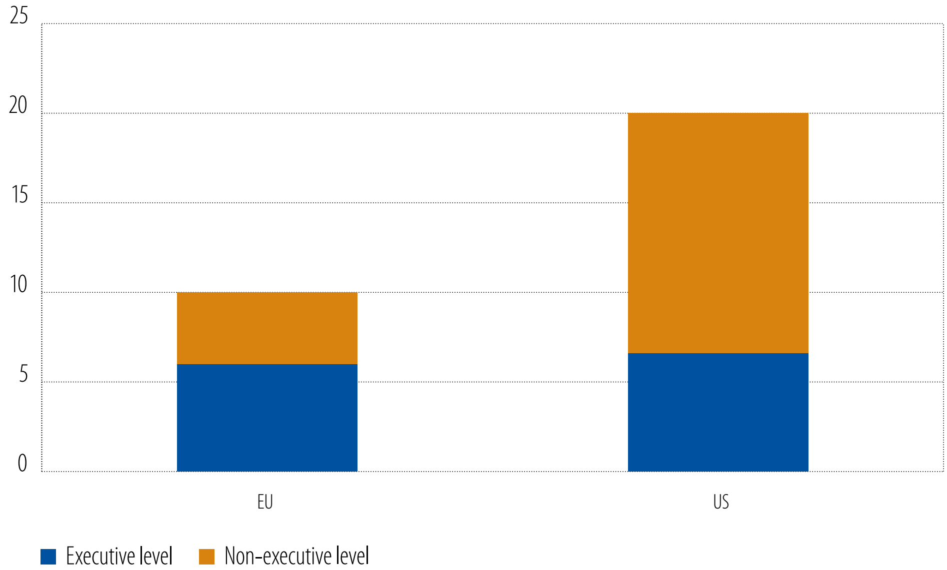
Top venture capital firms have been somewhat reluctant to set up office in locations that are outside their preferred geographic areas, so some type of incentive scheme might be needed to help change their mind. Successful examples of such initiatives include the role of Yozma, an Israeli government initiative that offers attractive tax incentives to foreign venture capital investments by promising to double any investment with funds from the government, and more recently the Israeli Biotech fund programme.

Policymakers should eliminate barriers to the use of stock options to help firms attract top talent. Lacking strong success stories makes it harder for European start-ups to attract talent. While this problem cannot be fixed easily, policymakers can help start-ups to become more attractive by abolishing some structural barriers. A concrete example is regulatory barriers for using stock options.

According to a recent study by Index Ventures (2018), US employees own on average 20% of late-stage start-ups. That percentage is cut in half in Europe. The study also shows that more than 60% of stock options are saved for executive level staff in Europe. In the US, two-thirds of stock options are reserved for employees outside the executive bubble (Figure 32). Besides motivating young employees to join start-ups, this encourages them to stick around long enough to reap the rewards.

One area that deserves special attention is female entrepreneurs. We showed that women-founded start-ups and scale-ups are massively under-represented in Europe. In addition, we showed that when it comes to accessing finance these firms face substantial bottlenecks vis-à-vis their male counterparts. This is true even if we account for differences in ambition, activity, and innovation behaviour. Whatever measures policymakers choose to stimulate more start-up and scale-up activities, they should reduce these barriers to tap the largely unexploited potential of female entrepreneurs.

Figure 32
Employee share of stock options (in %)



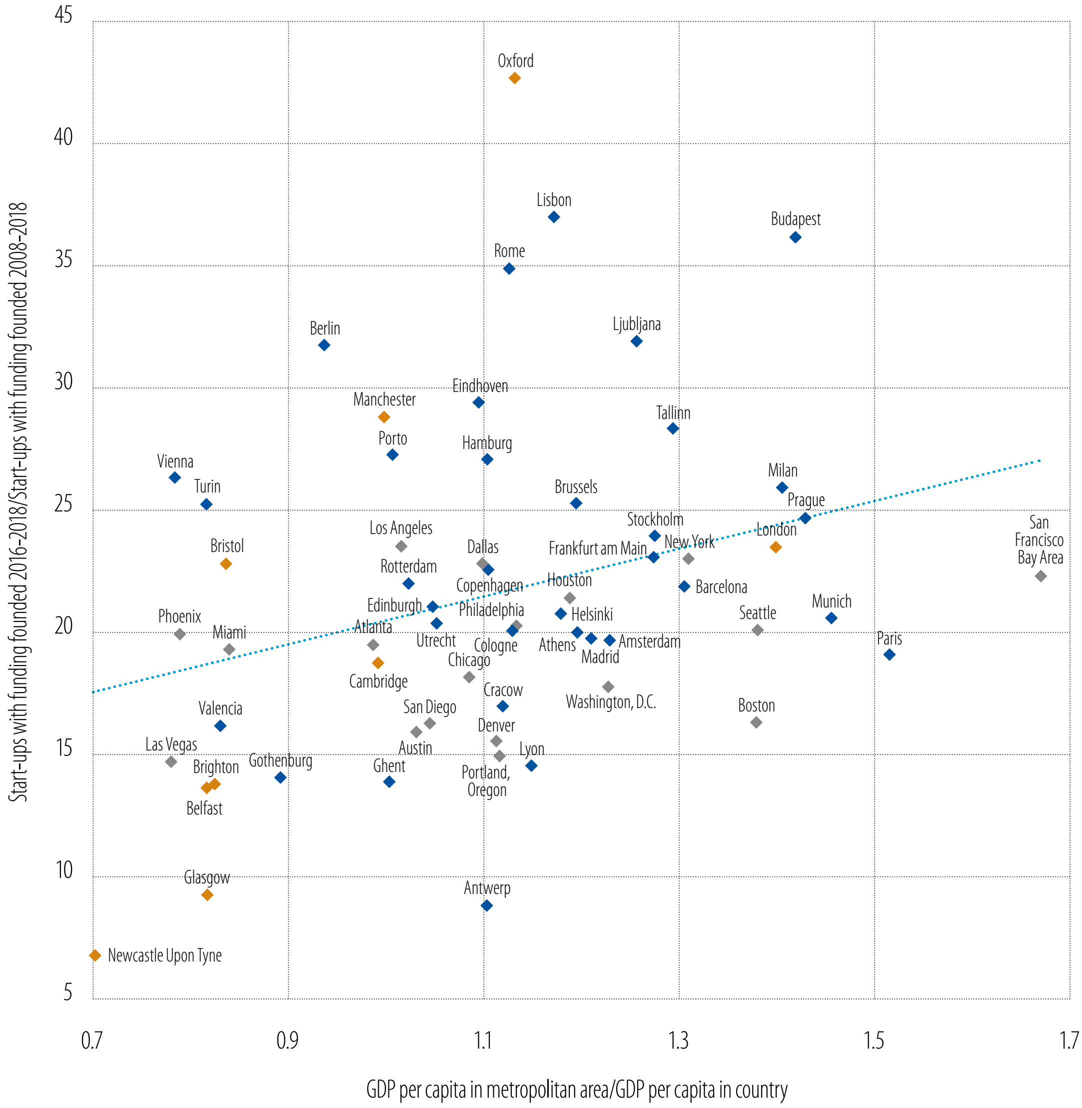
Source: Index Venture.

In their bid to stimulate start-up and scale-up activities, policymakers need to bear in mind the broader socio-economic implications of setting in motion increased start-up and scale-up activities. While start-ups and scale-ups are important industry dynamism and a key source of new growth opportunities, it is important to note that the mechanisms of past successes feeding current success lead to strong agglomeration tendencies. The evidence presented shows that pull forces are strongest in areas with past success stories. In addition, the positive effect that these success stories have on the broader start-up ecosystem – such as the development of broad support networks and shared infrastructure – tends to be limited to a certain geography.

An increase in start-up and scale-up activities is likely to go hand-in-hand with economic concentration. This can negatively affect other regions as well as start-up clusters themselves if prices and wages start to grow too quickly. These dynamics can already be observed in some clusters today. Figure 33 illustrates the situation. It plots per capita income in cities over the country per capita income (as a measure of economic concentration) against the growth in start-up formation in each city. The figure shows that the highest growth rates in start-up formation occur in cities that are rich with respect to the rest of the country. In other words, it shows that start-up formation tends to happen where there is already a lot of economic activity, potentially boosting geographical inequalities.

The negative effects of start-up and scale-up activities on regional inequalities should not be weighed against the large number of positive effects of more start-ups and scale-ups (including innovation, re-allocation of resources and labour demand). Instead, policymakers should work to mitigate the negative effect and help spread the benefits of more start-up and scale-up activities as widely as possible.

Figure 33
Economic concentration and start-up formation



Source: *Crunchbase, OECD Metropolitan Data, authors' calculation.*
Base: *Firms founded 2008-2018 that are still active and received formal funding.*

Box D

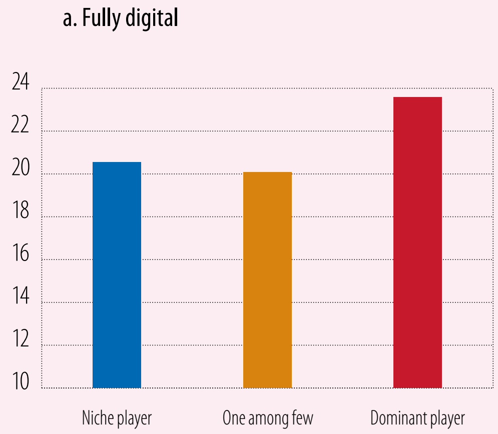
Start-up activities and market structure

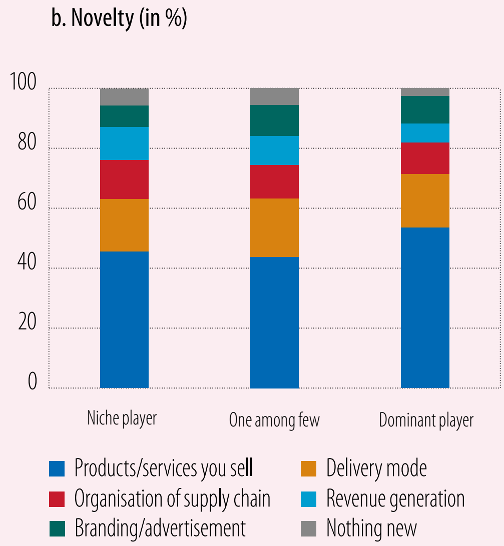
What do successful firms have in common? One way to approach this quesiton is by comparing firms that are dominant players in their market with firms that are niche players or one among many. In so doing, we find the following:

Dominant firms, i.e. firms that responded that they are either a dominant player in their market or the only player, are more likely to be "fully" digital. That is, they are more likely than other firms to state that they have organised their entire business around one or more digital technologies. These firms also state relatively often that the most novel aspect of their business is the product or service that they offer.

Figure D.1

Digitalisation and activity by market position (share of firms in %)



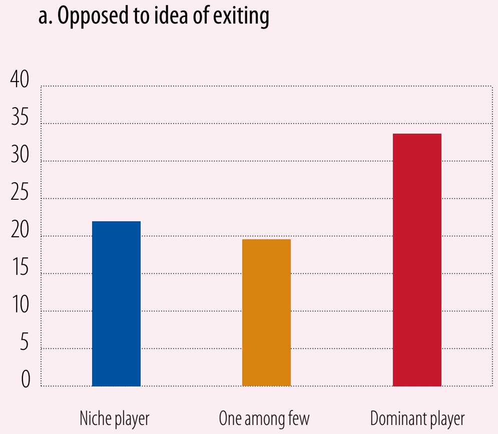


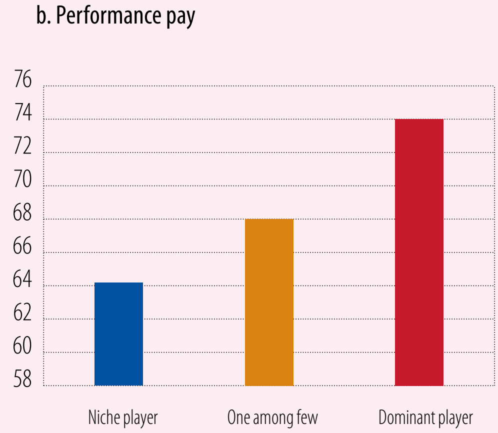
Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Questions: *Thinking about your current market position, are you a niche/small player, one among few established players, a dominant player, the only player in the market? Can you tell me for each of the following digital technologies if you have heard about them, not heard about them, implemented them in parts, or whether your entire business is organised around them?*

Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Questions: *Thinking about your current market position, are you a niche/small player, one among few established players, a dominant player, the only player in the market? What is the main activity of your company?*

Management qualities also differ between dominant firms and other firms. Dominant firms are more likely to state that scaling up their business is of primary importance. Their founders and investors are generally more committed to their enterprise, reflected in a lower willingngess to divest themselves of it. In addition, we find that the dominant players in the market tend to make more use of pay for performance than other firms.

Figure D.2
Market position and management (share of firms in %)



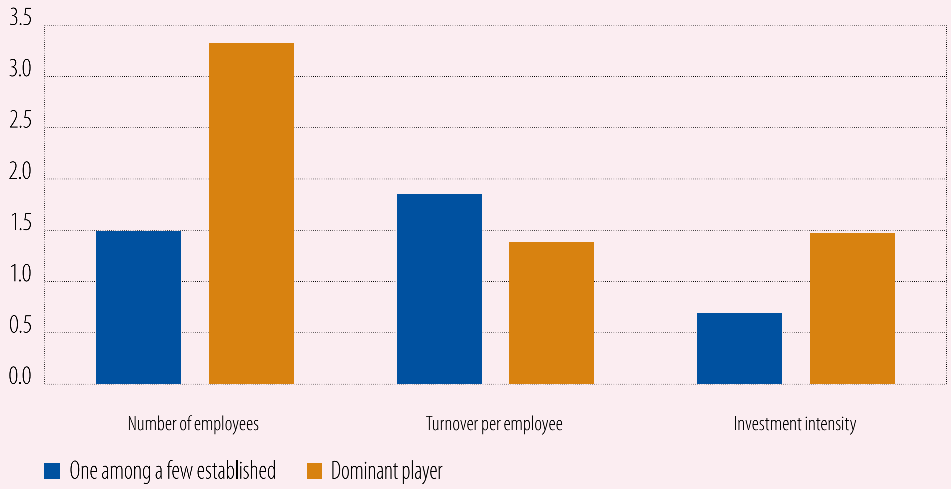


Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Questions: *Thinking about your current market position, are you a niche/small player, one among few established players, a dominant player, the only player in the market? How prepared would you say are the controlling owners to exit the company in the next three years?*

Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Questions: *Thinking about your current market position, are you a niche/small player, one among few established players, a dominant player, the only player in the market? Does the chief executive of your company award performance with higher pay?*

We find little evidence that dominant firms become complacent. They continue to invest heavily. Furthermore, they recruit a lot and they keep up with smaller firms' growth despite their generally larger size (Figure D.3).

Figure D.3
The impact of competition on firm performance (ratio compared to niche players)

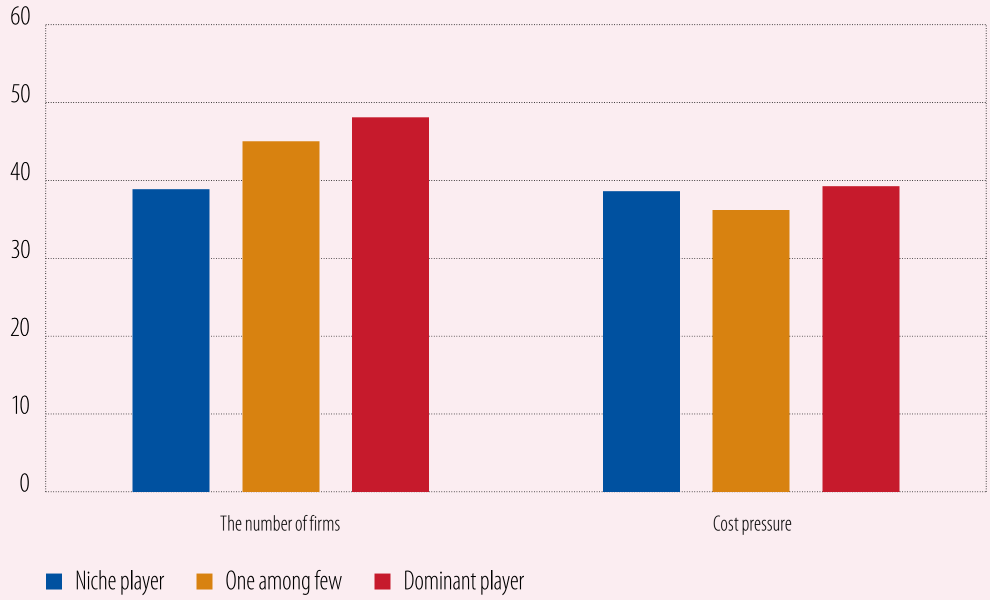


Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Questions: *Thinking about your current market position, are you a niche/small player, one among few established players, a dominant player, the only player in the market? How many people does your company employ at all its locations, including yourself? What is the approximate turnover of the firm? How much has your business invested with the intention of maintaining or increasing your company's future earnings?*

Dominant firms do not feel more competitive pressure than other firms. When we asked firms whether they expect new firms to enter their market, we found no statistically significant difference between dominant players and other firms. This suggests, maybe surprisingly, that dominant firms are not exposed to more competitive pressure than other firms. This raises the question of the impact of the market on firm performance.

Figure D.4

Competitive pressure (net balance of firms, in %)



Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Note: *Net balance shows the difference between firms expecting an increase to those expecting a decrease for each category.*
Questions: *Thinking about your current market position, are you a niche/small player, one among few established players, a dominant player, the only player in the market? Again, looking ahead to the next three years, do you think that your business will lead to an increase, decrease or have no impact on each of the following in your market?*

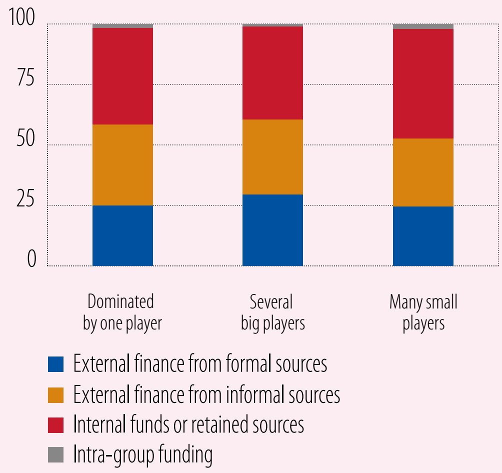
On the one hand, we find that operating in a market with a dominant player has its benefits. Start-ups and scale-ups active in markets that are dominanted by a single player tend to be able to rely more on external funding sources and have a much higher equity share in their funding mix than firms in more fragmented markets (pointing to lower access-to-finance issues).

Investors in these firms are also much more open to exits, presumably because exit options are more favourable in these markets (Figure D.5c). Further, firms in markets with a dominant player complain less about lack of staff with the right skills and the business environment.

Figure D.5

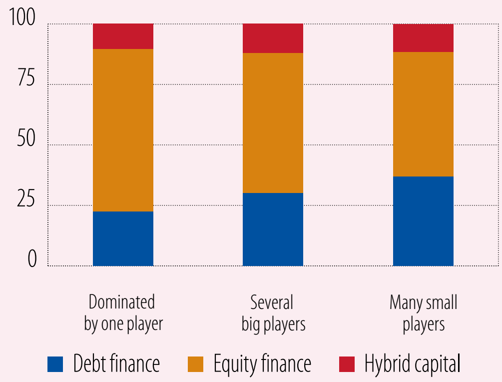
Finance, exit and barriers (in %)

a. Financing mix (funding share)



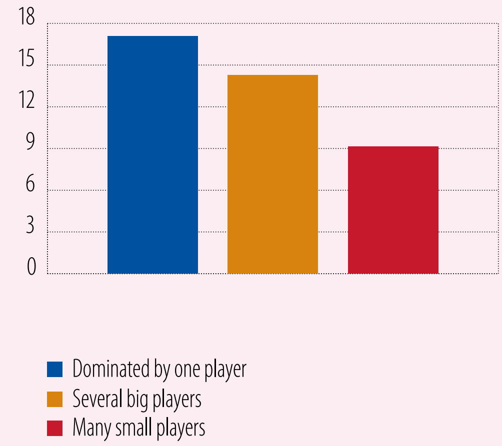
Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Questions: *Including yourself, is the market dominated by one big player making up more than 50% of the market, split among several big players making up more than 50% of the market, split among many small players? Approximately what proportion of your business activities have been financed by each of the following?*

b. External finance mix (external funding share)



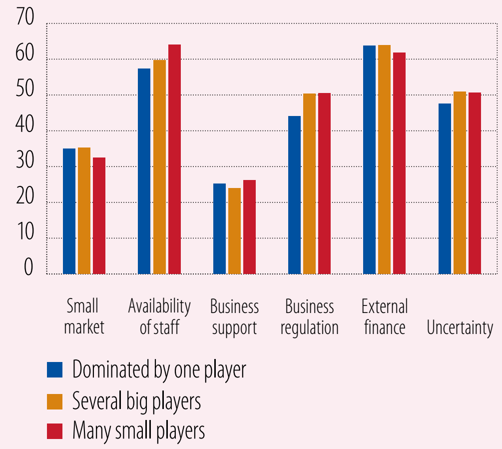
Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Questions: *Including yourself, is the market dominated by one big player making up more than 50% of the market, split among several big players making up more than 50% of the market, split among many small players? What proportion of the external finance was in the form of…?*

c. Exit (share of firms looking for exit options)



Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Questions: *Including yourself, is the market dominated by one big player making up more than 50% of the market, split among several big players making up more than 50% of the market, split among many small players? How prepared would you say are the controlling owners to exit the company in the next three years?*

d. Barriers (share of firms)

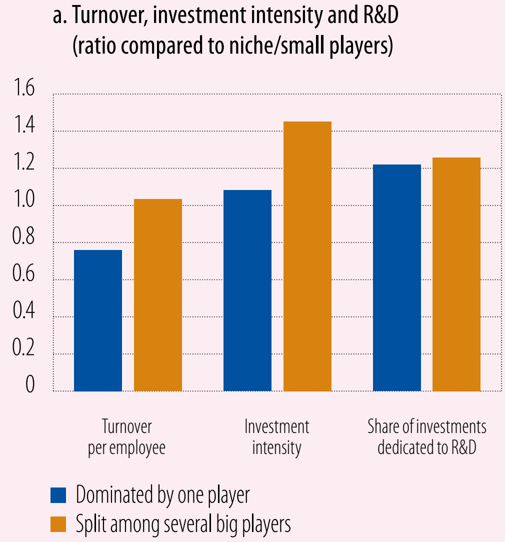


Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Questions: *Including yourself, is the market dominated by one big player making up more than 50% of the market, split among several big players making up more than 50% of the market, split among many small players? To what extent is each of the following an obtacle to the success of your business?*

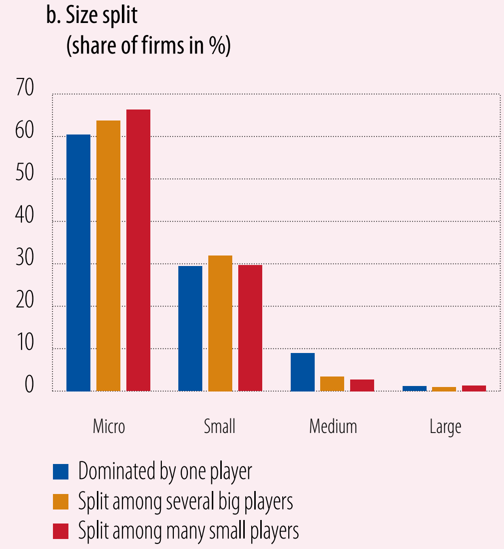
On the other hand, we see that firms that operate in markets that are split among several players show higher turnover per employee, higher investment intensities and also a slightly higher share of investment that is dedicated to R&D than firms operating in markets that are dominated by one player. What is more, firm size decreases with market concentration, suggesting that it is more difficult for firms to become large in markets that are dominated by one firm, raising the question of anti-competitive practices.

Figure D.6

The impact of market structure on firm performance



Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Note: *Investment intensity is measured as investment spending per employee.*
Questions: *I would now like to ask you about the structure of the market you operate in. Including yourself, is the market …? How much has your business invested in total/R&D with the intention of maintaining or increasing the company's future earnings?*



Source: *EIBIS Start-up and Scale-up Survey 2019.*
Base: *All firms.*
Questions: *I would now like to ask you about the structure of the market you operate in. Including yourself, is the market …? How many people does your company employ at all its locations, including yourself?*

Conclusion and policy implications

In this chapter we reviewed the importance of start-up and scale-up activities for overall economic activity. Start-ups and scale-ups are an important driver of innovation and productivity growth and matter for labour demand and competition.

We showed that Europe lags behind the United States for both start-up and scale-up activities. The gap, however, grows as firms get bigger, and is reflected in market penetration, funds raised per firm and well as firm size.

Our data point towards various structural barriers that particularly hamper growth at the later stage. These include a lack of economic integration in the services sector, a still fairly under-developed venture capital and venture debt market, as well as a lack of staff with the right skills and regulatory bottlenecks when it comes to founding and closing down start-ups.

The structural bottlenecks are often amplified by a lack of entrepreneurial dynamics. In this chapter, we showed the importance of past start-up success stories on start-ups and scale-ups and argued that the relative lack of such success stories accentuates problems in raising funding and attracting talent, making these barriers even more difficult to overcome.

We encourage policymakers to work backwards when trying to encourage start-ups and scale-up activities. In addition to addressing the structural bottlenecks identified, policymakers should work to ensure strong demand for new generations of start-ups and scale-ups as well as for a flourishing start-up ecosystem more generally.

Specifically, we suggest that policymakers complement structural policies aimed at creating a true single market, closing the later-stage funding gap, and reducing regulatory complexities with one or several of the following:
- incentivising more corporate acquisitions of start-ups;
- making more use of innovation prizes to address big societal problems;
- working towards a harmonised European tech stock market;
- addressing regulatory bottlenecks in the use of stock options to incentivise top talent to work for start-ups and scale-ups.

Special attention should be given to female entrepreneurs. We presented evidence that women-founded companies are not just under-represented in Europe, but are also often at a clear disadvantage vis-à-vis their male peers, particular when accessing financing.

However, when supporting more start-up activity, policymakers should reflect on the possible unintended consequences. Their important economic role notwithstanding, start-ups and scale-ups can exacerbate regional inequalities. Policymakers must think about ways to limit such tendencies and, if they still arise, be prepared to address the associated social and economic costs.

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Chapter 8

Reaching the European productivity frontier

The last few decades have seen a worrying and persistent slowdown in productivity growth. This has frequently been attributed to leaders pushing the frontier forwards while laggards are stagnating.

We have identified a persistent productivity gap between leading and laggard firms in Europe, mostly due to stagnating productivity at the bottom. In contrast to what has been suggested by previous studies, we do not find evidence of a widening productivity gap after 2012. Nevertheless, the gap remains persistent and firms at the bottom find it very difficult to climb up, while leading firms seem to be increasingly stable at the top. Complementing this, and in contrast to other regions, productivity growth for all firms in Southern Europe has been close to zero and is stagnating. The persistence of large differences in productivity across firms reflects a misallocation of resources and a hampered diffusion of knowledge and innovation.

The persistent lack of mobility and resource reallocation suggests unhealthy business dynamics and structural rigidities, justifying policy intervention. Given the differences in the movements of firms along the productivity distribution across and within regions, policy priorities should be region-specific. Firms in Central and Eastern Europe should enhance their skills and knowledge to move, gradually, towards the frontier. Firms in Southern Europe report a particularly challenging operating environment and encounter structural obstacles that hamper growth. The least productive firms tend to remain stationary, as constraints prevent their exit from the market and the reallocation of resources. In this context, measures to enhance firms' ability to grow, including easy ways to enter and exit the market, remain crucial. In Western and Northern Europe, on the other hand, firms tend to be closer to the global productivity frontier. For those firms, the ability to benefit from the smooth and enhanced functioning of the EU single market is the best way to enhance productivity.

The smooth functioning of the EU single market matters. Overall, by assessing the misallocation of resources throughout Europe, we have estimated a potential increase in EU productivity of 40% by removing frictions resulting from structural constraints and distortions. We also see room for new policies to further increase the diffusion of knowledge throughout Europe. There is a strong correlation between the share of frontier firms in a country and the intensity of knowledge transfer. In addition, knowledge flowing within the European Union's borders is often constrained within national borders or by other geographical barriers.

Introduction

In Europe, there is widespread debate on the outlook for productivity and the extent to which the productivity slowdown is a return to normal after exceptional gains. The return to normal view posits that past bursts of productivity growth were based on innovations that were more significant and had a bigger impact than anything witnessed in previous years or that might emerge in the future (Gordon, 2016). Other headwinds – i.e. ageing populations, growing inequality and labour market challenges – are expected to weigh further on productivity growth.

Optimists assert that the current productivity slowdown is a temporary phenomenon. They claim that while we are in a difficult transitional phase from an economy based on tangible production to one based on ideas, the underlying rate of technological progress has not slowed down (McAfee and Brynjolfsson, 2017; Mokyr, Vickers and Ziebarth, 2015). Nevertheless, it could take several years or even decades for recent technological changes to be reflected in productivity growth.

In addition, an increasingly common suggestion is that the current productivity paradox is actually driven by a widening gap between so-called frontier firms and laggard firms. This view states that while there are still leaders pushing the productivity frontier forwards, laggards are stagnating or slowing down (Andrews et al., 2016). This chapter finds a persistent productivity gap between frontier firms and laggard firms. The first part of the chapter discusses this gap in more detail, together with firms' movement towards (but also away from) the frontier. The second section uses EIBIS data to shed light on firm movements along the productivity distribution and on what determines these movements. Finally, the chapter discusses the role of knowledge diffusion and the misallocation of resources, reflecting on the role of structural rigidities and the inefficiency and fragmentation of the EU single market, which constrain EU productivity.

The European productivity gap

To assess whether the current productivity paradox is driven by a widening gap between frontier firms and laggard firms, this chapter largely replicates the methodology applied by Gal (2013) and Andrews et al. (2016) for European countries.[1] In line with previous studies, leaders are defined as the top 5% of the median number of firms in terms of total factor productivity (TFP), by industry, but across time.

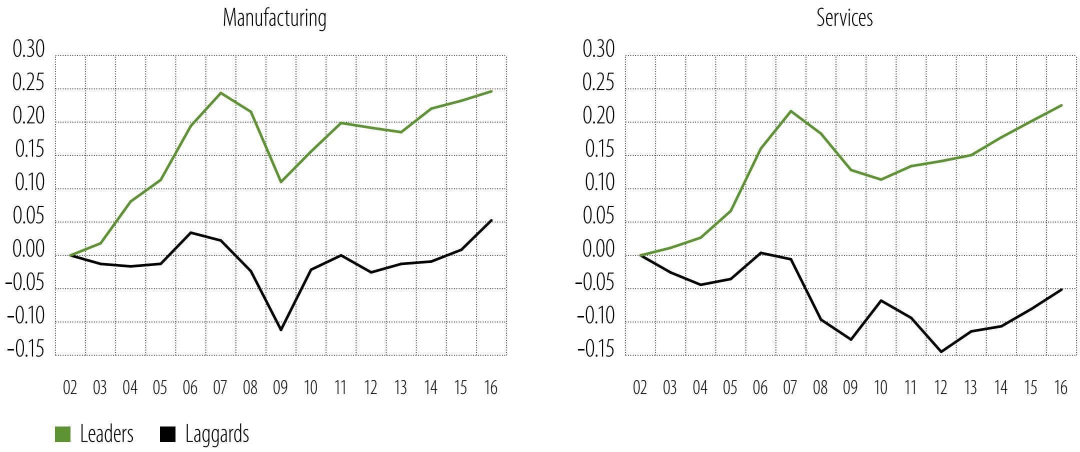
Our analysis confirms a widening total factor productivity gap between frontier and laggard firms in Europe until 2012. Figure 1 shows the evolution of total factor productivity growth for all European firms, normalised for 2002. The left-hand graph shows TFP evolution for the manufacturing sector and the right-hand panel for services. The frontier firms, also referred to as leaders, grew steadily until the beginning of the global financial crisis. TFP of the laggard firms (defined as all other firms not qualifying as leaders), on the other hand, declined during this period in both manufacturing and services. In the services sector, the widening gap is even more prevalent and persistent in the years immediately following the global financial crisis. However, the gap with the leader firms seems to close slightly after 2012 and both leaders and laggards seem to recover, for both sectors.[2]

1 See Box A on methodology for more background information on the estimation method.

2 The same calculations performed for the construction and utilities sectors confirm our main findings. In addition, in line with Andrews, Criscuolo and Gal (2016), we correct our TFP measure for mark-ups to mitigate the limitations from not observing firm-level prices. This correction does not change our results and indicates that frontier firms being able to charge higher prices and thus having more market power does not accentuate the gap observed.

Figure 1

Frontier vs laggard firms (TFP growth vs 2002)



Source: *EIB Economics Department calculations based upon Bureau van Dijk's Orbis database.*

Note: *Total factor productivity (TFP) is based on the estimation of a production function at the industry level. Once TFP is computed, the frontier is defined as the group of the top n firms, where n is the median number of firms corresponding to 5% of the sample available for each year. Hence, the frontier includes approximately the top 5% of firms by sector in terms of productivity, i.e. slightly less than 5% in the years for which the total sample is relatively larger and slightly more than 5% in the first years.*

The persistent productivity gap after 2012 is a signal of structural rigidities and a lack of resource reallocation. The figures above suggest that Europe has faced a persistent – rather than growing – productivity gap between the top firms and other firms over the last few years. Falling productivity growth has been associated with an increasing misallocation of resources and large differences in productivity across firms (Bartelsman, Haltiwanger and Scarpetta, 2013; Gopinath et al., 2017). Shifting resources to productive firms enhances productivity because it enables productive firms to grow and less productive ones to shrink or eventually exit the market. The degree of misallocation of resources is analysed at the end of section 2, while Box B is dedicated to how firms entering and leaving the market contribute to productivity gains.

In addition, stalling productivity growth is often explained by a breakdown in the transfer of knowledge. This idea was suggested by Andrews et al. (2016) and further confirmed by Akcigit and Ates (2019). Andrews et al. (2016) suggest that productivity laggards could disproportionately suffer from increased costs of innovation and the need to combine intangible assets such as human capital, organisation skills and technological capital. Similarly, tacit knowledge (meaning knowledge that is hard to quantify or pass from one person to another through verbal or written communication) and increasingly complex technologies could reduce knowledge flows, which are important since the adoption of new technologies further stimulates knowledge development and therefore results in productivity gains.

Box A

Methodology

Measuring leaders and laggards

Estimation procedure

The total factor productivity (TFP) figures used in this chapter are based on the estimation of a production function. As in the Organisation for Economic Co-operation and Development's (OECD) 2013 and 2016 papers (Gal 2013, Andrews et al. 2016), the estimation was calculated using pooled observations (firm-level data) of all European countries at an industry level (disaggregated at a NACE 2-digit level). The data used comes from Bureau van Dijk's Orbis database. Sector coverage spans 67 industries, as it includes firms with more than nine employees from 2002 to 2016. To allow for inter-country and intertemporal comparability, nominal values were transformed into real ones using appropriate deflators and purchasing power parity (PPP) conversion factors. The deflators come from the OECD, disaggregated at a NACE 2-digit level, and are available for different production phases (intermediate goods, value added, etc.). Where NACE 2-digit values are not available, higher values are used and the closer aggregated figure or variation applied. The conversion rate for PPP is also sector-specific,[3] and all variables were pre-treated by trimming the outliers. Specifically, the Wooldridge (2009) approach using the generalised method of moments (GMM) was applied (as implemented by Levinsohn and Petrin[4]). Material costs were used as a proxy variable for productivity, together with lagged values of the other inputs, to address endogeneity. Total factor productivity is calculated as the residual after labour and capital elasticities (by sector) are applied to the respective factors. Once TFP is computed, the frontier is defined as the group of the top n firms, where n is the median number of firms corresponding to 5% of the sample available for each year. The frontier therefore includes approximately the top 5% of firms by sector in terms of productivity, i.e. slightly less than 5% in the years for which the total sample is relatively larger and slightly more than 5% in the first years. The reason for basing the definition of leaders on a fixed number of firms across time is to take into account the fact that Orbis has increasing coverage over time, which could artificially underestimate average productivity at the frontier only because of the expanding sample.

From Orbis to EIBIS

The estimation results of the previous steps were applied to the firms in the EIBIS sample to benefit from the information on the characteristics of the firms that can be extracted from the EIBIS survey. The elasticity of labour and capital estimated as described above were applied to the interviewed firms, using the matched EIBIS-Orbis information, to compute TFP for EIBIS firms without re-estimating their production function. In addition, the values of the frontier threshold by sector as well as the boundaries of the quintiles of the distribution were applied. In this way, the sample of the EIBIS firms (i.e. represented by macro-sector, size class and country) was superimposed on the TFP map estimated using the full Orbis database.

Measuring knowledge flows

The specification that can be estimated based upon patent citations results from modelling the share of ideas learned in country *j* out of those generated in country *i* within interval τ since their invention: $\theta_{ij}(\tau) = e^{f(i,j)}(1 - e^{-\omega\tau})$. The first term of this equality refers to the set of bilateral regional characteristics acting as barriers to knowledge flows. The second term captures the fact that the likelihood of knowledge in country *j* becoming available in country *i* increases over time. Since both terms interact in a multiplicative way, the main assumption taken from this specification is that relative knowledge flows do not depend upon time elapsed, π. In other words, an increase in knowledge flows due to a larger time interval is assumed to be proportional for all countries. This results in the

3 As in the OECD 2013 and 2015 paper, the PPP conversion factor is taken from the Groningen Growth and Development Centre (GGDC), and specifically from Inklaar, R. and Timmer, M.P. (2009). https://www.rug.nl/ggdc/productivity/pld/earlier-release/

4 From https://sites.google.com/a/umn.edu/amil-petrin/home/Available-Programs

following relationship between the relative intensity of knowledge flows between country *i* and *j*, within a fixed time interval:

$$\theta_{ij} = Ce^{f(i,j)} = \exp\left[\alpha + \beta_1 (OutCountry)_{ij} + \beta_2 (OutNext)_{ij} + \beta_3 (TechDis)_{ij} + \beta_4 (TechAdv)_{ij}\right].$$

The variable OutCountry is a dummy set to 1 if the cited and citing countries do not coincide. OutNext captures the effect of citations flowing out of a neighbouring country. TechDis refers to technological specialisation and TechAdv captures whether both countries are different in terms of technological development. The data reflecting these distances are generated based upon the CEPII gravity dataset (Head, Mayer and Ries, 2010).

The relationship between c_{ij}, the count of patent citations from country *i* to *j*, and Φ_{ij}, the actual flow of ideas from country *i* to *j* is assumed to be: $c_{ij} = \gamma_j \Phi_{ij} e^{\varepsilon_{ij}}$. γ_j captures country-specific effects and $e^{\varepsilon ij}$ is a randomly distributed disturbance term where ε_{ij} is zero mean random noise. Using this relationship between citations and actual flows of ideas and defining the relation between count of patents and number of ideas generated in country *i* as $\Upsilon_i = \delta_i P_i$, the following relationship can be derived:

$$\theta_{ij} = \frac{\Phi_{ij}}{\Upsilon_{ij}} = \frac{c_{ij}}{\gamma_j \delta_i P_i e^{\varepsilon_{ij}}} = Ce^{f(i,j)}.$$

Substituting the first equation in the last one and rearranging results in the estimable specification defined above. For more information on the estimation method, see Peri (2005).

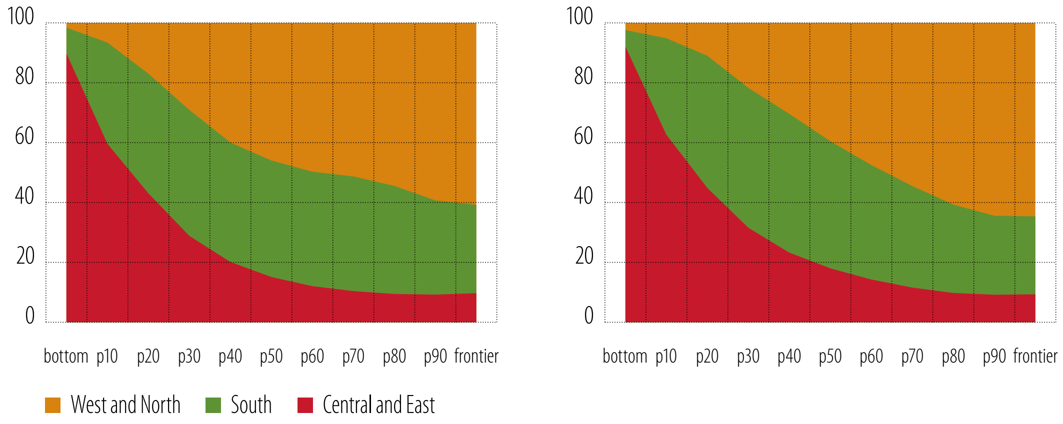
Total factor productivity in different European regions

Within the European Union, Western and Northern Europe are home to most of the top performing firms in terms of productivity. Figure 2 provides an overview of the share of different country groups over the European TFP deciles in 2006 (left-hand panel) and 2016 (right-hand panel). As expected, and as normally reflected in terms of input prices, Western and Northern Europe account for most of the highly productive firms and Central and Eastern European firms are more often situated at the bottom of the distribution. Southern Europe has a critical mass of firms over the full TFP distribution, though from 2006 to 2016 there was a shift of the distribution towards the bottom.

Central and Eastern Europe has seen a positive evolution in terms of productivity, although it is not enough to close the productivity gap with Western and Northern Europe. In Western and Northern Europe, total factor productivity is growing steadily across the entire distribution, despite a dip coinciding with the global financial crisis (see Figure 3). Both bottom and top firms have experienced an increase in productivity in this region and there is no evidence of an expanding gap. For Central and Eastern Europe, the picture is also rather positive. Even though most firms in Central and Eastern Europe are located in the lower part of the European distribution curve, firms in the region are making gains, especially at the bottom. Nevertheless, this overall positive evolution does not seem to be sufficient to enable firms from Central and Eastern Europe to climb up the European productivity ladder and close the gap across regions.

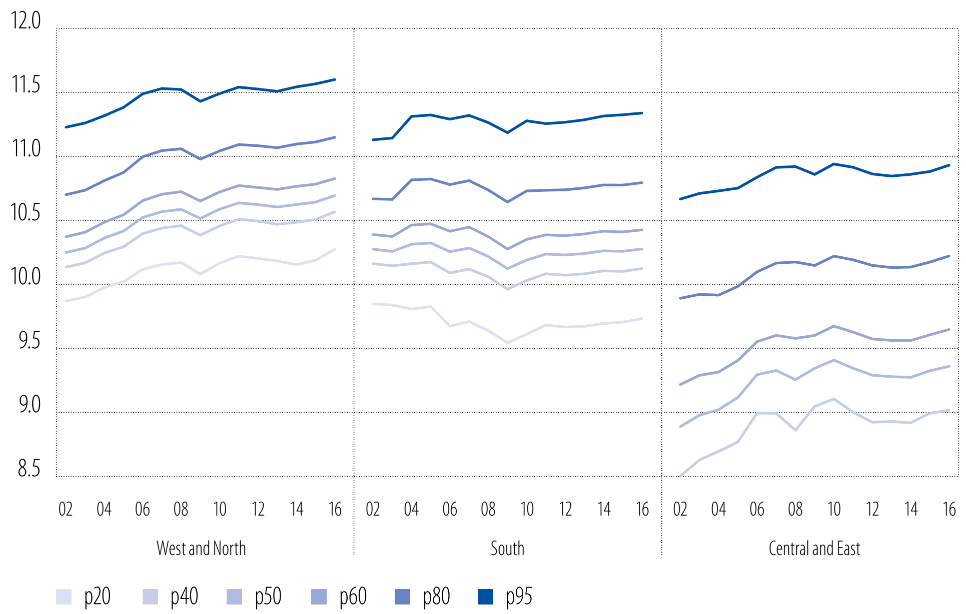
For firms in Southern Europe, productivity is stagnating, with firms at the bottom even losing ground. Figure 3 shows that in Southern Europe there is no clear improvement over time, especially not for laggard firms. Similarly, the distance between the regional frontier and laggard firms increased over time, especially until 2010. In general, the evolution in Southern Europe coincides closely with the evolution of the productivity gap in Figure 1. Gopinath et al. (2017) show that losses in productivity have aggravated over time due to a misallocation of resources, especially in Southern Europe.

Figure 2
TFP deciles over different country groups in 2006 (left-hand panel) **and 2016** (right-hand panel)



Source: *EIB Economics Department calculations based upon Bureau van Dijk's Orbis database.*

Figure 3
TFP distribution of the different regions



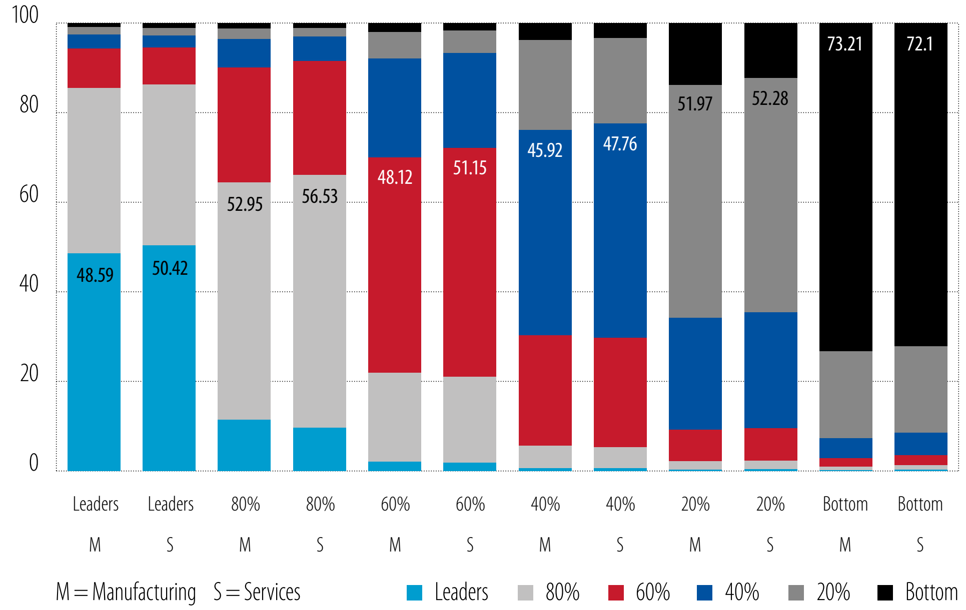
Source: *EIB Economics Department calculations based upon Bureau van Dijk's Orbis database.*
Note: *The different figures present the regional TFP distributions. Percentile 95 thus refers to the 95th percentile of that specific region. The same applies to all other percentiles.*

Mobility of firms over the total factor productivity distribution

Almost half of the European firms at the frontier are still there three years later. Figure 4 presents the output of a transition matrix for European firms across different categories of the TFP distribution. Transition matrices help to disentangle firms' movements over time. One main concern is that globalisation and new technologies have resulted in a winner-takes-all situation in many industries, leading to the supremacy of superstar firms (Van Reenen, 2018; Autor et al., 2019). Figure 4 shows that the transition matrices for the manufacturing and services sectors are rather similar. It also shows some immobility among leading firms, with approximately 50% in both manufacturing and services remaining at the top of the distribution after three years.

Firms in the bottom quintile of the productivity distribution are very likely to stay there, suggesting that most of the worst performers are immobile. More than 70% of European firms remain in the bottom quintile of the TFP distribution between year t and year t+3, both in manufacturing and services. This likelihood of remaining at the bottom is higher than in all other quintiles of the distribution (see Figure 4), and is also confirmed when analysing this phenomenon over time, with an average of 59% of manufacturing firms still trapped at the bottom after ten years.

Figure 4
European transition matrix

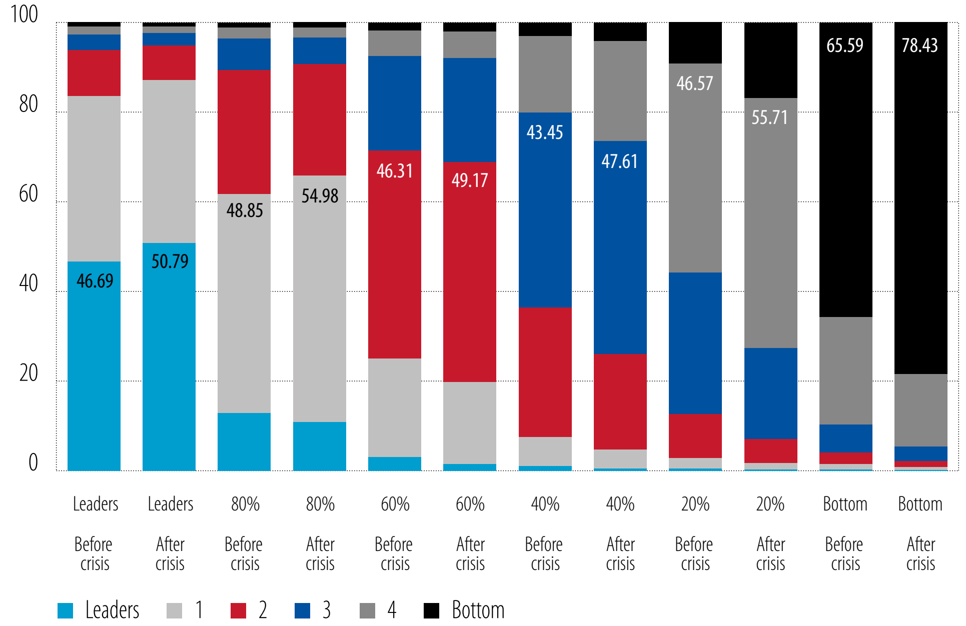


Source: *EIB Economics Department calculations based upon Bureau van Dijk's Orbis database.*
Note: *Transition matrices are examined to assess mobility over the different categories of the TFP distribution. Firms are ranked in terms of TFP over the different sectors, both in year t and year t+3, and divided into quintiles. The transition matrix shows the mobility of firms across the TFP quintiles from one year to the next. The top class (leaders) refers to the frontier firms as defined above. The other categories are composed of firms in the remaining quintiles of the distribution, with the first category, 80%, referring to firms in the top quintile, excluding frontier firms.*

The mobility of European firms decreased, on average, after the start of the global financial crisis in 2008, especially for those in the bottom quintile (see Figure 5). This rigidity has steadily increased over time (see Figure 6). In addition, when focusing on the top part of the distribution, there is a clear weakening in the ability of firms to move toward the frontier. This entrenchment at the top supports the finding that market concentration has increased (Criscuolo et al., 2014; Bajgar et al., 2019). While Figure 5 focuses on the manufacturing sector, the same picture emerges when looking at the services sector.

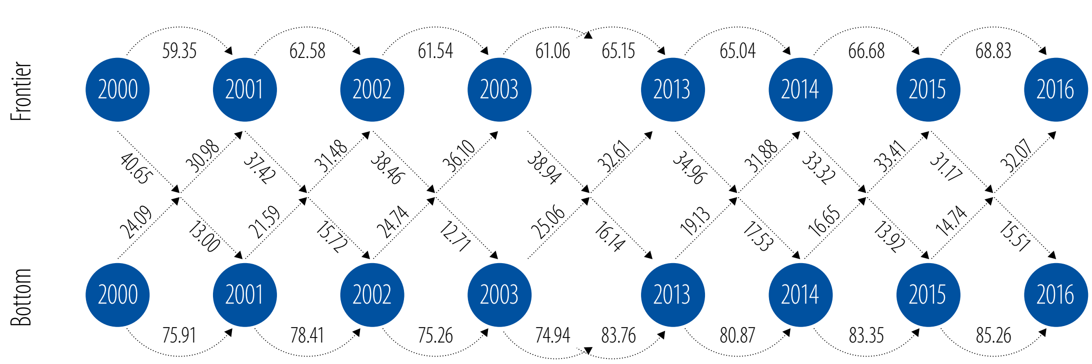
Firms from Western and Northern Europe are more likely to remain at the frontier, while Central and Eastern European firms are more likely to stay at the bottom. Almost 80% of firms in the bottom quintile from Central and Eastern Europe are not able to climb higher on the European productivity distribution (see Figure 7), which is only partly driven by the high presence of Central and Eastern European firms in the bottom quintile (confirmed by regional transition matrices). On the other hand, firms from Western and Northern Europe are slightly more likely to stay at the European frontier, implying that once a firm from this region has reached this level, it finds it easier to stay there for at least three years.

Figure 5
Transition matrix before and after the crisis (manufacturing)



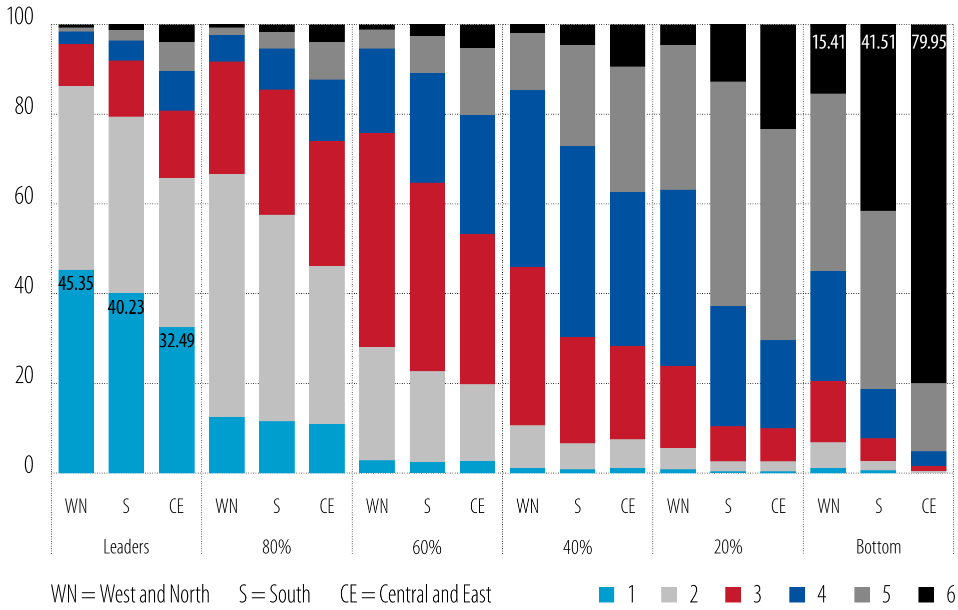
Source: *EIB Economics Department calculations based upon Bureau van Dijk's Orbis database.*
Note: *Transition matrices are examined to assess the mobility over the different categories of the TFP distribution. Firms are ranked in terms of TFP over the different sectors, both in year t and year t+3, and divided in quintiles. The transition matrix shows the mobility of firms across the TFP quintiles from one year to the next. The top class (leaders) refers to the frontier firms as defined above. The other categories are composed of firms in the remaining quintiles of the distribution, with the first category, 80%, referring to firms in the top quintile, excluding frontier firms.*

Figure 6
Evolution over time at the frontier and at the bottom (manufacturing)



Source: *EIB Economics Department calculations based upon Bureau van Dijk's Orbis database.*
Base: *Surviving frontier/bottom firms.*
Note: *The figure shows the evolution over time on a year-by-year basis. It shows, for each year, what percentage of the frontier/bottom firms stayed in the frontier/bottom and what percentage downgraded. It also shows what percentage of firms in the frontier upgraded from another quintile of the TFP distribution.*

Figure 7
Transition matrix over different regions (manufacturing)



Source: *EIB Economics Department calculations based upon Bureau van Dijk's Orbis database.*
Note: *Transition matrices are examined to assess mobility over the different categories of the TFP distribution. Firms are ranked in terms of TFP over the different sectors, both in year t and year t+3, and divided into quintiles. The transition matrix shows the mobility of firms across the TFP quintiles from one year to the next. The top class (leaders) refers to the frontier firms as defined above. The other categories are composed of firms in the remaining quintiles of the distribution, with the first category, 80%, referring to firms in the top quintile, excluding frontier firms.*

Box B
Entry and exit, allocation efficiency and productivity growth

Corporate ecosystem entries and exits are recognised as important drivers of business dynamics. Figure B.1 plots the entry and exit rate in the EU corporate ecosystem.[5] Net entry follows a cyclical cycle and has been positive on average over the last few years. Net entry is higher during upswing periods (such as since the beginning of 2013) and lower during downturns (such as during the sovereign debt crisis). This cyclical pattern is mostly driven by changes in entry rates, and surprisingly exits did not increase significantly during the crisis.

The absence of a cyclical pattern in the exit rate suggests that evergreening, whereby banks grant loans to high-risk borrowers in order not to impair their reported capital and profitability, has taken place at the expense of exiting the market. This seems to be at odds with the normal cyclical behaviours, in which recessions enable weaker firms to exit the market, thereby freeing resources for the rest of the economy and enabling these resources to move to the most productive firms. When the banking sector is relatively weak and encumbered with impaired assets, the incentives for evergreening may rise at the expense of firms recognising a loss, which would impair capital (Brei and al., 2019; Gropp et al., 2018; Andrews and Petroulakis, 2018).

5 Given data limitations, building an aggregate over a relatively long period of time was not possible for all the regions.

The entry of new, more productive firms and the exit of incumbent, less productive firms can support productivity growth. To assess the impact of entry and exit on productivity, sectoral labour productivity growth is broken down into a trend and a component resulting from firm allocation efficiency. Using an accounting equation, the Olley-Pakes approach breaks down labour productivity into sector-wide trend productivity plus firms' allocation efficiency, expressed as a within-sector covariance between firms' market share and productivity. The idea behind the breakdown is that if firms with higher productivity have a higher market share, then their distribution contributes positively to productivity.

In general, this breakdown suggests that allocation efficiency has weighed on labour productivity in the European Union. Figure B.2 shows the breakdown computed using the Orbis database with a very large number of firms in most EU economies. The allocation component accounted for 40% of productivity growth on average over the period. The contribution of the allocation component, shown as red bars on the right axis, dropped during the crisis and has now rebounded slightly, but it still less than half the level before the crisis. Over the same period, trend productivity almost approached pre-crisis levels. This suggests that lower efficiency explains most of the slowdown in productivity growth.

The productivity boost resulting from allocation efficiency increases as firms enter the market. We regress each component on measures of ecosystem activity, entry rate and exit rate (separately), as well as a series of variables intended to control for the influence of the macroeconomic cycle. The results indicate that the only economically and statistically significant relationship is between the allocation component and firm entry but not between allocation efficiency and exit.

Figure B.1
West and North: exit and entry in the corporate sector (% population)

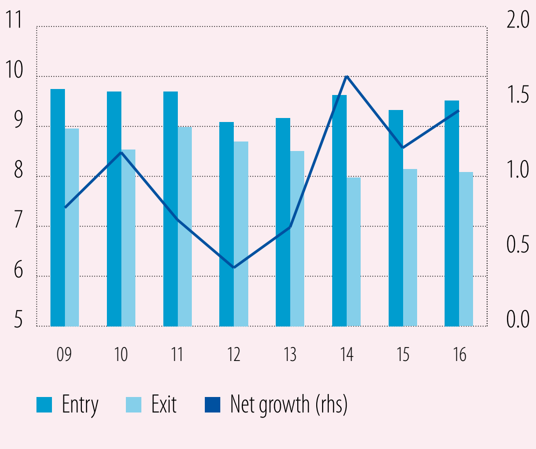
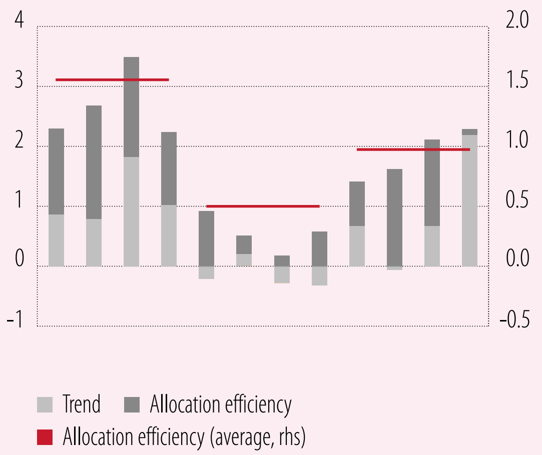


Figure B.2
Olley Pakes decomposition of manufacturing labour productivity (%, year over year)



Source: EIB Economics Department calculations based on Eurostat.

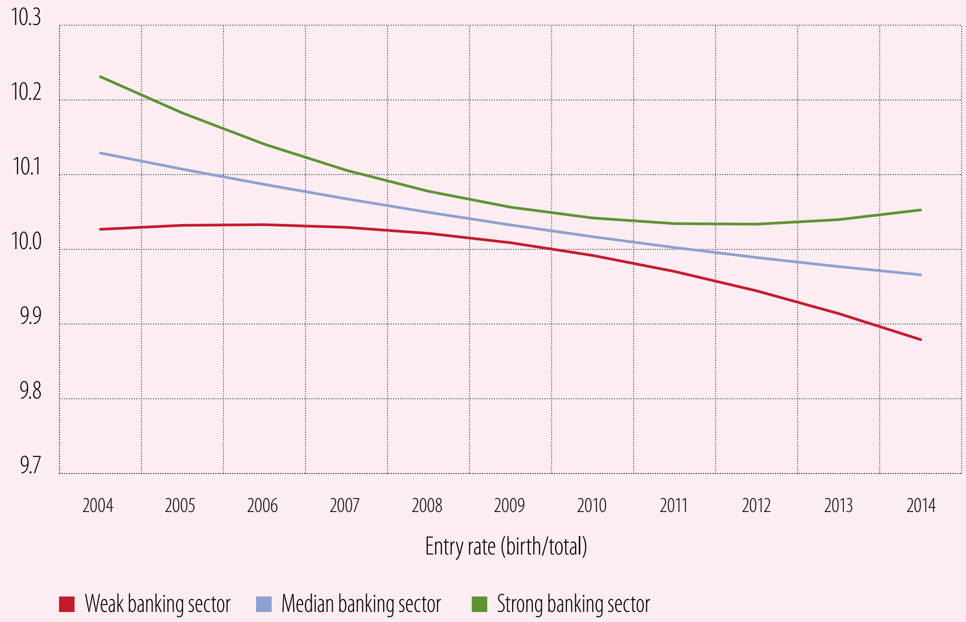
When an economic downturn is driven by tightening financial conditions, the typical boost to overall productivity that results from weaker firms closing down is reduced. We study the extent to which the relationship between firm entry or exit and allocation efficiency depends on the condition of the banking sector. To this end, we allow for possible quadratic effects, accounting for potential non-linearities. In the empirical specification, we estimate a quadratic model conditional on different levels of banking sector strength, measured by Tier 1 ratio and solvency ratio. We find that a weak banking sector prevents firms from entering the market and fostering productivity. Figure B.3 shows the impact of various entry rates on the productivity allocation efficiency component for three states of the banking sector. A weaker banking sector blunts the capacity of new firms to contribute to productivity gains.

Access to finance has a major impact on how firms allocate resources. Credit-rationed companies may not pursue the most productive investment projects if they do not have access to the necessary funding. At the same time, firms with abundant and cheap financing may find it profitable to engage in projects that would have not been profitable otherwise. When the banking sector is weak, the ability to channel resources to highly productive projects may then be distorted by the allocation of corporate credit.

Figure B.3

Sensitivity of allocation efficiency to bank strength

(contribution of allocation efficiency to labour productivity)



Source: *EIB Economics Department estimations based on Eurostat, ECB and Orbis (Maurin and Wolski, 2019).*

Looking at productivity through the lens of the EIB investment survey

Data from the EIB Investment Survey (EIBIS) enable us to deepen our analysis of firm dynamics, linking them to specific firm characteristics. Firstly, EIBIS data make it possible to attribute a specific pattern of movement to firms in a representative balanced panel. Secondly, using EIBIS panel data to define firm movements enables us to assess firm characteristics that are related to productivity and the obstacles faced by different productivity movers and regions.[6]

6 We compute TFP for EIBIS firms applying the estimation results from Orbis. In this way, we impose the sample of EIBIS firms on the total factor productivity estimates of the full Orbis database (methodology described in Box A).

Six categories of firms have been compiled based on their movements along the TFP distribution from 2011 to 2016.[7] These categories comprise firms that:

(1) are stable at the frontier (in all the years observed) – **Stable at frontier**;
(2) started elsewhere in the distribution but arrived at the frontier – **Arrived at frontier**;
(3) improved their ranking during the period of observation – **Upgrader**;
(4) are stable (their last ranking is equal to the first) – **Stationary**;
(5) worsened their position – **Downgrader**;
(6) are stable at the bottom of the distribution – **Bottom**.

Table 1
Share of firms in each category (in %)

	Movement category	West and North	South	Central and East	European Union
1	Stable at frontier	12.08	6.98	2.11	5.74
2	Arrived at frontier	3.23	1.94	1.41	1.99
3	Upgrader	16.88	20.7	23.18	21.03
4	Stationary	40.02	42.85	30.95	36.02
5	Downgrader	27.59	25.21	19.15	22.68
6	Bottom	0.2	2.31	23.21	12.55

Source: *EIB Investment Survey (EIBIS).*
Base: *All firms that could be classified in one of the movement categories.*
Note: *The grey areas reflect a share of firms in a particular region that is higher than the EU average.*

The majority of European firms show relatively poor dynamics, falling into either the stationary or downgrader categories. Across all regions, some 70% of all firms come under these two categories or the bottom category (see Table 1). In addition, the table largely confirms the previously noted regional differences.

In addition to the above findings, the table shows that while Central and Eastern European firms are mainly found at the bottom, this region has the highest share of upgraders. Nevertheless, only around 3.5% of firms from Central and Eastern Europe reach the top categories (stable at frontier and arrived at frontier).

The importance of size and investment

Larger firms are more likely to be at the frontier. Figure 8 shows the size distribution of firms in the different categories of productivity movement.[8] Large firms are overrepresented in the first two categories (stable at frontier and arrived at frontier) (Figure 8). Microfirms, in contrast, are almost totally absent from the first two categories and have a major presence among firms permanently at the bottom, but also among upgraders.

Compared to the other regions, Southern Europe has a very high share of small and microfirms among its upgraders and firms arriving at the frontier. Southern Europe has fewer large firms overall. While firms at the frontier are mostly large, size drops sharply in the subsequent categories. Taking the

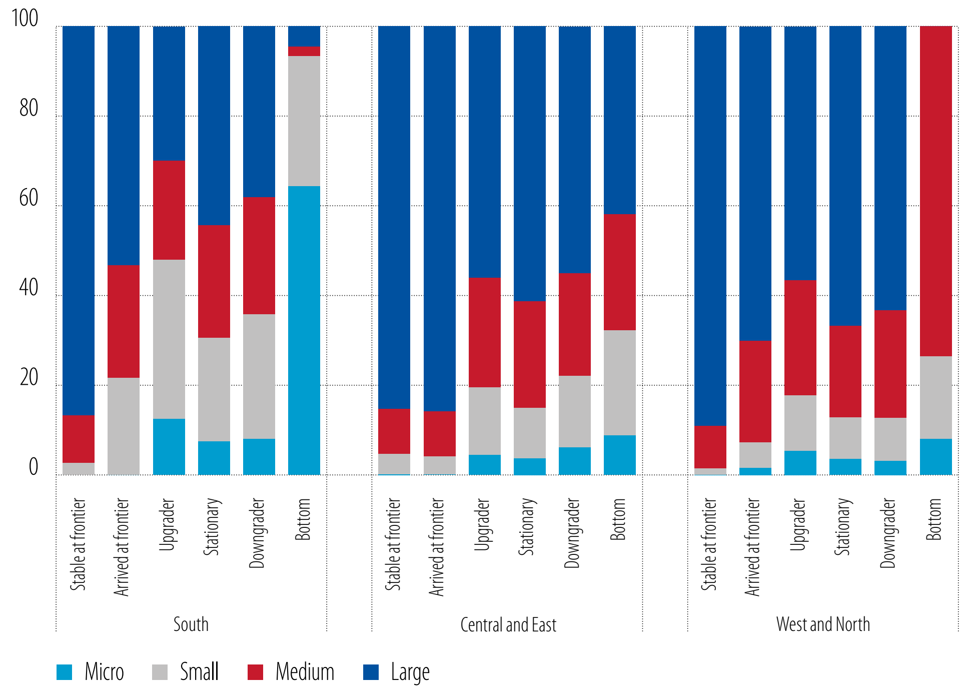
7 The different categories are mutually exclusive, implying that a firm that has arrived at the frontier is no longer classified as an upgrader. Similarly, firms stable at the frontier or at the bottom are not assigned to the class of stationary firms. Only firms with complete TFP data from 2011 to 2016 are categorised in one of the classes of movement. Consequently, the resulting dataset forms a balanced panel for these years.

8 Microfirms have fewer than ten employees. Small firms are defined as firms with ten to 49 employees, while medium firms have 50 to 249 employees. The number of employees in large firms is equal to or larger than 250.

example of Italy, Andrews, Criscuolo and Gal (2015) suggest that a large part of the productivity gap can be explained by the fact that many of the most productive firms are relatively small compared to those at the global frontier. The fact that these firms never grow to a sufficient size might explain why aggregate productivity in the region is lagging. With this in mind, it might be especially relevant for policymakers to introduce reallocation-friendly policies that enhance the ability of national frontier firms to attract resources and scale up. Southern Europe also has more small and microfirms in its bottom categories, although merely looking at the size distribution does not indicate whether this is genuinely problematic. However, given the dispersion between top and bottom firms in South Europe (as shown in Figure 3), the concentration of small and microfirms at the bottom could indicate that bottom firms are not able to fulfil their growth ambitions or to overcome exit barriers.[9]

Figure 8

Share of firms in each category, by region and size class (in %)



Source: *EIB Investment Survey (EIBIS).*
Base: *All firms that could be classified in one of the movement categories.*
Note: *Due to the low number of firms in this category, the results for the category of bottom firms (6) in Western and Northern Europe may not be representative.*

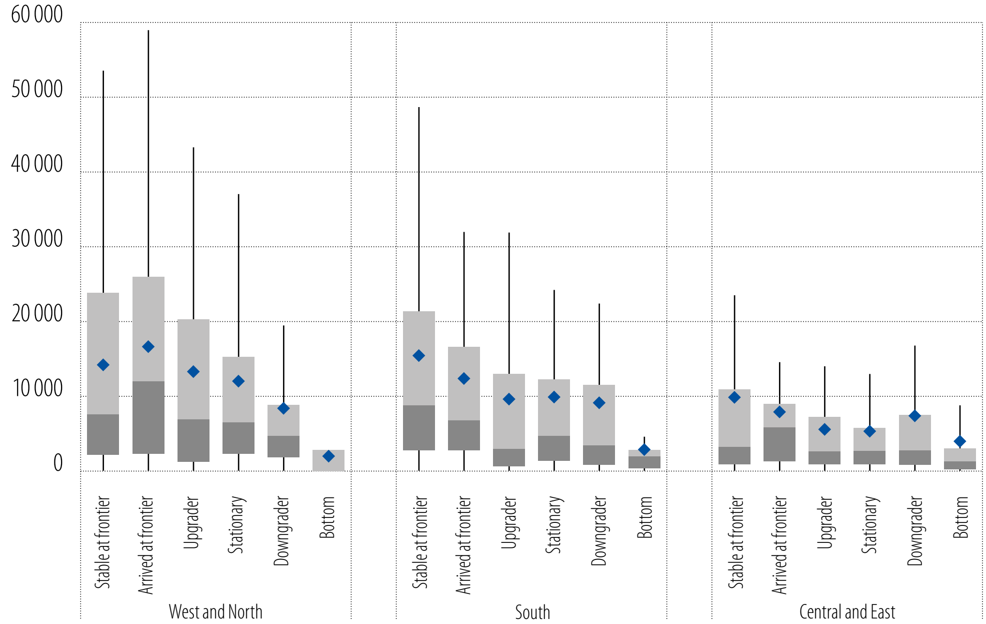
The relationship between TFP growth and business growth (measured in sales) seems to be weaker for firms located in Southern Europe. One worry could be that small firms with improving productivity have less opportunity to grow because of their small size. As pointed out in Bugamelli et al. (2018) in a study on Italy, raising productivity depends on removing all factors that curb a firm's willingness or ability to grow. A simple regression in which the average sales growth of small firms is related to average TFP growth from 2011 to 2016 shows a negative (and significant) coefficient for the dummy variable representing firms from Southern Europe (using firms from Western and Northern Europe as the reference category).[10] This confirms that firms in Southern Europe might find it more difficult to materialise their productivity growth.

9 A more detailed analysis of a Southern European country (Italy) is presented in Box E.
10 This only seems to be an issue for Southern Europe, as the same coefficient is not significant for firms located in Central and East Europe.

Downgraders and firms unable to leave the bottom category have the lowest investment intensities (Figure 9). Together with size, investment by the different firm categories helps us better understand their growth ambitions. Firms in the bottom category have very low levels of investment, which is especially striking given the rigidity of these firms over time. Bottom firms are likely not able to fulfil their growth ambitions or to overcome exit barriers.

Figure 9

Investment intensity across regions and firm categories (investment per employee)



Source: *EIB Investment Survey (EIBIS).*
Base: *All firms that could be classified in one of the movement categories.*
Note: *Due to the low number of firms in this category, the results for the category of bottom firms (6) in Western and Northern Europe may not be representative.*

Knowledge creation and innovation

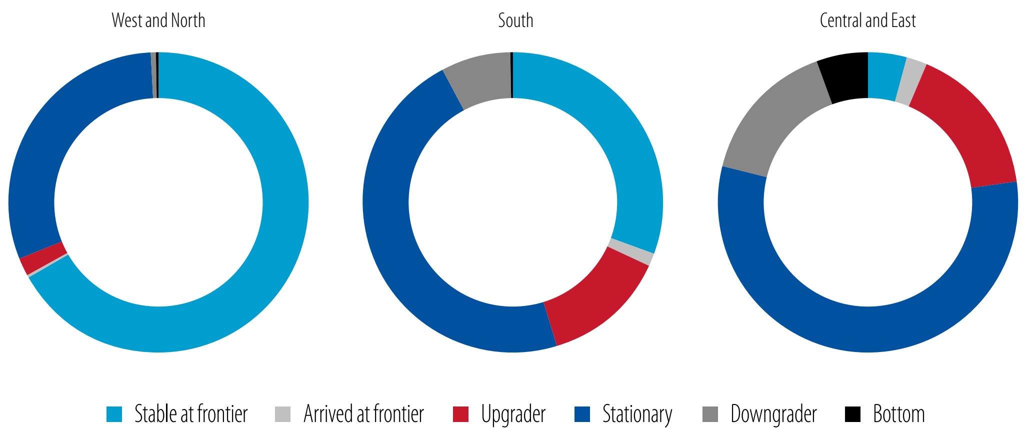
Knowledge creation and innovation are often directly linked to productivity performance. Western and Northern Europe are generally recognised to be leaders in this domain while Southern, Central and Eastern Europe are lagging behind (Box C and European Commission, 2019). EIBIS data enable us to look at the knowledge creation and innovation activities of the different types of productivity movers in each European region.

Leading regions seem to benefit from the R&D investments of their leading firms (see Figure 10). Leading firms in Western and Northern Europe are responsible for 70% of regional R&D, despite only accounting for 12% of firms. They are also more innovative and particularly active in the global arena (Figures 11 and 12).

At the other extreme, leading firms based in Central Europe have a relatively small role in regional R&D or as leading innovators. This reflects the fact that frontier firms in Central Europe are part of European production chains. Southern European firms sit in between two extremes, with leading firms looking more like those in Western and Northern Europe but stationary firms absorbing a considerable share of R&D investment. In addition, leading firms in Southern Europe are more digitally savvy than their peers in other regions (Figure 13).[11]

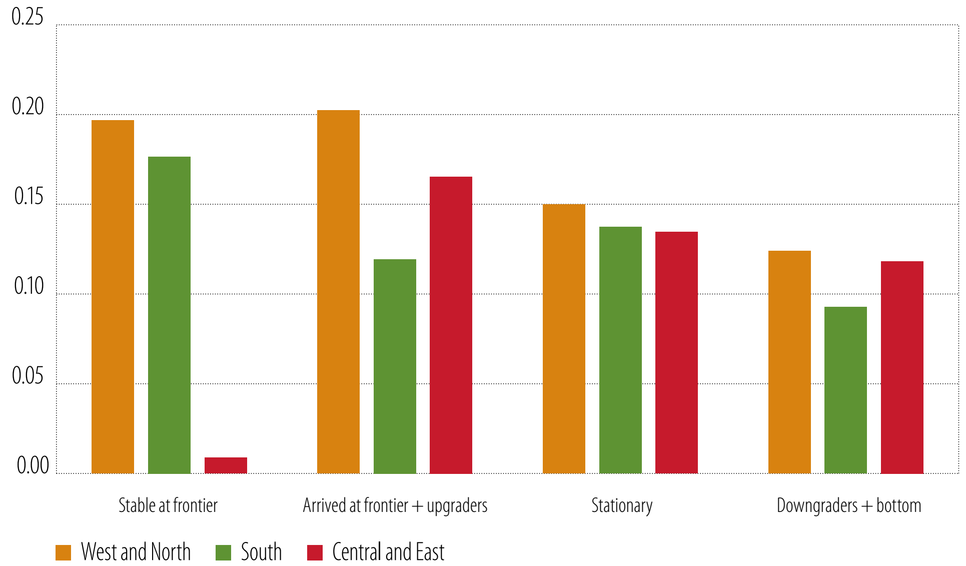
11 For the first time, the most recent wave of the EIBIS survey contains data on digitalisation. We calculated a very straightforward TFP measure, considering the top 5% firms as frontier firms for each sector, because the movement categories cannot be calculated for only one wave of data.

Figure 10
R&D investment across regions and firm categories



Source: *EIB Investment Survey (EIBIS).*
Base: *All firms that could be classified in one of the movement categories.*
Note: *Due to the low number of firms in this category, the results for the category of bottom firms (6) in Western and Northern Europe might not be representative.*

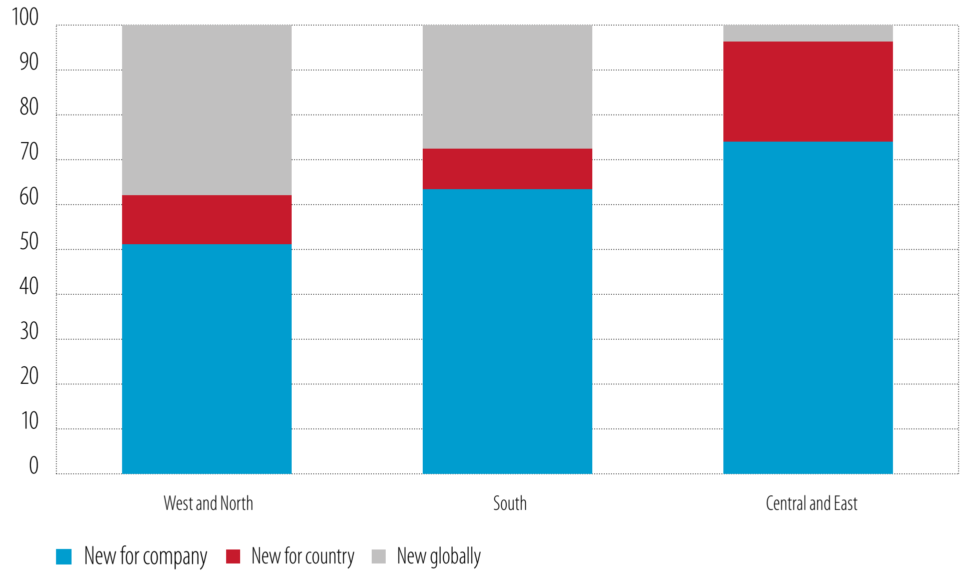
Figure 11
Share of innovators that are also investing in R&D, across regions and firm categories
(leaders amongst innovative firms and/or R&D spenders)



Source: *EIB Investment Survey (EIBIS).*
Base: *Firms that invest in R&D and/or are active innovators (not necessarily new to the country or global market).*
Note: *Due to the low number of firms in this category, the results for the category of bottom firms (6) in Western and Northern Europe might not be representative. For this specific exercise, the number of firms in this category dropped to 1, which explains why it is not shown in this graph.*

Figure 12

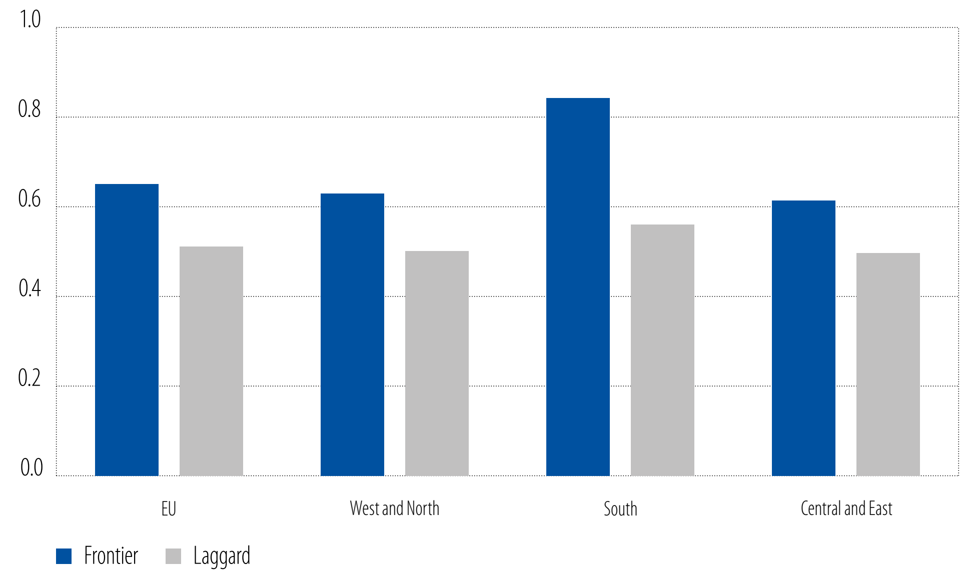
Innovative products, processes or services introduced by leading firms across different regions



Source: *EIB Investment Survey (EIBIS).*
Base: *Innovative firms belonging to the category Always at Frontier.*
Note: *Innovative products, processes or services are defined based upon the questions: What proportion of total investment was for developing or introducing new products, processes or services? Were the products, processes or services new to the company, new to the country or new to global markets?*

Figure 13

Share of frontier and laggard firms that are digital, in the EU and its regions



Source: *EIB Investment Survey (EIBIS) – last wave.*
Base: *All firms for which TFP could be calculated.*
Note: *Digital firms are defined based upon the 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? A firm is considered digital if it said that it used at least one of the different digital technologies mentioned in parts of the business or if its entire business is organised around them.*

What prevents firms from moving up the productivity ladder?

Obstacles to investment

As suggested above, firms making productivity gains invest more than firms losing ground or stuck at the bottom of the distribution. It is therefore important to look into the different obstacles faced by these firms.

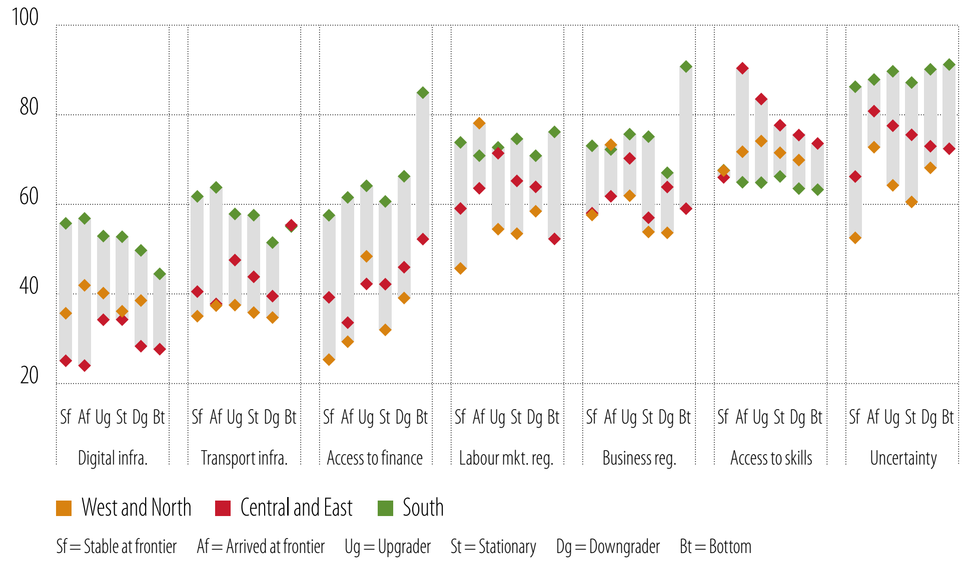
In general, Southern European firms in all the various movement categories suffer the most from obstacles to investment, further accentuating the difficulties they face in scaling up their size and productivity (Figure 14). Southern European leaders in particular consider inadequate access to digital and transport infrastructure to be obstacles to investment. Firms at the bottom of the productivity distribution see these issues as less of an obstacle, presumably because they are not looking to digitalise further or to widen their target market. In spite of some intra-regional differences, other regions tend to perceive access to digital and transport infrastructure as less of a problem.

Central and Eastern European firms complain less of barriers than firms in Southern Europe, but more than firms in Western and Northern Europe. A more dynamic economic environment could explain this more positive sentiment. Central and Eastern European firms, especially the ones moving upwards in the productivity distribution, cite a lack of skills as a significant investment obstacle. That sentiment could stem from the outward migration patterns in Central and Eastern Europe. In addition, productivity upgraders are more likely to indicate regulations and uncertainty as obstacles.

Western and Northern European firms perceive fewer obstacles to investment than their Southern and Central European counterparts. Nevertheless, a lack of skills and different regulations hamper firms that are making efforts to grow in terms of productivity. Growing firms are expanding in the global market and have to deal with different regulations at a country or regional level. These firms likely have to overcome more obstacles due to the incompleteness of Europe's single market – their access point to the global market. Firms that are stable at the frontier complain less about different regulations, suggesting they have already overcome most of the obstacles.

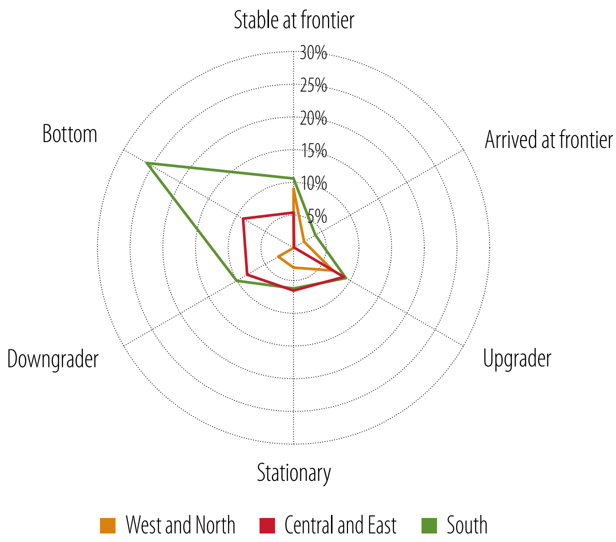
Southern European firms at the bottom of the productivity distribution are the most likely to cite business regulations and lack of access to finance as obstacles to investment (see Figure 14). Similarly, the share of financially constrained firms is considerably higher in Southern Europe than in Central Europe and Western and Northern Europe, particularly for downgraders and firms that remain at the bottom (Figure 15). In, addition, Southern European firms at the bottom that receive external funding indicate that they are dissatisfied with all aspects of external finance (namely the type of financing, collateral asked for, time it takes, cost and amount received).

Figure 14
Obstacles to investment by category and region (minor and major obstacles)



Source: *EIB Investment Survey (EIBIS).*
Base: *All firms that could be classified in one of the movement categories.*
Note: *Due to the low number of firms in this category, the results for bottom firms (6) in Western and Northern Europe might not be representative and are not shown in the graph.*

Figure 15
Financially constrained firms across different regions and firm types



Source: *EIB Investment Survey (EIBIS).*
Base: *All firms that could be classified in one of the movement categories.*
Note: *Due to the low number of firms in this category, the results for the category of bottom firms (6) in Western and Northern Europe might not be representative.*

Box C

Patent data as a measure of innovation activity

Patents are documents issued by an authorised agency, granting the applicant an exclusive right to produce or to use a specific new device, apparatus or process for a limited period. The legal protection conferred by a patent gives its owner the right to exclude others from making, using, selling, offering for sale or importing the patented 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. A patent application to the European Patent Office (EPO) can be valid in several countries, at most in all the 30 countries that have signed the European Patent Convention.

The stated purpose of the patent system is to encourage invention and technical progress by providing a temporary period of exclusivity over the invention in exchange for its disclosure. By providing protection and exclusivity, a patent is a policy instrument intended to encourage inventors to invest in research and the subsequent innovative work that will put those inventions to practical use. Due to the temporary exclusivity, intellectual property rights provide patentees with a competitive advantage. Patents can also be licensed or used to help create or finance a spin-off company. It is therefore possible to derive value from them even if their owner does not have its own manufacturing capability (e.g. in the case of universities).

As such, patents reflect a country's inventive activity and its capacity to exploit and develop knowledge by translating it into potential economic gains. The disclosure obligation in the patent system, and the detailed information that is disclosed, implies that patents represent a rich source of technical information, which may prevent the re-invention and re-development of ideas. The elaborate and well-structured amount of information that is systematically stored in patent documents also allows for systematic and objective quantitative analyses with the purpose of obtaining knowledge about the progress of technological knowledge. Indicators based on patent statistics are widely used to assess the inventive and innovative performance of a country or a region.

Nevertheless, some caveats have to be taken into account when reading and interpreting patent-based indicators. First of all, the propensity to patent varies across technological domains and across regions. Second, not all innovations are patented (for example, for reasons of secrecy), and not all patented inventions are innovative or even marketable products; a granted patent does not necessarily attest that the patented technology is important or has any commercial value. The value distribution of patents is known to be rather skewed. Lastly, part of the patent activity represents strategic behaviour (e.g. fencing or scaring off potential competitors) rather than innovative and valuable R&D efforts.

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 Organisation (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 most important and largest ones 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 was produced in collaboration with ECOOM (The Centre for Research & Development Monitoring).

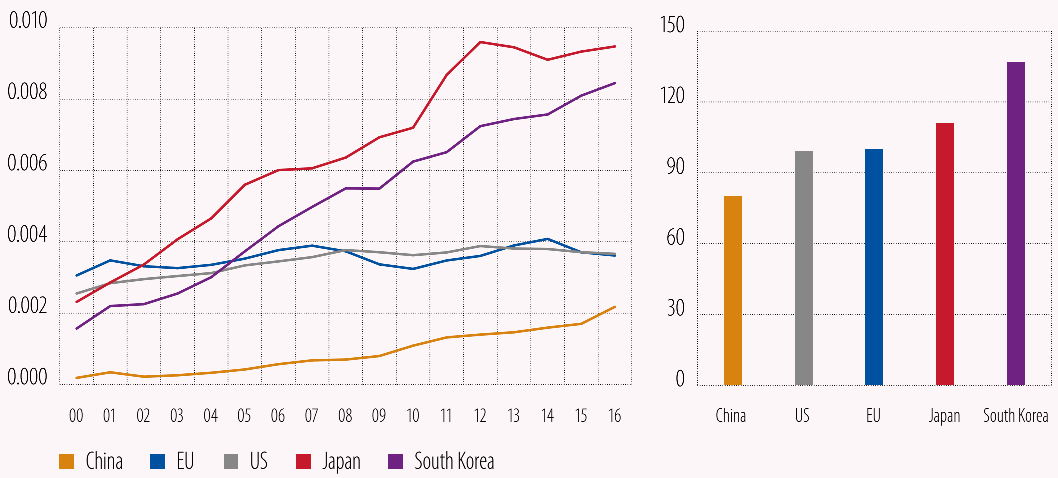
Knowledge creation in the European Union

It is often stated that the European Union is poor in creating knowledge compared to other regions, such as the United States, and is starting to lose ground to China. In general, the patent data collected do not reflect badly on the European Union. Data referring to absolute patent counts suggest that the European Union is still a leader in patent volumes together with the United States. On the other hand, the data also show that China is rapidly catching up. This trend is similar to the evolution of R&D expenditures over time, confirming that patent data can be reliably used to measure R&D activities.

Once the patent data, and more precisely the patent counts, are weighted by gross domestic product (GDP), the leading countries in the ranking over time are Japan and Korea. The left-hand panel of Figure C.1 clearly shows how China is rapidly catching up. In addition, the ranking of the weighted patent data in 2016 largely coincides with the global ranking from the last version of the European Innovation Scoreboard presented in the right-hand panel of Figure C.1 (European Commission, 2019). In the latter ranking, Europe surpasses the United States for the first time. The European Innovation Scoreboard provides a comparative assessment of the research and innovation performance of the EU Member States and selected third countries.

Figure C.1

Creation of knowledge based upon patent count weighted by GDP (lhs) **and innovation performance based upon the global innovation performance scoreboard** (rhs)



Source: PCT patent count (PATSTAT), GDP series (World Bank) and European Innovation Scoreboard.

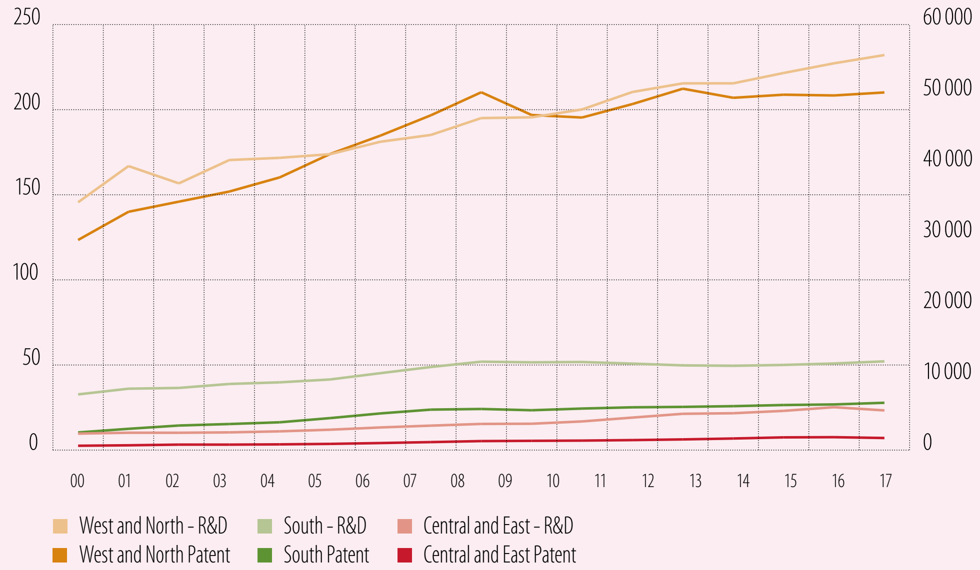
Within the European Union, Western and Northern Europe are clearly leaders in terms of patenting, while Southern and Eastern Europe lag behind. Figure C.2 clearly shows how Western and Northern Europe leads, both in terms of patenting (solid line) and in terms of R&D expenditures (dotted line). The weaker knowledge creation in certain regions coincides with weaker TFP figures in the same regions.

This box provides a general introduction on patent data and its use in measuring innovation activities. Overall, both the theoretical argument and the figures presented above suggest that patent data can be used to reliably reflect the innovation activities of firms. These findings are also in line with the most recent publication of the European Innovation Scoreboard, ranking Western and Northern European countries mainly as innovation leaders and strong innovators, countries in Southern Europe as moderate innovators and countries in Central and Eastern Europe mainly as moderate and even modest innovators.

Box D provides some further insights into technology-specific R&D investments based upon PATSTAT data, showing that there are large differences in R&D investment associated with patents across technologies, firms and industries. This implies that, although patent and R&D data are strongly correlated at more aggregate levels, firm-level R&D investments per patent vary according to the sector and technology.

Figure C.2

Patenting activities (patent count, rhs) **and R&D expenditures** (USD bn, ppp, lhs) **across European regions**



Source: *PCT patent count (PATSTAT), OECD (2019).*
Note: *Research and development expenditures are USD billions in constant prices using 2010 base year and purchasing power parities.*

The breakdown of knowledge diffusion?

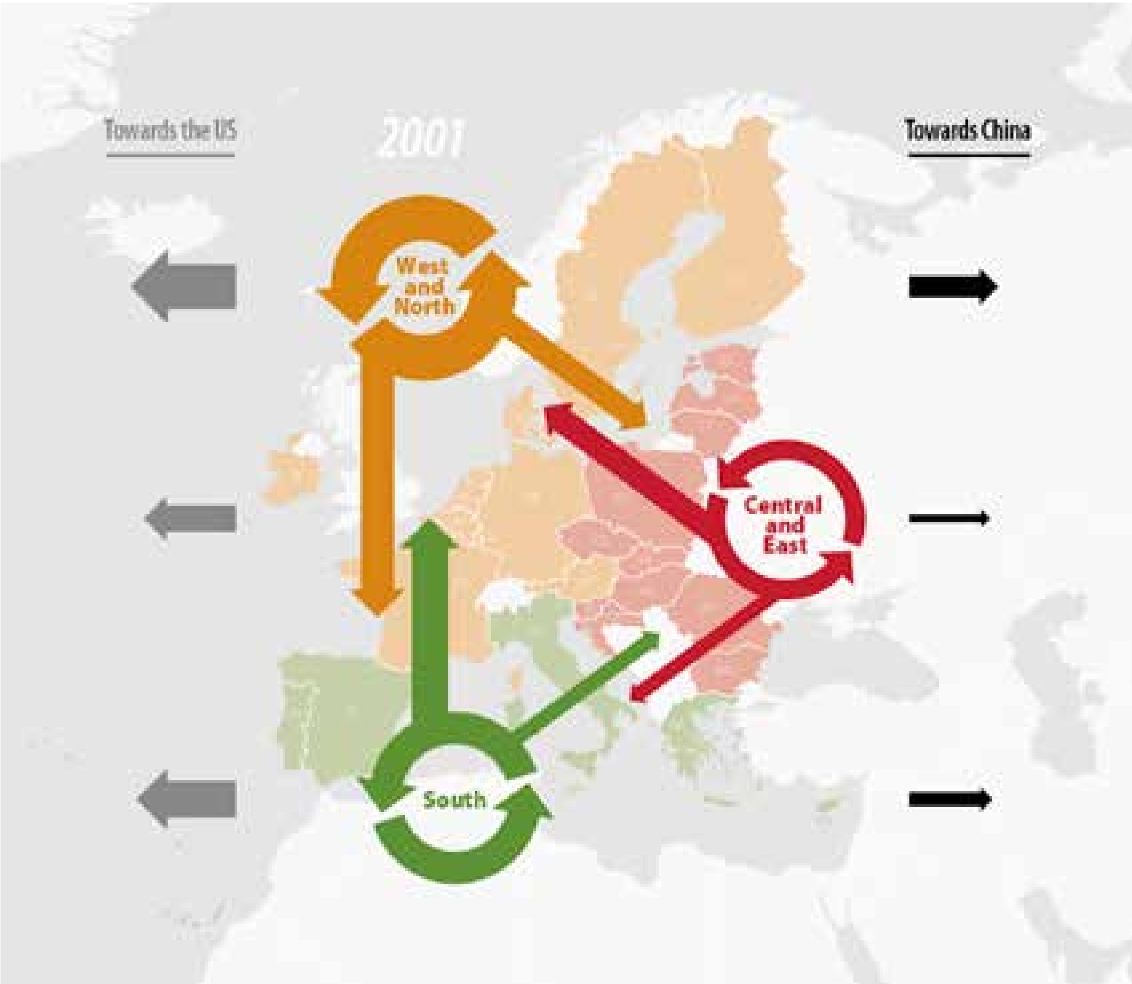
The persistent productivity gap between frontier firms and laggard firms and the rigidity at the bottom might be explained by the inability of weaker firms to learn from leading ones. The idea that knowledge creation, and its circulation and exploitation, is the basis of knowledge-based economies and enables economic growth is well established in the literature (Griliches, 1992; Cockburn and Henderson, 1998; Gambardella, 1995). A lack of knowledge transfer is often considered as one of the main reasons for the persistent gap in productivity between leaders and laggards (Andrews et al., 2016; Akcigit and Ates, 2019). The increasing complexity of technology can reduce knowledge flows. In fact, reduced flows of knowledge may explain the winner-takes-all phenomenon and the general decline in the contestability of markets (Akcigit and Ates, 2019). This is consistent with the literature, which shows that laggard firms are finding it increasingly difficult to leave the bottom of the European productivity distribution. This section uses patent data to assess how knowledge creation and transfer takes place across the different European regions and how it compares with the rest of the world.[12]

12 More information on patent data can be found in Box B, which provides some general background on the use of patent data in order to measure innovation. This box also gives some general insights on the innovation activities of European countries, measured with patent data. A further illustration of how patent data can be exploited is shown in box C.

In contrast to the suggested breakdown of knowledge transfer, knowledge flows have increased over time. Overall, citations of previous patents increased from 2001 to 2015 (Figure 16). The figure shows a rough measure of backward citations, or citations of patents used as a basis for new inventions, flowing from the different European regions.[13] The circles refer to backward citations within the respective region while the arrows refer to knowledge flowing from the region to other regions, the United States and China.

Across Europe, Western and Northern Europe is the leading region in the number of citation links while these links increased most for Central and Eastern Europe. Globalisation is partly responsible for the absolute increase in citation links. However, when comparing the figures from 2001 and 2015, we note that some citation linkages intensified more than others. Within the European Union, citations to, from, and within Central and Eastern Europe saw a particular increase. The rise suggests that this region made more use of knowledge generated outside of national borders and that it is also increasingly a source of knowledge within Europe.

Figure 16
Evolution of global citation linkages over time



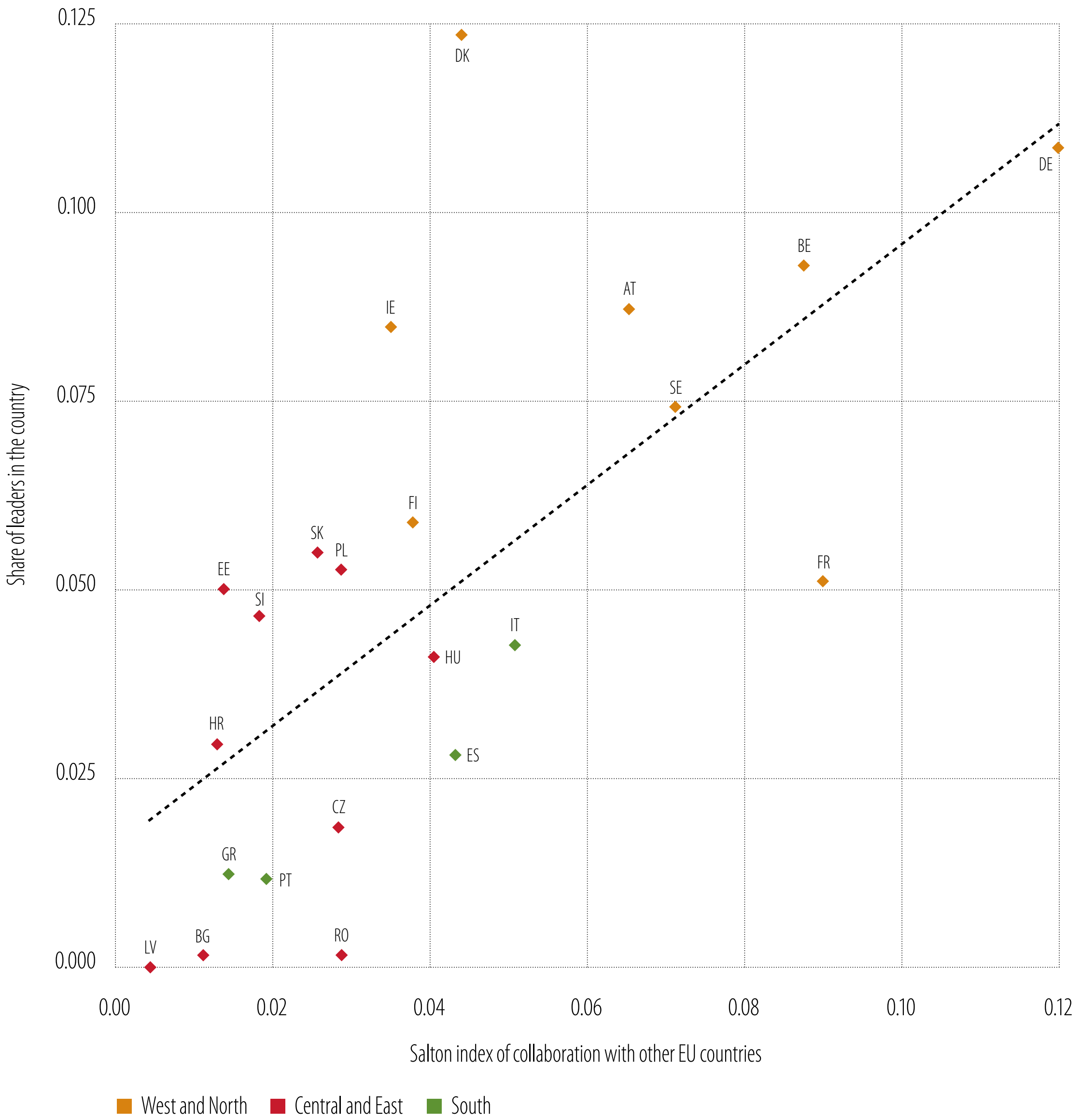
13 Backward citations are defined as citations referring to previous patents upon which the current invention described in the patent application is based. The thickness of the arrows and the circles is proportional to the natural logarithm of the number of cross-country backward patent citations.

Source: *EIB Economics Department calculations based upon PATSTAT (European Patent Office) data in collaboration with ECOOM (Centre for Research and Development Monitoring, Belgium).*
Note: *The figure shows the citation links within and between the different European regions: Western and Northern Europe, Southern Europe and Central and Eastern Europe. In addition, it shows to what extent the different European regions cited the United States and China. For a given year, the thickness of the arrows is proportional to the number of citations.*

Countries with greater knowledge flows have the most productivity leaders (Figure 17). One of our premises is that knowledge transfer enables productivity growth and the presence of leaders in an economy. Figure 17 shows that there is a strong positive correlation between the share of leaders and the extent of collaboration and citations.[14] The clear link between leading countries and knowledge flows calls for a better understanding and mapping of these flows in the European Union. The remainder of this section will provide a more detailed analysis of knowledge flows in the European Union and its different regions.

14 Collaboration is measured with co-patents, which are patents with multiple applicants or inventors. When looking at the number of co-applications or co-inventors at country level, we can see how many patents were applied for, having multiple applicants from the country-pair under consideration. Collaboration is measured by the Salton index of collaboration with other European countries. A similar relationship emerges when knowledge flows are measured with citation data or when alternative definitions of top performers are applied. Similarly, when solely focusing on bottom firms, the relationship between collaboration and the percentage of firms at the bottom of the TFP distribution is negative, implying that countries with more intense knowledge flows have fewer firms at the lower end of the TFP distribution.

Figure 17
Salton index of collaboration with other EU countries and share of leaders in the country



Source: *EIB Economics Department calculations based upon PATSTAT (European Patent Office) data in collaboration with ECOOM (Centre for Research and Development Monitoring, Belgium) and Bureau van Dijk's Orbis database.*

Note: *The share of leaders in the country refers to the share of frontier firms in a single country. The Salton index,* $r_{i,EU}$*, captures the number of collaborative patents between country i and the rest of the European Union, normalised by the total patent count n of the country itself and the remaining countries in the European Union:* $r_{i,EU} = r_{i,EU\text{-}i} / \sqrt{n_i n_{EU\text{-}i}}$*. The line shows the fitted linear regression.*

The strongest ties in terms of knowledge flows remain national. Outside national boundaries, the strongest ties are within Western and Northern Europe, mainly between countries sharing borders. The home-country bias differs between countries (diagonal cells in Figure 19, based on the relative intensities of citation linkages between the countries citing patents and those being cited). For example, Germany and France are more reliant on foreign patents. Given that these countries are also technologically strong suggests that a reliance on foreign patents increases technological performance

(European Commission, 2014). In addition, the intensity of collaboration and citations between some neighbouring Western and Northern European countries is relatively high. Belgium, Germany, France, Luxembourg and the Netherlands engage in heavy knowledge sharing, and also the Nordic countries work quite intensively together and frequently cite each other's patents.[15]

In line with this, Western and Northern Europe also has the strongest global ties. Western and Northern European countries work more intensively with both China and the United States (Figure 18), and some of the Nordic countries seem to be particularly active in co-patenting with China. This is in line with the findings of Hellström (2016), which showed increased interactions between China and these regions.

The collaboration and citation intensity of Southern Europe and Central and Eastern Europe outside their respective borders remains relatively low. This is particularly true for Central and Eastern Europe. This finding is in line with the research on productivity and suggests a strong correlation between the evolution of productivity and knowledge flows.

Both geographical and technological barriers seem to have a major impact on the extent to which knowledge flows across countries, with variations existing across European regions (see Figure 20 and Figure 21).[16] When crossing a country border, average knowledge flows drop to 30% of their initial level. In other words, 70% of knowledge generated in the average country is not transferred outside of its national borders, but remains local. In addition, only 23% of knowledge flows crosses two country borders, and knowledge flows drop significantly to countries with different developed technologies (the TechDis barrier shown in Figure 20) and R&D spending per worker (the TechAdv barrier shown in Figure 20).[17] In addition, knowledge generated in Western and Northern Europe flows more easily across borders and technological barriers than knowledge generated in Southern Europe and substantially better than knowledge generated in Central and Eastern Europe (Figure 21).

Over time, knowledge flows less easily within Western and Northern Europe (Figure 22).[18] Technologies have become increasingly complex and hence more difficult to transfer to other advanced firms. As pointed out by Ackigit and Ates (2019), big proprietary data play a larger role in the production process, making established incumbents increasingly immune to competition from follower firms who are relatively close in terms of technological development. This might be especially true when focusing on Western and Northern Europe, where most leaders are located and most knowledge creation is taking place (see Box C).

The previously discussed Central and Eastern European productivity growth figures correspond with the increase in knowledge flowing from Western and Northern Europe to this region. This apparent link is in line with other findings, suggesting that technologies developed at the frontier are spreading more rapidly across countries that are lagging behind and have shorter adoption lags (Comin and Mestieri, 2018). This suggests that globalisation has benefited countries with a greater number of laggards more than it has leading countries. In addition, the increase in available knowledge complements the rise in productivity in this region, since new technologies are seen to stimulate productivity.

Despite positive changes within the region and a clear increase in knowledge flows, Central and Eastern Europe remains at the bottom of the European productivity distribution. Countries with

15 This is based upon a country-level Salton index, $r_{i,j} = r_{i,j} / \sqrt{n_i n_j}$, weighting the total co-patents between country i and j by the square of the product of total number of patents in both countries in order to correct for the size of the different countries.

16 Knowledge flows and the determinants of these flows are estimated in line with Peri (2005) and Eugster et al. (2018).

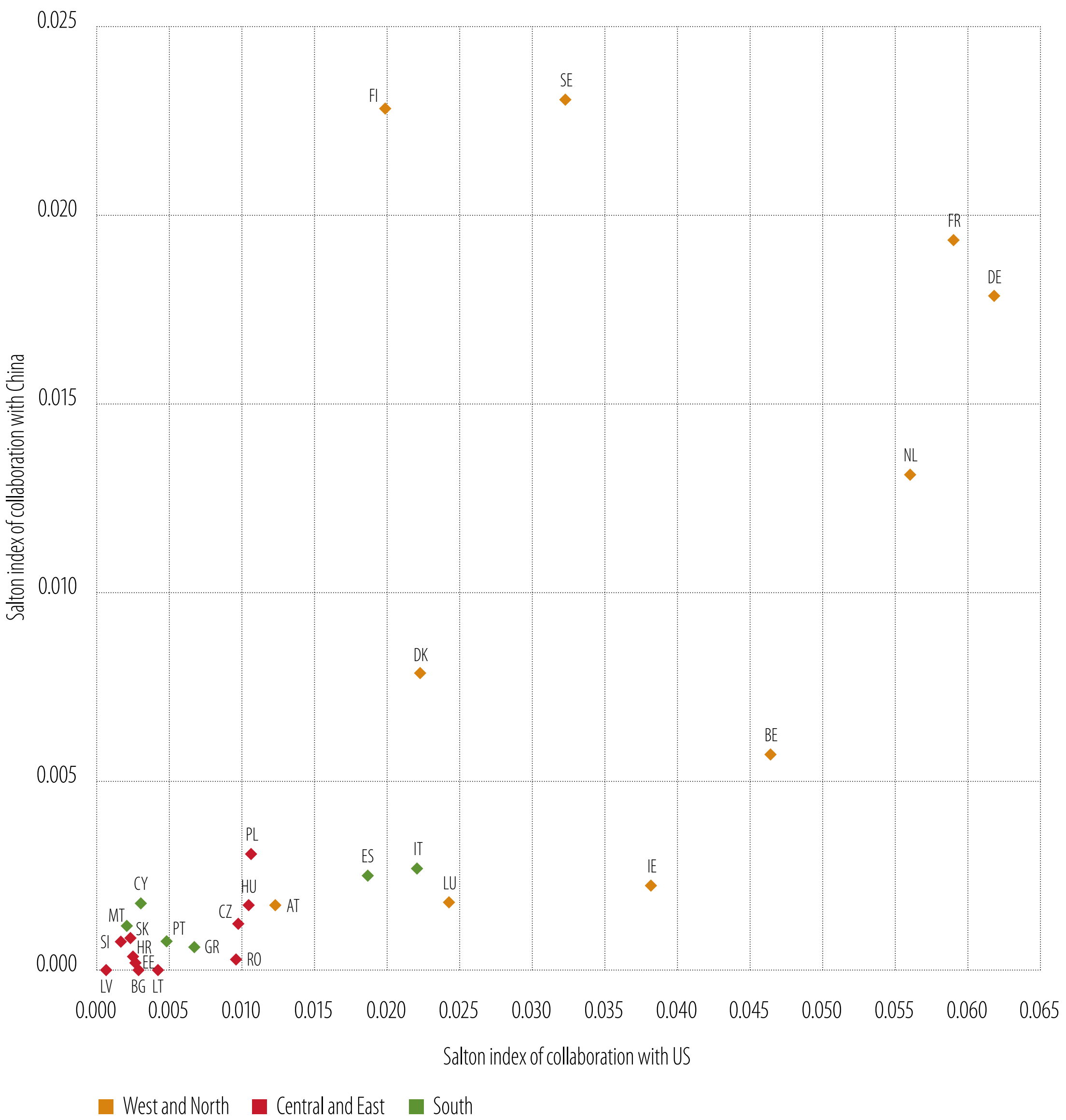
17 TechDis is inspired by Peri (2005) and is equal to 1 minus the uncentred correlation coefficient between the technology vectors of countries i and j. The vectors of technology are based upon the relative share of patents in one of the 35 Fraunhofer technology classes, calculated for each country. TechAdv reflects the difference in R&D spending per worker.

18 To estimate knowledge diffusion over time, the estimation to calculate knowledge flows is repeated for different time periods. In concrete terms, the estimation is performed for 2001-2003, 2004-2006, 2007-2009, 2010-2012 and 2013-2015. Based upon the estimates for each time period, average knowledge flow intensities for each citing region (keeping the cited region fixed to Western and Northern Europe) can be calculated. As suggested by other scholars, the same estimations were also performed for citation pairs containing the number of citations over time periods longer than five years (without limit) as a robustness check. All results hold when changing the time interval of the citation pairs. In addition, when comparing the knowledge diffusion over time, the estimation is also repeated for different time periods. Again, all results are robust to this specification.

lower productivity levels may not be as effective in allocating their factors of production to the most efficient use, even if knowledge is increasingly flowing to their regions. The finding is closely related to the concept of "National Innovative Capacity" introduced by Furman, Porter and Stern (2002), who state that the capacity or ability of a region to "produce and commercialise a flow of innovative capacity" depends on infrastructure, the environment in industrial clusters and the links between the two. The authors claim that although knowledge creation is a very important determinant of productivity, it should be complemented by institutional factors to ensure productivity gains.

Figure 18

Salton index of collaboration between the EU and China, and the EU and US

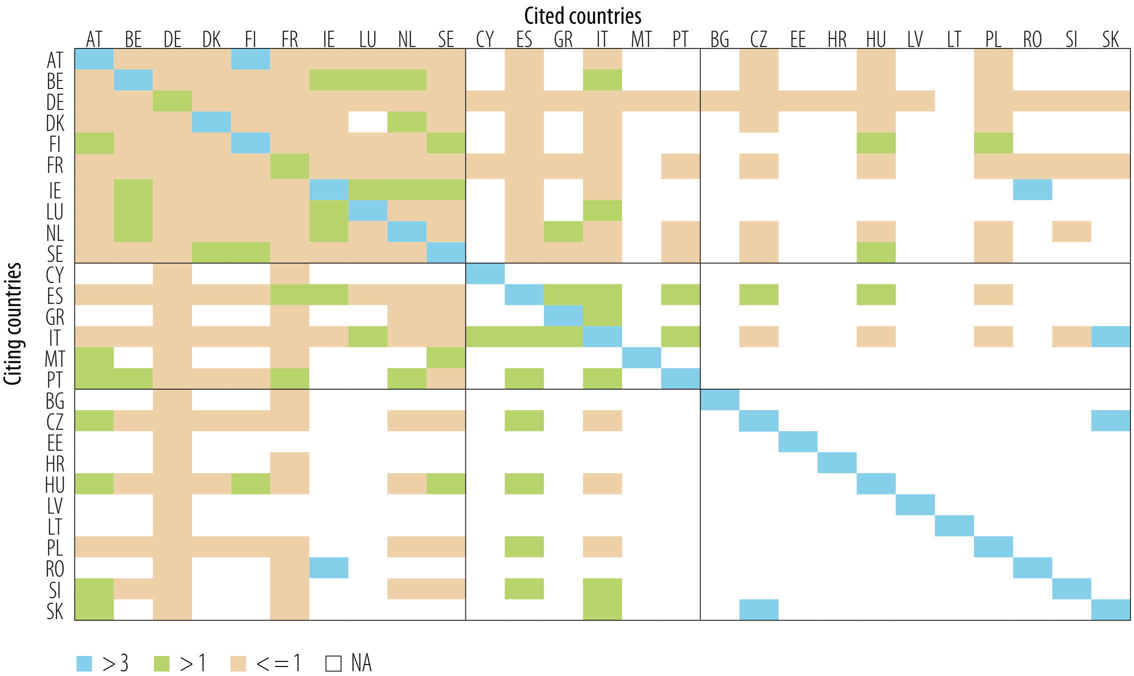


Source: *EIB Economics Department calculations based upon PATSTAT (European Patent Office) data, in collaboration with ECOOM (Centre for Research and Development Monitoring, Belgium).*

Note: *The figure shows the Salton indices of collaboration with the United States (x-axis) and China (y-axis). A country-level Salton index, $r_{i,j} = r_{i,j} / \sqrt{n_i n_j}$, weights the total co-patents between country i and j by the square of the product of total number of patents in both countries to correct for the size of the different countries.*

Figure 19

Cross-country citation linkages



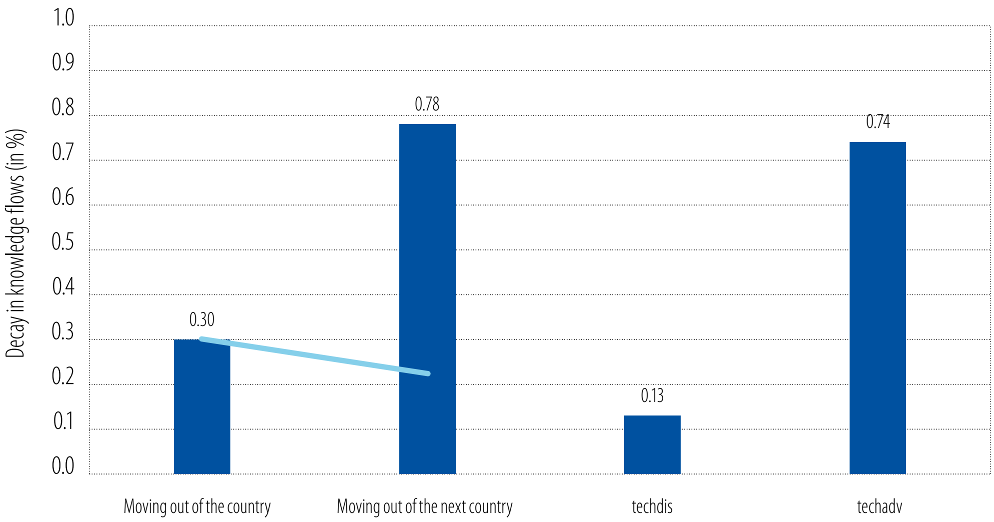
Source: *EIB Economics Department calculations based upon PATSTAT (European Patent Office) data, in collaboration with ECOOM (Centre for Research and Development Monitoring, Belgium).*

Note: *The figure shows the cross-country citation links for the different European countries.*

This index, $CCC_{ij} = \frac{\left({}^{\#cit\ of\ i\ to\ j}/_{total\ \#\ cit\ of\ i} \right)}{\left({}^{((\#cit\ to\ j))}/_{(total\ \#\ cit)} \right)}$ *represents the relative intensities of citations between citing country* i *and cited country* j.

Figure 20

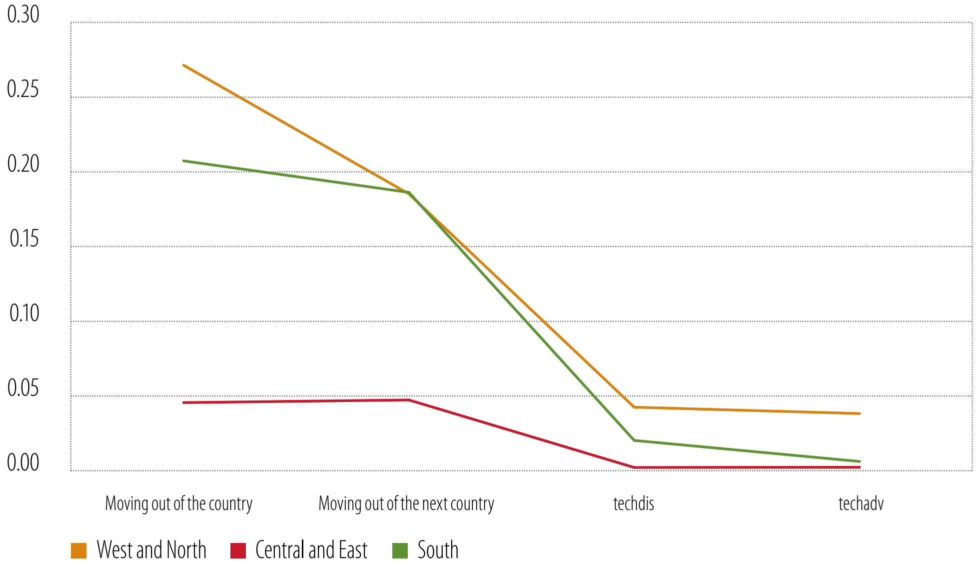
Barriers to knowledge flows (in %)



Source: *EIB Economics Department calculations based upon PATSTAT (European Patent Office) data, in collaboration with ECOOM (Centre for Research and Development Monitoring, Belgium) and the CEPII gravity dataset.*

Note: *The different bars reflect to what extent knowledge flows drop when crossing the related barrier. Since OutNext implies that OutCountry is also crossed, the effect of this OutNext barrier is shown cumulatively by the blue line.*

Figure 21
Cumulative decay in knowledge flows over different regions

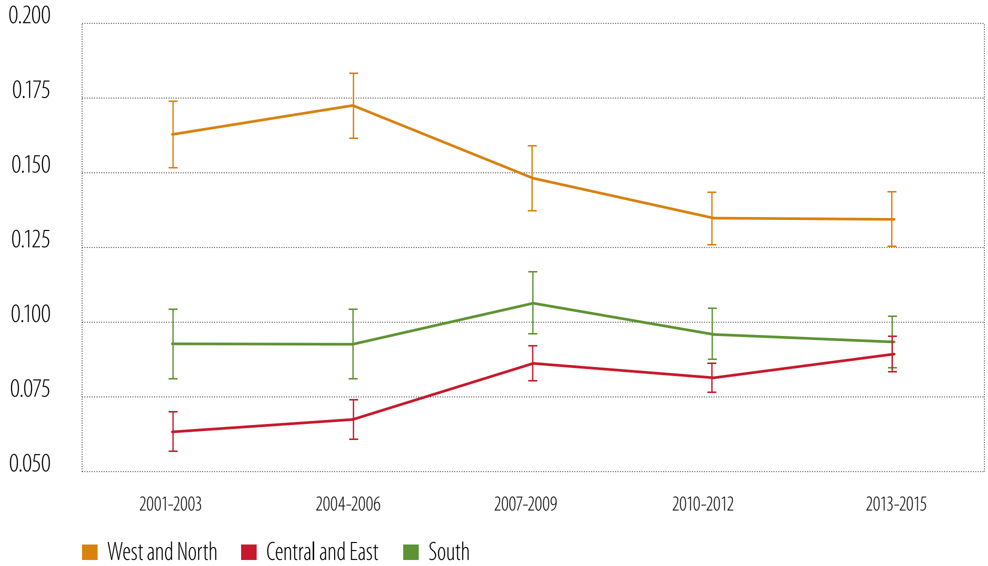


Source: *EIB Economics Department calculations based upon PATSTAT (European Patent Office) data, in collaboration with ECOOM (Centre for Research and Development Monitoring, Belgium) and the CEPII gravity dataset.*
Note: *The different lines show the cumulative drop in knowledge flows for the different regions. For Southern and Central and Eastern Europe, the effect of OutNext, or moving out of the next country, is not significant. For Central and Eastern Europe, the effect of TechAdv, or R&D spending per worker, is not significant*

In line with productivity levels, knowledge flows from Western and Northern Europe to Southern Europe have essentially remained constant over time. The lack of a clear evolution over time confirms that knowledge transfer might explain productivity trends. The findings above suggest a general stagnation in productivity, especially for Southern Europe. In addition, over time, the intensity of knowledge flowing from Western and Northern Europe to Southern Europe and Central and Eastern Europe converges. While initially, there is a significant difference in the knowledge flowing through the different barriers to Southern Europe and Central and Eastern Europe, Figure 22 shows that this difference becomes insignificant in the last periods.

Overall, while there are some clear differences across the different regions, there is no clear evidence that a breakdown of the knowledge transfer can fully explain the European productivity gap. The evolution of knowledge flowing from Western and Northern Europe to other regions does not coincide with the initial increase in the gap between leaders and laggards. On the other hand, more recent trends could support our finding that the gap has not widened over the past few years.

Figure 22
Average predicted knowledge diffusion for the different regions



Source: *EIB Economics Department calculations based upon PATSTAT (European Patent Office) data, in collaboration with ECOOM (Centre for Research and Development Monitoring, Belgium) and the CEPII gravity dataset.*
Note: *The different lines show the knowledge flowing from Western and Northern Europe, both within the region (excluding the same country-pairs) and to the other regions (Southern Europe and Central and Eastern Europe), where 1 is assumed to reflect a situation in which knowledge moves freely, namely within the same country.*

Box D
The price tag of patents

This box estimates technology-specific R&D investments using research and development data from the EU Industrial R&D Investment Scoreboard combined with patent data. The results show that there are large differences in the R&D investment associated with patents across technologies, firms and industries.

The relationship between R&D and patenting activities – known as the propensity to patent (Scherer, 1983) – has been widely investigated in the field of the economics of innovation. However, it is typically difficult to assign R&D investments to individual patents and specific technologies on a systematic basis. There are at least two different approaches to deriving appropriate indicators for the value of patents: i) building quality measures from patent documents to proxy different dimensions of value (Squicciarini et al., 2013); and ii) trying to infer the (private) economic value of patents from the associated monopoly rents using firm-level data (Kogan et al., 2017). Both approaches are more focused on assessing the value of an invention for a given firm rather than trying to assess the effort made by the same firm to get this invention. The difference is relevant because firms may get higher than average returns from their inventions irrespective of their investment efforts (Arthur, 1996; Antonelli and Scellato, 2011).

The analysis is based on firm-level data for the top 2 000 R&D investors worldwide as reported by the 2015 edition of the EU Industrial R&D Investment Scoreboard (Guevara et al., 2015). The source of patent data is PATSTAT 2018B edition. Patents are classified into technical fields according to the International Patent Classification system (IPC), which has a hierarchical structure providing detailed information on the technological content of a patent; this has been mapped into 35 technological fields by the WIPO in order to reduce complexity, allowing for straightforward comparisons across countries and sectors, and facilitating analyses of technological development.

Figure D.1 reports the estimated R&D investment per patent for the 35 WIPO technological fields following the methodology of Gkotsis and Vezzani (2018). The results show that R&D investment per patent is particularly high for developing pharmaceuticals patents, followed by biotechnology and IT methods for management-related technologies. At the other extreme, textiles, micro-structural and nano-technology and optics are among those requiring the lowest investment per patent.

Firms' technological strategies are key in determining technology-specific R&D per patent. The results of multilevel regression analysis show that the relationships between technological specialisation and economies of scale in knowledge production on the one hand, and technology-specific R&D investments on the other, vary significantly across sectors. Table D.1 provides a graphical representation of these specific sectoral details. The cost of specialising seems particularly relevant for firms operating in the pharmaceuticals and biotechnology, transport and aerospace and defence sectors. At the same time, these sectors also experience low or lower economies of scale. The economies of scale in knowledge production are particularly low in the pharmaceuticals and biotechnology sector, in part at least due to the high costs associated with testing and performing clinical trials to get drug approvals. On the other side of the spectrum are firms operating in the information and communication technology (ICT) producer, industrial, health (medical machines), and other manufacturing sectors. Firms in these sectors tend to combine low costs of specialisation with high returns to scale.

The classification in Table D.1, inspired by Pavitt (1984), may provide a framework that is relevant for designing policies to encourage R&D investments and understand their possible impact across sectors. For example, in pharmaceuticals and biotechnology, firms face the highest specialisation costs coupled with very small economies of scale in R&D investments. An optimal policy design would presumably be very different from that suitable for ICT producers (low specialisation costs and high scale effects).

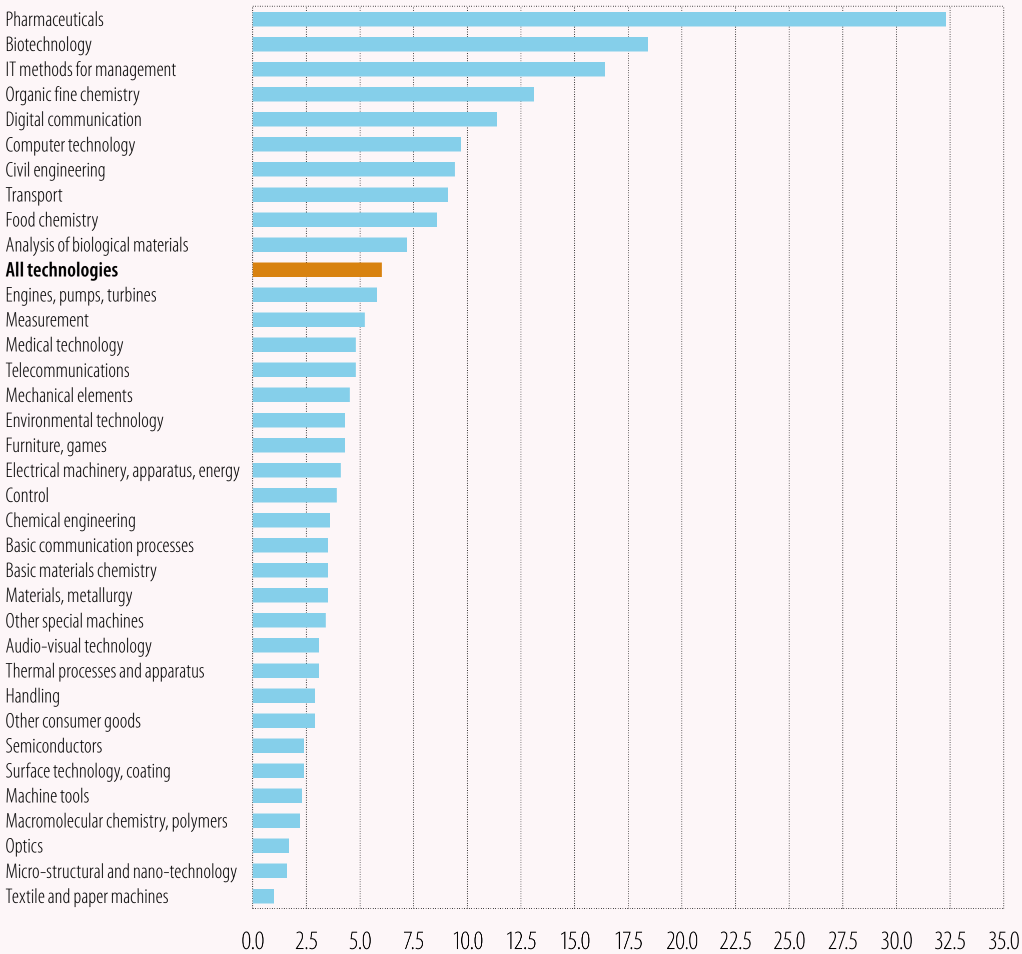
Table D.1

Grouping sectors by relative specialisation costs and economies of scale

		Economies of scale	
		Lower	Higher
Specialisation costs	Lower	Telecommunication Automobiles and parts Electronic and electrical equipment Chemicals	ICT producers Industrials Health Other manufacturing
Specialisation costs	Higher	Pharmaceuticals and biotechnology Aerospace and defence Transport Other services	Energy ICT services Oil and gas

Source: *Gkotsis and Vezzani (2018).*
Note: *This table summarises the results of a multilevel regression analysing the contribution of different factors of technology-specific R&D investment per sector.*

Figure D.1
Average investment per patent (in EUR millions)**, by technology field**



Source: Gkotsis and Vezzani (2018).

Misallocation of resources

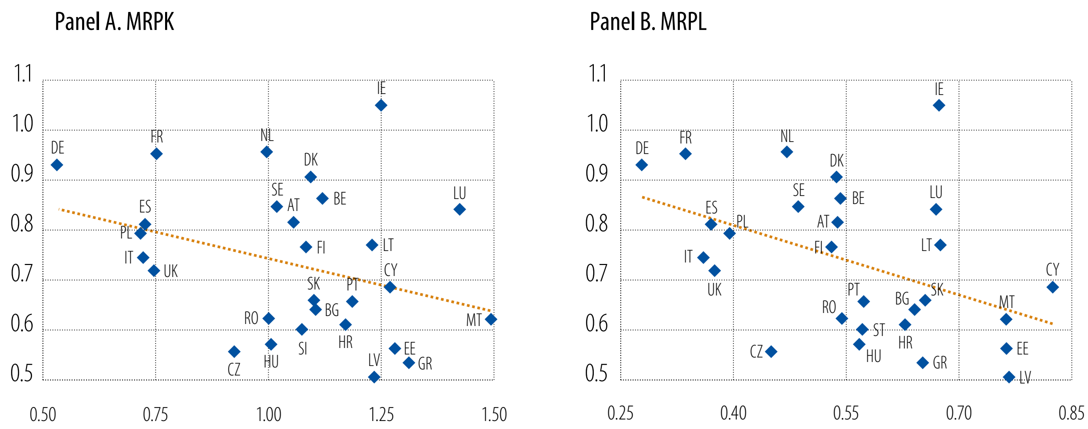
The persistency of a gap between frontier and laggard firms signals a misallocation of resources. Misallocation can be measured by looking at the dispersion of the marginal revenue product of capital (MRPK) and labour (MRPL). Figure 23 shows a wide variation in these measures for individual EU countries and a negative correlation with TFP.

Overall, differences in a country's business, institutions and policy environment drive the differences across countries in the allocation of capital and labour. For example, national regulations and language barriers play an important part in the efficient allocation of capital and labour across the European Union.

The removal of constraints and distortions placed on EU firms could result in large productivity gains. At the EU level, the differences in the use of resources among firms remains large compared to the United States. Gorodnichenko et al. (2018) suggest that the dispersion is about 50% wider than that found by other studies on the United States (Asker, Collar-Wexler and De Loecker, 2014; Bartelsman, Haltiwanger and Scarpetta, 2013). Gorodnichenko et al. (2018) also claim that the overall productivity gain from removing those constraints and distortions could be more than 40%.[19]

Figure 23

Productivity and dispersion of marginal revenue products



Source: *Gorodnichenko et al. (2018). Total factor productivity data are for 2015 and come from Penn World Tables. The standard deviation of the marginal revenue product of capital (MRPK) and labour (MRPL) is computed using data on firms in EIBIS for 2015 and is expressed in logarithm. MRPK is defined at a firm level as the product of the capital share and turnover per fixed asset. MRPL is the product of the labour share and turnover per employee.*

Note: *The line shows the fitted linear regression.*

The efficient allocation of resources is closely related to the ability of firms to enter and exit the market. These dynamics generally play an important role, and the process of net entry contributes positively to productivity growth and is crucial for creative destruction (Bartelsman, Haltiwanger and Scarpetta, 2009). This means that it is important to stimulate the entry of promising firms but also to make it easier for the least efficient firms to exit the market. The previous sections showed evidence that firms can find it very difficult to rise above the bottom of the productivity distribution, especially in Central and Eastern Europe. This suggests that these firms face significant barriers scaling up or exiting their market and may thus trap valuable resources in unproductive activities (European Commission, 2017).

An improved allocation of resources across Europe could support knowledge transfer and consequently overall productivity. Differences in returns across firms could have large impacts across the market, slowing down technological progress and (productivity) growth. With this in mind, Ayerst (2016) suggests that policies and institutions generating misallocation of resources might create disincentives to adopt the best and most modern technologies. One important explanation is that these misallocations may reflect market imperfections. As suggested in the previous section, if there are large differences in returns across firms, there is less indirect pressure on the firms with the highest returns to improve their productivity by adopting new technologies, consequently hampering knowledge flows from the most productive national firms to others (Andrews et al., 2016).

19 As proxies for constraints and distortions among firms, Gorodnichenko et al. (2018) use EIBIS data on firm demographics (firm age, size, subsidiary status and exporter status), obstacles to long-term investment, and source of investment finance. They argue that this group of variables can be interpreted as firm-level constraints and distortions because they reflect predetermined factors and issues with the business environment. Clearly, the magnitude of the gains depends on the interpretation of variables collected in the group that aims to capture firm-level constraints and distortions.

Box E

Inequality in productivity: a note on Italy

This box examines patterns of leaders and laggards[20] for the population of Italian joint stock manufacturing companies from 2006 to 2017. The aim is to understand to what extent this pattern can be related to geographical issues and particularly core-periphery dynamics (Bugamelli et al., 2018, conducts a review of productivity trends in Italy). The environment in which firms operate affects the productivity of individual firms: agglomeration economies, knowledge spillovers, economies of scope and the availability of specialised labour, components, services, and finance are all elements favouring productivity growth. The core-periphery issue is especially meaningful in economies with deep geographical divides like Italy. We focus on finance and quality of governance, looking at whether leaders and laggards make different use of these inputs and whether this difference is stronger for peripheral laggards.

To look at core-periphery patterns, we identify local labour markets in Italy. Figure E.1 reports the share of leaders in local labour markets relative to total Italian leaders. The darkest areas are those with the highest share of leaders (above 2%). Note that the darkest areas are concentrated in the north, where large urban centres are located. There is a clear divide between the north and the south of the country that did not change from 2007 to 2017. This naturally reflects the overall distribution of economic activities in these areas. However, the concentration of leaders is very high. The 20% of local labour markets with the highest concentration of leaders account for approximately 80% of all leaders in the country. The least productive areas on a national scale (with very few leaders) predominantly compose the production structure in the southern part of the country.

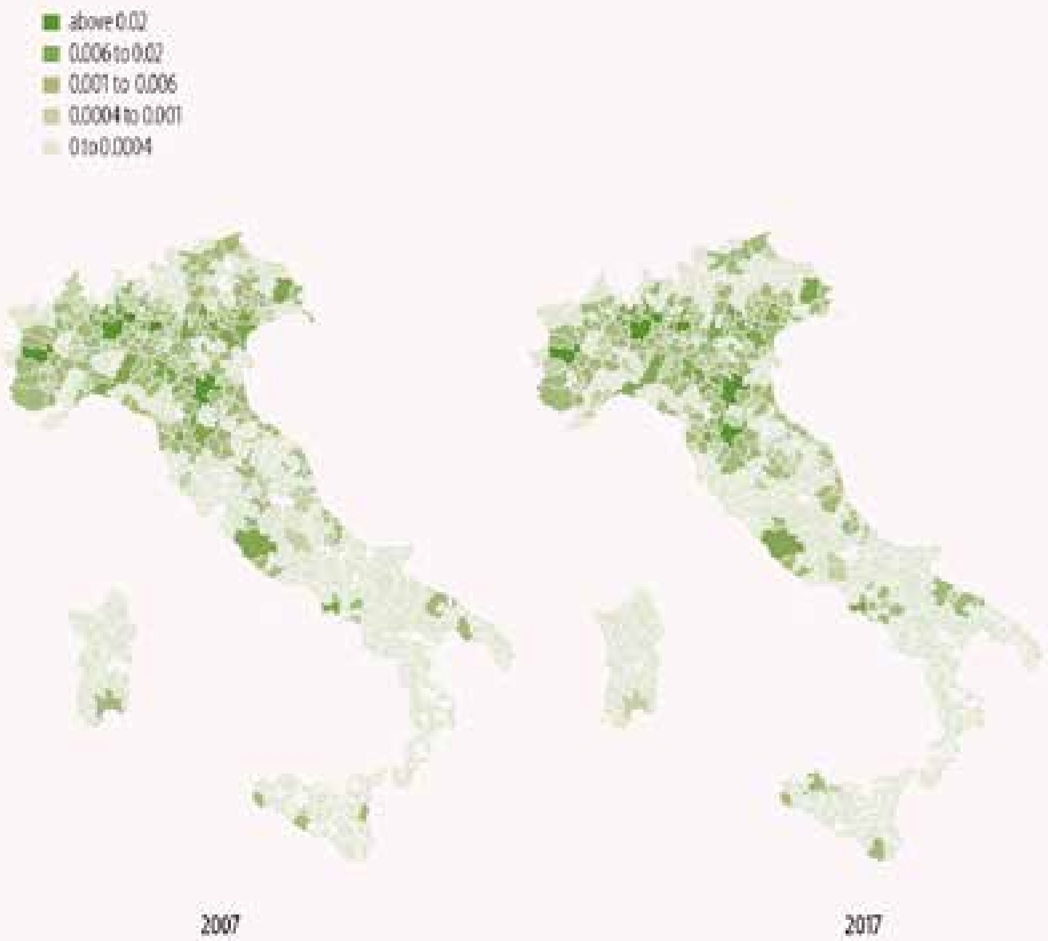
The position of firms in the productivity distribution is not necessarily static. Computing transition matrices for the different macro regions (north, centre and south) in the country shows that in the south, leadership is more volatile and extreme laggardness more prevalent than in the north. Only 33.3% of southern leaders at *t-5* are still there in *t*, almost 15% fewer than northern leaders. Similarly, almost 70% of firms in the bottom part of the distribution in the south in *t-5* are still there after five years, vs approximately 48% in the north.

Here a question arises regarding the extent to which the gaps between leaders and laggards are related to access to and use of specific inputs, particularly finance and managerial capabilities. According to Andrews et al. (2016) and Akcigit et al. (2019), the lack of convergence between frontier and laggard firms could slow patterns of technology diffusion. Both finance and managerial capabilities are crucial factors in firms' innovation strategies. Access to these inputs might be seriously affected by core-periphery patterns, in the sense that firms located in peripheral locations may find it more difficult to find equity finance or market-based finance to fund investment in innovation. Similarly, firms in peripheral locations might have a harder time finding managers and directors with sufficient international exposure to technological frontiers[21].

20 The estimation methodology is identical to the one described in Box A, with the exception that firm level fixed effects were used. Leaders are similarly identified as the 95th percentile in each year and sector, maintaining the number of firms constant.

21 Ordinary least squares (OLS) and linear probability regressions were run with TFP or the probability of upgrading or downgrading (i.e. of the firm changing its position in terms of these percentiles: above 95th, between 95th and 80th, between 50th and 80th, between 20th and 50th and below 20th) as dependent variables. The two inputs, finance and managerial capabilities, were used as explanatory variables for the whole country and for the macro regions.

Figure E.1
Distribution of leaders across local labour markets



Source: Authors' calculations based upon Cerved database and ISTAT.
Note: Distribution of frontier firms across labour markets.

Regarding finance, we looked at leverage (total debts over total net assets), dependence on bank lending (total debts to banks over total debts) and a measure of access to capital markets (total bonds over total net assets). We worked under the assumption that well-capitalised firms and firms able to access capital markets have more resources to invest in productivity improvements and that access to financial assets other than bank lending (equity and market debt) is less available in peripheral regions. Our analysis confirms that laggards are considerably more leveraged (more than twice the figure for leaders) and more bank-dependent, and make less use of market finance (although this is a marginal funding channel for all groups). Firms with more access to capital markets and less bank dependence have higher productivity and are more likely to upgrade their relative position. Note that bank dependence (but also market finance) is positively related to the likelihood of weaker productivity. In addition, firms in the south (both leaders and laggards) are more leveraged and use less market finance. Interestingly, access to capital is only relevant for firms in the north. While bank dependence is negatively related to all forms of upgrading in the north, it is positively related in the south. This supports the presumption that bank lending remains the only viable channel of financing and upgrading in peripheral areas. The negative relationship between bank credit and productivity in northern areas may reflect the fact that firms with high exposure to the banking system and a limited ability to tap other sources of funding suffered from severe credit rationing during the financial crisis. Several papers have shown that this credit rationing curtailed investment and that there was severe misallocation of bank credit during the crisis (Bugamelli et al., 2018).

A second crucial input for productivity upgrading is the quality of governance and management. We focus on chief executives and other board members and work under the simple assumption that a stronger connection on the part of directors to economic and social environments beyond local networks increases firms' chances of improving their performance. To this end, we look at three measures of board openness. The first is the share of board members born in the same local labour market where the firm is based (share of born locally). The assumption is that locally born directors are more likely to be part of local economic and social networks, increasing the probability that they are selected for their network and not necessarily on merit. The second measure is the share of board members who also participate in other boards within the same labour markets (share of network). The third measure reflects the share of directors who also sit on other boards outside the local labour market (share of network out). Our results suggest a negative relationship between the local composition of the board and TFP performance. If we compare leaders and laggards in the three macro regions, laggards have a higher share of locally born board members and fewer of them are part of any other local or external boards. The local composition of boards is higher in the south than in the north, with the centre ranking in between the two.

Table E.1

Openness of governance

	Laggards			Frontier		
	North	Centre	South	North	Centre	South
Share of born locally	0.65	0.62	0.78	0.55	0.51	0.65
Share of network	0.14	0.12	0.1	0.33	0.33	0.31
Share of network out	0.12	0.08	0.06	0.32	0.28	0.25

We may expect international networks to be less relevant in peripheral economic areas, where they merely rely on local social and economic networks. In a regression analysis, directors being born locally has no significant relationship with upgrading from laggard to leader status in the south, in contrast to the north and the centre. Nevertheless, the extent of embeddedness in networks is positively correlated with productivity and with the probability of upgrading in the south, albeit less than for northern firms. This suggests that these networks are less likely to be important in the south.

In conclusion, there is robust descriptive evidence of a strengthening of the leaders-laggards divide between core areas in the north of Italy and peripheral economic areas in the south. This divide questions the ability of southern regions to converge with the north. In the north, there is a much larger concentration of leaders, whereas the industrial population in the south is mainly composed of firms with low levels of productivity. This pattern is consistent with the view that firms in the peripheral areas are less likely to have access to high quality inputs. In finance, laggards that make less use of capital markets are generally more exposed to banks and more leveraged than leaders. The difference is larger for firms based in southern regions. Similarly, laggards have larger shares of board members with limited networks outside the firm's home offices. The local composition of directors is more significant for southern laggards.

Conclusion and policy recommendations

Against the backdrop of a slowdown in productivity, this chapter confirms a persistent gap between productivity leaders and other firms in the European Union. While firms at the bottom end of the distribution have major difficulties in climbing up, leading firms seem increasingly stable in their position at the top. Persistent productivity differences between leaders and other firms may be driven by a misallocation of resources and hampered knowledge transfer. In this respect, Western and Northern Europe is the best productivity performer and is more embedded in the global market than other regions.

The persistence of the gap is largely the result of Southern European firms' inability to make productivity gains. Overall productivity growth in this region has been close to zero, and the large share of bottom firms pulling productivity figures downward points to a misallocation of resources and an inability to exit markets. Knowledge in Southern Europe also mainly stays within the region and the adoption of knowledge from leading countries stagnates over time. In addition, the challenging operating environment and structural obstacles weighing on growth are a significant burden for small productive firms – firms whose growth could generate positive effects for the region and for the European Union.

Central and Eastern Europe has a large share of productivity upgraders that could become new leaders. Central and Eastern Europe is experiencing a positive productivity trend despite the fact that many companies are struggling to leave the bottom of the productivity distribution and a large share of the region's frontier firms are actually part of European production chains. This positive trend goes hand in hand with the region's increased adoption of knowledge from Western and Northern Europe. Central and Eastern European firms should further enhance their skills and knowledge base to move, gradually, towards the frontier.

Persistent low mobility and a lack of resource reallocation suggest unhealthy business dynamics and structural rigidities, which justify policy intervention. Since regional differences exist in the ability of firms to move along the productivity distribution, policy priorities should be region-specific, without jeopardising the smooth functioning of the EU single market. Firms in Southern Europe report a particularly challenging operating environment, and many firms are hitting structural obstacles that hamper growth. The least productive firms tend to remain stationary, as constraints prevent market exit and resource reallocation. Measures to enhance firms' ability to scale up and their overall dynamism, including their ability to enter and exit the market, remain crucial. In Western and Northern Europe, on the other hand, firms tend to be closer to the global frontier. Therefore, benefiting from the smooth and enhanced functioning of the EU single market seems to be the main priority for improving productivity. Policymakers should take these regional differences across firms into account (sometimes even at a sub-national level as described in Box E). At the same time, to close the gap between leaders and other firms, it is essential to smooth the differences in business, institutional and policy environments across the European Union. Improved efficiency of resource allocation across Europe could further support knowledge diffusion and aggregate productivity, although this must be managed with appropriate policies.

In general, policies aimed at increasing the efficiency of resource allocation and knowledge transfer across Europe should ensure that countries enable labour, capital and skills to flow to the firms that need it most. Collaboration should be promoted to increase the flow of knowledge. Working with universities in particular has the potential to facilitate the exchange of technology by providing smaller and less productive firms with access to sources of knowledge that typically require large upfront investments. In addition, the ability of firms to absorb new knowledge is crucial to their learning from stronger firms at the productivity frontier. Investment in innovation, including research and development, skills and organisational know-how therefore enables countries to absorb, adapt and reap the full benefits of new technologies. Similarly, investment in education and skills is particularly important to ensure that workers have the capacity to learn new skills, make the most of digitalisation and adapt to changing technologies and working conditions. Finally, global connections can be further extended via trade, foreign direct investment, participation in global value chains and the international mobility of skilled labour.

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Chapter 9

Investment in skills for competitiveness and inclusiveness

Skill constraints top the list of EU firms' concerns for the third year in a row. Nearly eight out of ten companies in the European Union find the limited availability of staff with the right skills to be an obstacle to investment, with the firms that drive economic dynamism in Europe particularly affected. Not having enough of the right skills comes at a significant cost for Europe as it hampers not only firms but also individuals from realising their full potential. Firms could be more productive and maximise the benefits of new technologies. Similarly, workers with the right skills are in a better position to weather the risks from job automation and adapt to changing tasks.

Digitalisation is transforming labour markets and changing skill needs fast. Failure to respond to these structural transformations risks amplifying divergences between people and places across the European Union. The double challenge for the European Union lies in tackling rising inequalities as a result of technological change and spurring innovation to ensure more sustainable and equitable growth. Having enough of the right skills is vital to this task. Moreover, a sound skills base makes it possible to shape digitalisation and leverage its potential for product and job creation.

Technological change and its future impact on jobs require both bold and immediate measures and a long-term perspective to foster adaptive and inclusive systems for skills development. New technologies look set to transform many jobs in Europe substantially and rapidly, but education and training systems are changing slowly. Steps to support learning throughout a person's career must be taken now to avoid the emergence of a more polarised and less competitive European Union in 2030. Providing the conditions needed to enable dynamic and innovative firms to thrive and create good jobs is a way to support skill formation and realise the returns from learning.

Introduction

Skill constraints have topped the list of firms' concerns for the third year in a row. Almost eight out of ten companies (77%) in the European Union find that the limited availability of people with the right skills poses an obstacle to investment. In addition, it is typically growing and more innovative firms and those trying to improve productivity which experience stronger skill constraints. Not being able to find the right skills comes at a considerable cost for companies and the EU economy as a whole.

Missing skills challenge the competitiveness and inclusiveness of the European Union. The right skills are crucial to developing innovation, driving the adoption of new technologies, realising their benefits and enabling them to spread beyond a narrow group of firms. For the people of the European Union, not having the right skills means higher social risks today and greater vulnerabilities to future changes.

Rapid technological change and its impact on skills demand raise concerns over whether individuals' skills will adapt quickly enough to mitigate the risks of being replaced by machines, avoid high rates of technological unemployment, and prevent further polarisation on EU labour markets. Public policies focused on skills are central to providing the EU workforce with the right skills to complement new technologies and thus mitigate labour market polarisation. But how can investment in skills help to promote inclusive growth in times of rapid technological transformation?

This chapter looks at the impact of technological change on the European labour market and analyses its implications for skills policies. The first section provides an overview of the current EU labour market and how it is being shaped by the ongoing technological transformation. The second section analyses, which firms are missing skills more than others and the third section assesses the costs of bottlenecks. The fourth section turns to technological transformations ahead, assessing the potential impact of job automation at a local level, its impact on the European Union and potential ways to respond. The conclusion addresses policy implications.

The EU labour market, skills and technological change

The recovery in the European labour market has continued. Despite slowing growth, labour market conditions further improved in 2018 and the first half of 2019. Unemployment dropped to 6.7% in June (-0.6 percentage points year-on-year). Employment in the European Union reached record levels with some 241 million people working and the employment rate exceeding 73%.[1]

Most jobs created are permanent and full-time. In 2018, full-time jobs accounted for 81.5% of employment in the European Union, while temporary contracts made up 13.1%.[2] However, there are strong differences in contract practices across EU members and the proportion of the workforce on part-time and temporary contracts is higher than 15 years ago, signalling structural shifts in labour markets that had already started before the financial crisis.[3] Workers on atypical contracts and the self-employed face higher social risks, like poverty and exclusion.

The EU workforce has become more diverse. The higher employment rate reflects increased participation of women and elderly workers in the labour force compared to a decade ago, albeit to different extents across Member States. More non-EU citizens are working in the European Union and a larger number of EU citizens work in another EU country.

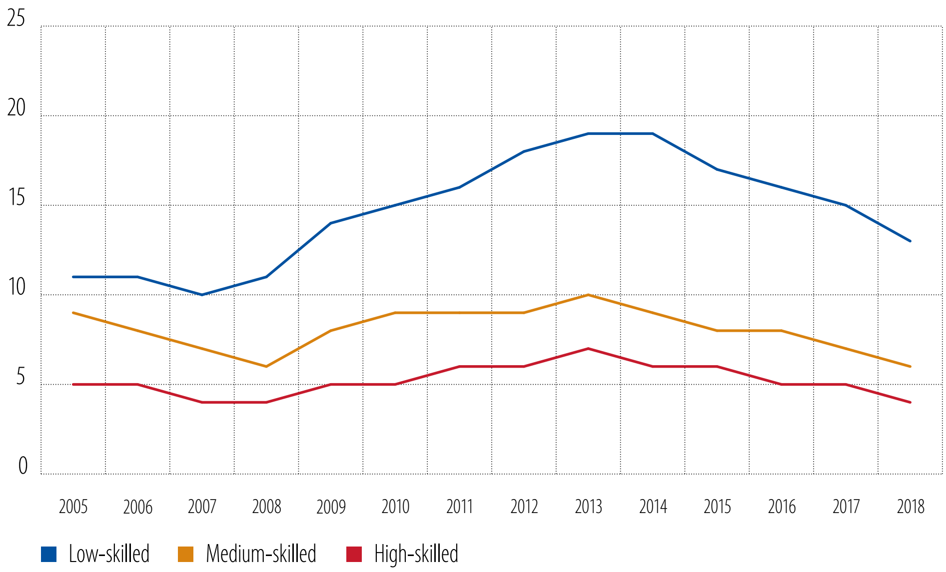
1 Active population, 15-64 years.
2 For the 20-64 age group. Source: Eurostat and European Commission.
3 Part-time work has increased by about 3 percentage points and employment on a temporary contract by 1.7 percentage points since 2003.

Productivity growth in the European Union has continued to disappoint. Compared to the years before the financial crisis, growth in labour productivity has slowed (+1.6% on average across the European Union from 1996 to 2007 vs +0.7% from 2012 to 2018). Productivity growth in the European Union has also been slower than in the United States in recent years (+0.8% on average from 2012 to 2018), and the longstanding transatlantic gap in total factor productivity growth persists.[4]

Wage dynamics have been subdued until recently. While growing again since 2013, increases in real labour costs were slower than GDP growth from 2012 to 2018. Subdued wage growth has been associated with uncertainty and persistent slack in labour markets, particularly in the euro area (ECB 2018), as well as structural labour market inefficiencies (segmentation, weakened bargaining power). Wage increases have been more dynamic recently, mostly driven by Central and Eastern Europe (+9.6% compared to +2.7% for the whole European Union, first quarter 2019, year-on-year).[5]

Despite the labour market recovery, strong disparities persist. Unemployment for low-skilled workers has not returned to pre-crisis levels and their employment prospects have worsened. While unemployment rates for high-skilled workers are back at or below 2007/2008 levels for people with higher- and mid-level skills, this is not the case for lower-skilled individuals (Figure 1). Contrary to the overall trend, the employment rate for low-skilled workers in the European Union has stagnated and even declined by some 3 percentage points for low-skilled males. Low-skilled individuals who work are more likely to be on a non-standard contract and face a higher risk of precarious employment (European Parliament, 2016).

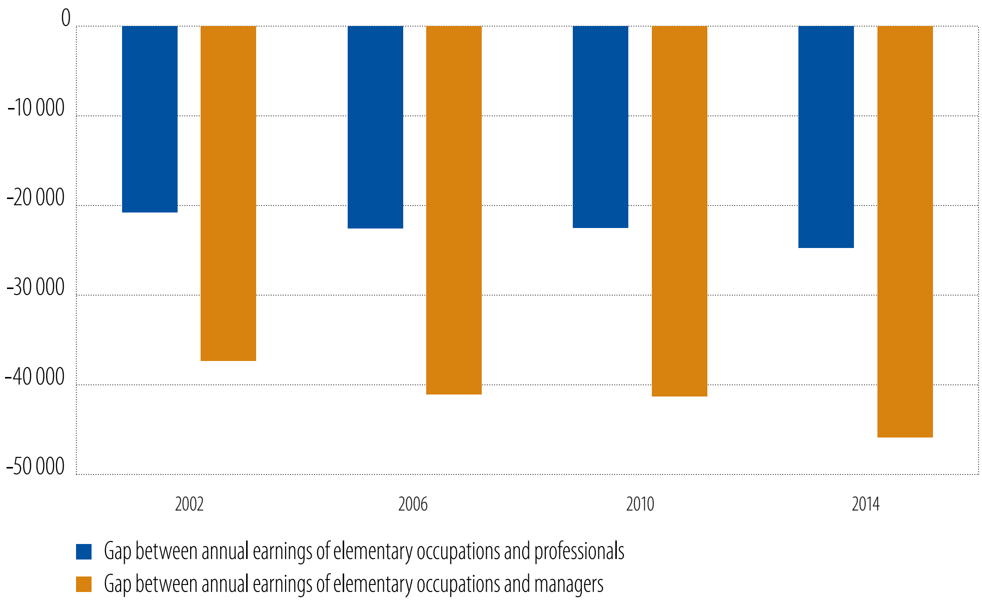
Figure 1
Unemployment by skill level (%), **European Union**



Source: *Eurostat.*
Note: *Percentage of the active population. Age: 20-64. For the 28 EU members. "Low-skilled" refers to less than primary, primary and lower secondary education (ISCED 0-2). "Medium-skilled" refers to upper secondary and post-secondary non-tertiary education (ISCED 3&4). "High-skilled" refers to tertiary education (ISCED 5-8).*

4 Average growth rate for labour productivity per person employed, constant prices. Source: OECD.
5 Wages and salaries; industry, construction and services.

Figure 2
Differences in annual earnings for selected low and high-skilled occupations (EUR), **European Union**



Source: EIB Economics Department calculations, Structure of Earnings Survey.
Note: EU28 for 2010 and 2014. EU27 for 2006. EU25 for 2004. For 2006 and 2002, "Managers" include legislators and senior officials.

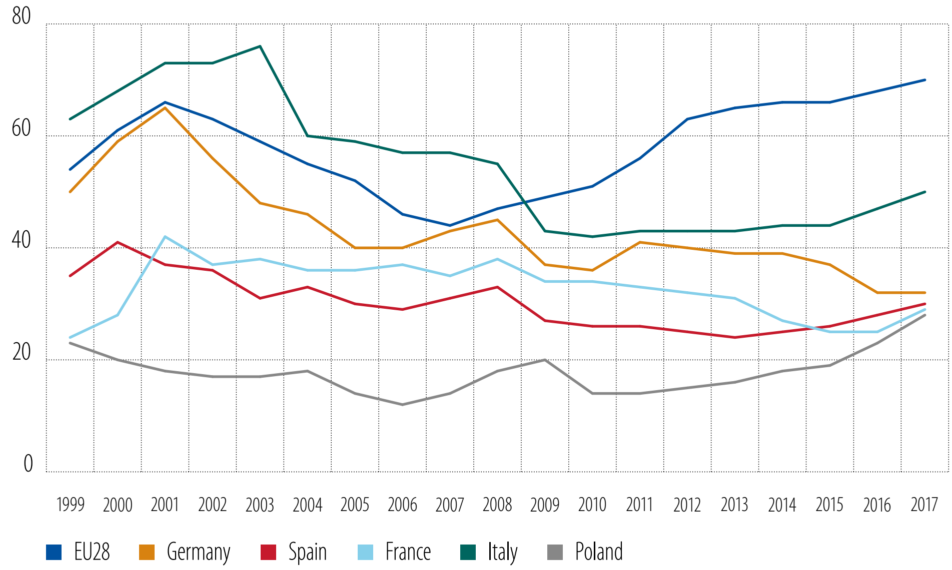
Regional differences in unemployment are larger than they used to be with similarly positive labour market conditions, and urban-rural discrepancies have widened. Within-country differences have shrunk in line with overall reductions in unemployment in some countries (e.g. Germany), but disparities among regions across the European Union have widened (Figure 3). Reasons include cuts in public investment following the financial crisis and regions being stuck in the middle-income trap (European Commission, 2017). Employment rates are higher in urban compared to rural areas and unemployment is higher in rural areas in a majority of Member States.[6] Over the last 15 to 20 years, capital regions have shown stronger employment growth than other metropolitan and non-metro regions (Lavalle et al., 2017) and account for substantial shares in net job creation in many EU countries (Figure 4).

Greater polarisation of EU labour markets has been linked to the ongoing technological transformation. Recent advances in digital technology have tended to benefit high-skilled workers and those in less-routine occupations (EIB, 2018 and IMF 2017, 2018). Developments on EU labour markets reflect these patterns. There is some evidence of greater polarisation at the occupational level, with jobs in the middle-skill and middle-pay bracket accounting for lower shares of employment (Cedefop, 2016 and European Commission, 2018), increasing wage polarisation between occupations at different skill levels (Figure 2) and greater polarisation in terms of working hours (Da Silva, Laws and Petroulakis, 2018). Several analyses find that the introduction of labour-saving technologies (robots) in EU countries has affected employment and wages, typically to the detriment of lower-skilled workers, although the effects tend to differ across countries, depending on factors such as labour supply, demand elasticities and institutions (Graetz and Michaels, 2015; Dauth et al., 2017, 2018; Chiacco et al., 2018).

6 Employment rates were higher in urban areas for 15 out of 23 Member States with data available and unemployment higher for 13 (for 2017). Source: European Commission (2019).

Figure 3

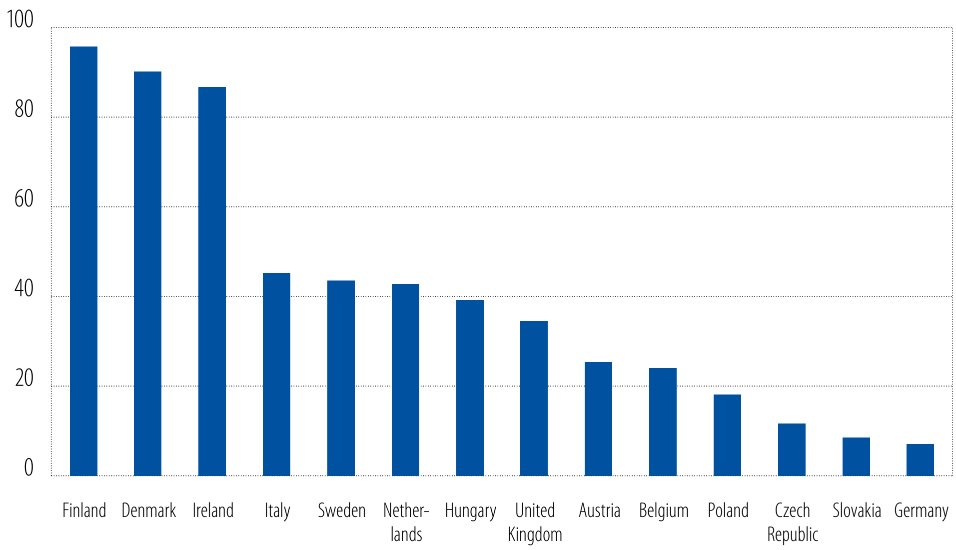
Dispersion of regional unemployment rates by NUTS2 regions (%), European Union and selected Member States



Source: *Eurostat, European Commission (2019).*
Note: *The dispersion of unemployment rates is the coefficient of variation of regional unemployment rates, i.e. the ratio of the standard deviation to the mean and multiplied by 100 to make it a percentage. The indicator measures the spread of regional unemployment rates as regards the national or EU unemployment rate. If all the regional unemployment rates are equal, dispersion is zero. Higher values of dispersion imply greater differences within a country.*

Figure 4

Share of net job creation in capital regions vs total job creation, 2006-2016 (%) selected Member States



Source: *OECD, calculations based on regional statistics database.*
Note: *Capital regions in Portugal, Spain and Slovenia lost jobs between 2006 and 2016.*

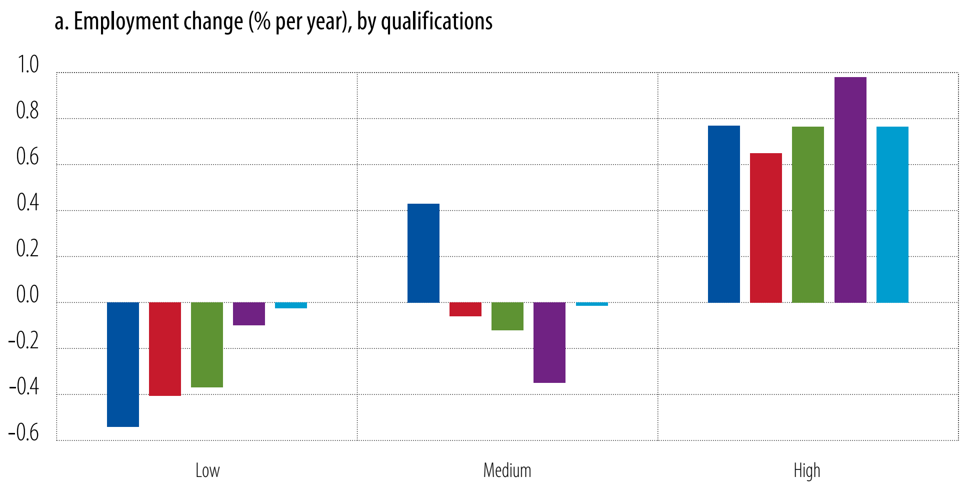
Technological transformation affects where businesses are located, often amplifying concentration. Digital technologies influence economic activity through local job creation and destruction. Moreover, an increasing body of literature suggests that both of these elements have fuelled agglomeration forces as people and firms increasingly cluster in favoured locations to share information and develop leading innovations (Moretti, 2012 and Rodriguez-Pose, 2017). Moreover, matching skills and jobs is easier in denser labour markets and people have more opportunities to update their skills (European Commission, 2017). As a result, gaps between big cities and left-behind places have widened.

The ongoing digital transformation is a double-edged sword for EU labour markets. On the one hand, it unleashes business dynamics, creates new jobs and promises a productivity boost. On the other hand, it is a disruptive force, driving displacement and divergences. Growing perceptions of inequality by Europeans – with about 80% feeling that inequalities have increased and finding income differences too great (Eurobarometer, 2018 and European Commission, 2019a) – also show that the impact of technological change is increasingly being felt.

Rapid technological change increases the risk of skills demand and supply being out of sync. In the European Union, 43% of employees have experienced a recent change in the technologies they use at work. About one in five employees think that several of their skills will very likely become outdated in the next few years and another 25% consider this moderately likely (Cedefop, 2018). Projections for the European Union until 2030 point to further polarisation, with the strongest employment growth expected at the top and the bottom wage quintile.[7] The polarisation also indicates a shift in the skills demanded, with continued rapid growth in the demand for high-skilled workers, while the share and number of jobs for those with low or no qualifications is expected to fall (Eurofund, 2018). Moreover, the trend towards increasing employment in services is projected to continue (Figure 5a and b). Changes in the structure of jobs across and within different sectors and technological change could give rise to tensions between skills demand and supply and potentially fuel further polarisation over the coming years, as skillsets are increasingly in demand or are not always readily available.

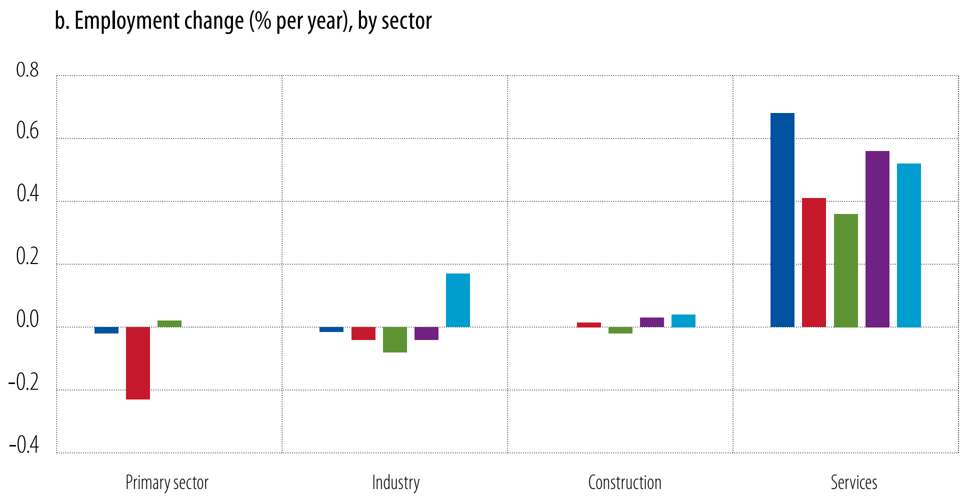
Figure 5

Change in EU employment (% per year) **by job-wage quintile** (2015-2030)



Source: Cedefop and Eurofund (2018).
Note: Changes estimated for the period 2015-2030. Columns refer to quintiles. Jobs are ranked from the highest to the lowest wage and then allocated to quintiles based on the job-wage ranking by each EU member. Each quintile represents 20% of the employment at the starting period. The job to quintile assignment remains fixed over time so that the charts map the growth of employment in a particular quintile and refer to the growth of jobs assigned to that quintile at the start of each period of observation. For further information on job rankings and quintile assignment, see Eurofund (2018).

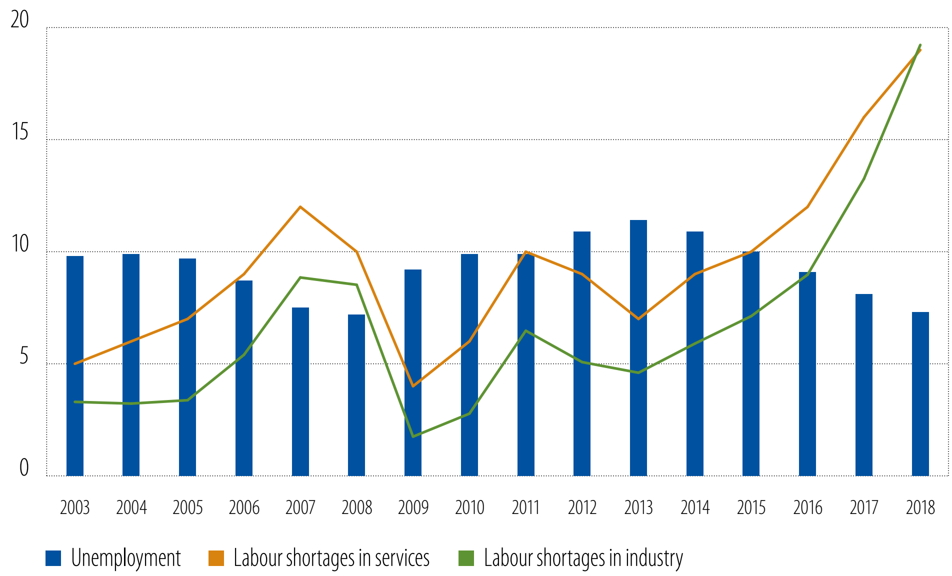
7 While projections indicate greater polarisation at EU aggregate level, the picture is more heterogeneous among Member States, suggesting that specific national characteristics as well as policies and institutions can shape the outcome of technological changes on labour markets.



Source: *Cedefop and Eurofund (2018).*

Firms' concerns about skills availability are exacerbated by fast-changing demand and slower-adjusting supply. Labour shortages in the European Union are more acute than a decade ago when unemployment was similarly low (Figure 6). Current shortages appear more strongly linked with the availability of high-qualified rather than low-qualified labour (Thum Thysen and Vandenplas, 2019)[8], pointing to a qualitative component and potential mismatches between the skillsets available and company needs.

Figure 6
Labour shortages and unemployment (%)



Source: *Eurostat, European Business Survey.*
Note: *Index for shortages refers to share of firms citing labour as a factor limiting production.*

8 The measure of labour shortages is negatively and statistically significantly correlated with unemployment rates for medium- and high-skilled workers but less so with unemployment for low-qualified people (Thum-Thysen and Vandenplas, 2019). In addition, the total active population has increased by around 10 million compared to 2007 (for the entire European Union). While higher levels of shortages could also indicate a greater mismatch on labour markets (Colsolo and Dias da Silva, 2019), one reason for the mismatch could be an increased disconnect between the skills firms are seeking and those available, partly reflecting technological change.

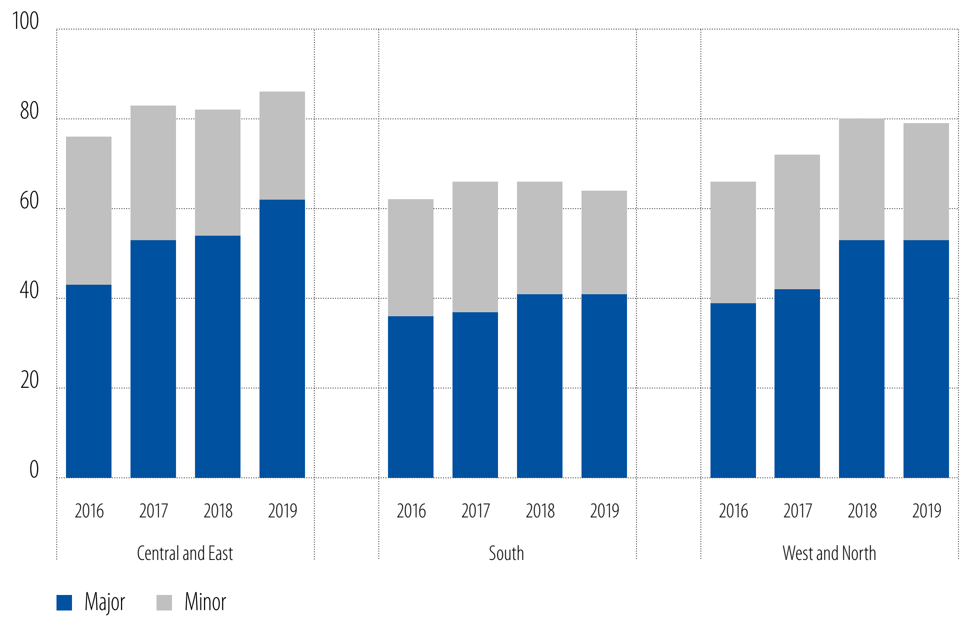
Which firms are missing skills the most, and why are gaps a problem?

Which firms are particularly prone to experience skill gaps, and what are the associated costs? We analyse data from the EIB Investment Survey (EIBIS) to assess which type of firms are experiencing skill gaps and examine the costs for firms and the EU economy. We approximate skill gaps using firms' assessment of the limited availability of skills as an obstacle to investment. Analysis by EIB economists has shown that this primarily reflects difficulties in hiring new staff (EIB, 2018), indicating the existence of skill shortages.[9]

Skill gaps are the obstacle most frequently cited by EU corporates.[10] Firms in Central and Eastern Europe have been particularly likely to report missing skills over the last three years, and new results emphasise the persistence and saliency of gaps: 86% report the limited availability of skills as a problem and 62% consider it a major issue (+4 and +8 percentage points, respectively, compared to 2018 – Figure 7). For firms in Western and Northern Europe, skill gaps are high but similar to 2018 (79%). Southern European companies remain least likely to report skill constraints. While lower levels of skill constraints for Southern Europe reflect the later start of the labour market recovery (EIB, 2018), skill concerns have increased over the last four years in all countries in the region except Italy.

Across the European Union, growing firms face skill gaps more frequently. Firms that have been taking on new staff report the limited availability of people more frequently as a problem (83% compared to 73% for firms with no staff increase over the last three years). This is even the case in Southern Europe, where labour markets still have more spare capacity.

Figure 7
Share of firms reporting missing skills as an investment impediment (%), **by country group**



Source: *EIBIS 2016-2019.*
Base: *All firms.*
Question: *Thinking about your investment activities in your country, to what extent is the limited availability of staff with the right skills an obstacle? Is it a major obstacle, a minor obstacle or not an obstacle at all?*

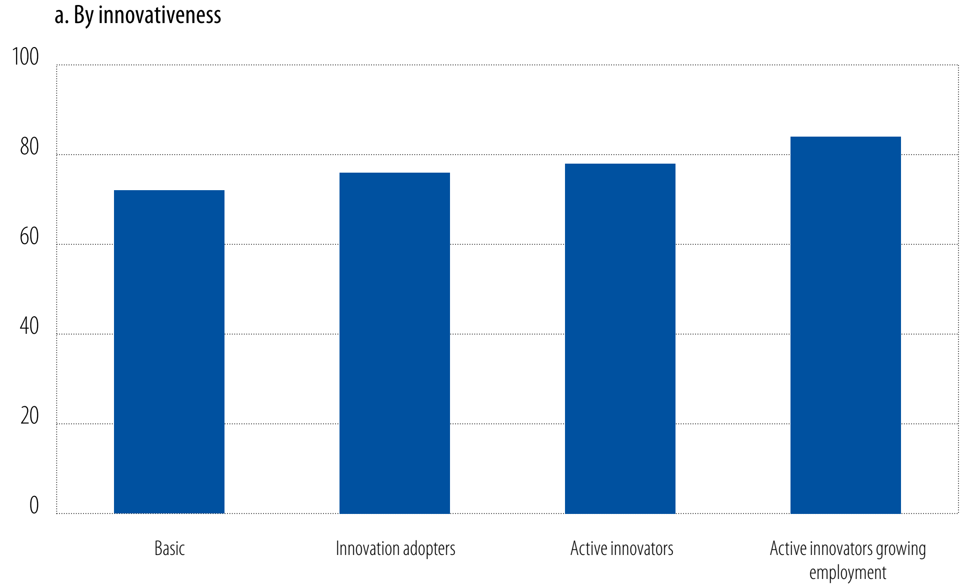
9 In EIBIS, firms indicate to what extent the limited availability of staff with the right skills is an obstacle to investment. See EIB (2018) for discussion and Chapter 7, Box B for measurement and reliability of this type of analysis.

10 For comparison with other obstacles, see Chapter 1.

Innovative firms miss skills more often.[11] While companies actively pursuing innovation tend to pay higher wages (EIB, 2018), they experience skill gaps more often across the European Union (Figure 8a and b).[12] Shortages are particularly pronounced for firms growing employment and in Central and Eastern Europe, where more than 90% of actively innovating firms report skills problems. The persistent difference between non-innovative and innovative firms – even against the backdrop of a general tightening of labour markets – points to more complex and advanced skill needs for more innovative firms and labour adapting to changing needs slowly. On the one hand, it seems normal for firms seeking more complex skillsets to be more likely to experience gaps. On the other hand, these are the firms driving the dynamics of the EU economy. Greater participation in lifelong learning – a factor helping to speed up skills adaptation – appears to be one element of firms' operating environment mitigating constraints for more innovative companies.[13]

Figure 8

Share of firms reporting missing skills as an investment impediment (EU27 2016-2019, %)



Source: *EIBIS 2016-2019.*
Base: *All firms.*
Question: *Thinking about your investment activities in your country, to what extent is the limited availability of staff with the right skills an obstacle? Is it a major obstacle, a minor obstacle or not an obstacle at all?*
Note: *"Active innovators" refers to firms going beyond innovation adoption, either incremental or leading innovators or firms with substantial investment in R&D but not reporting new products yet (developers).*

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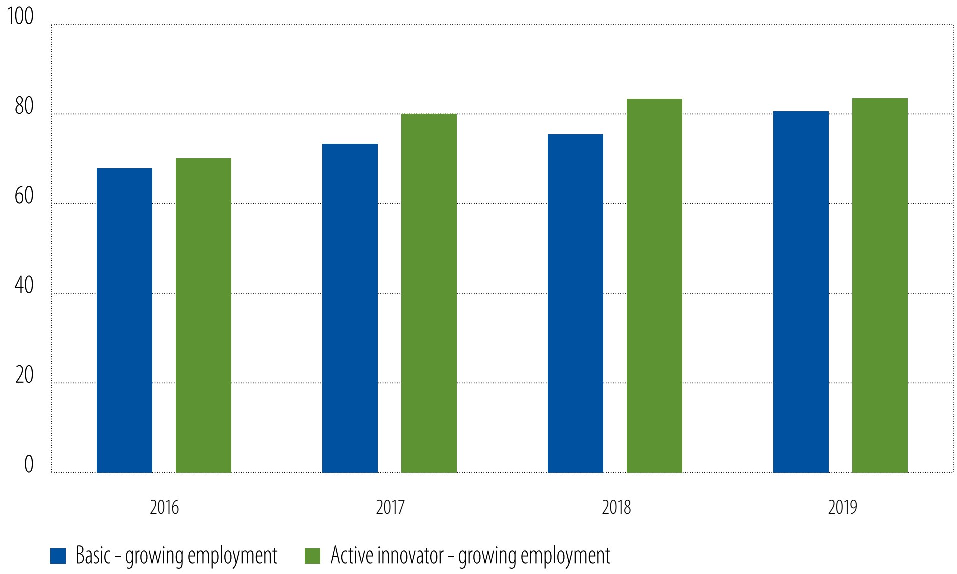
11 Firms' innovation profiles are based on the EIBIS survey questions on investment in research and development and introducing new products, together providing an indication of innovation activity. Leading innovators introduce new products for the country and globally, incremental innovators introduce products new to the company and developers do not introduce any new products (yet) but have substantial R&D. Adopting firms do not invest in R&D but still introduce new products or processes developed by other firms. Basic firms do not introduce new products or processes and do not have substantial R&D.

12 This refers to firms going beyond innovation adoption, i.e. either incremental or leading innovators or firms with substantial investment in R&D but not reporting new products yet (developers).

13 Based on probit regressions assessing the impact of firms' innovativeness on reporting of (major) shortages controlling for wave and sector. While being an active innovator is positively associated with reporting skills shortages, both cyclical factors (higher unemployment) and higher training participation levels have a negative effect.

b. By innovativeness and employment growth



Source: *EIBIS 2016-2019.*
Base: *All firms.*
Question: *Thinking about your investment activities in your country, to what extent is the limited availability of staff with the right skills an obstacle? Is it a major obstacle, a minor obstacle or not an obstacle at all?*
Note: *This refers to firms going beyond innovation adoption, either incremental or leading innovators or firms with substantial investment in R&D but not reporting new products yet (developers). Firms "growing employment" report having increased their staff numbers compared to three years ago.*

Frequent mentions of skill gaps by digital firms further attest to changing skill needs. While the share of firms stating skill gaps by country also reflects the tightness of local labour markets and low unemployment in some areas, mentions by digital firms tend to be higher.[14] The share of digital firms citing a skills gap also shows a weaker correlation with the unemployment rate, which implies that even at high levels of unemployment, digital firms often have difficulties finding the right talent (Figure 9). This reflects the higher labour demand by digital firms (which tend to grow faster than non-digital ones) and labour markets' difficulties in providing the specific skillsets that digital firms need.

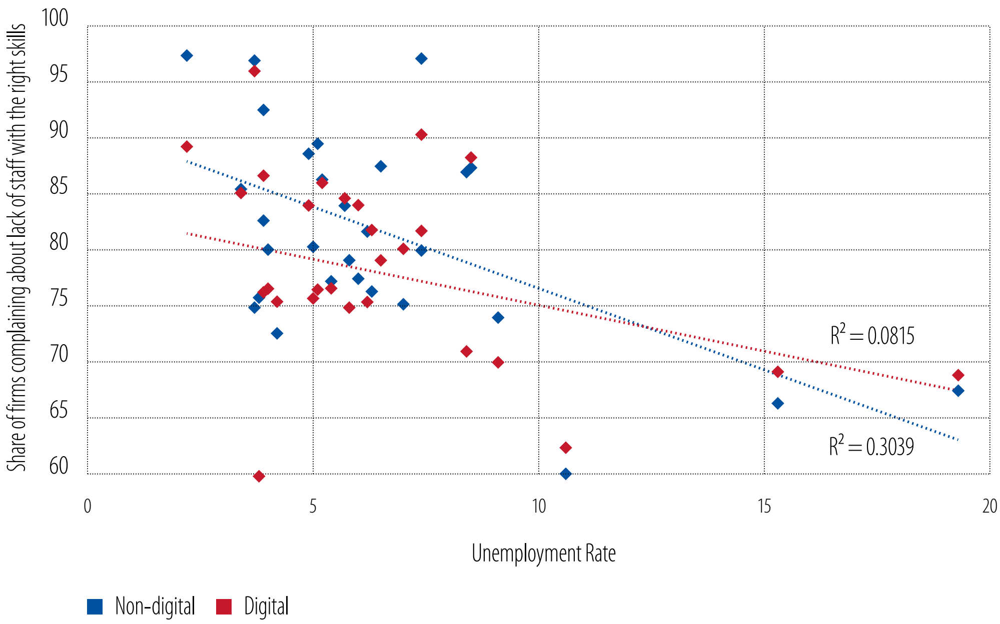
Skill gaps affect firms shortly after they have been set up and intensify as they grow. The limited availability of skills is a barrier for two out of three innovative start-ups in the European Union. The only bigger obstacle is a lack of access to finance. Once firms start to grow, lack of skills becomes prevalent, with 72% of fast-growing firms (scale-ups) reporting it as an obstacle. That a substantial share of start-ups and scale-ups experience a skills gaps points to a changing demand in the market for skills as the these fast-growing firms are typically built on new, technology-related ideas and processes and require corresponding skillsets.[15]

14 EIB (2018).
15 For further discussion, see Chapter 7 on start-ups and scale-ups.

Companies catching up with the technology frontier are more likely to experience skill gaps.[16] Firms that have been improving their productivity report skill shortages more often in Western and Northern and in Central and Eastern Europe (Figure 10). In contrast, firms that have already established their place at the technology frontier face fewer difficulties when searching for qualified staff as they are likely to benefit from their reputation and other network effects when recruiting. The difference between leaders and firms trying to close the gap is particularly wide in Central and Eastern Europe. For Southern Europe, the lack of differentiation across firm groups reflects lower demand and competition for labour as well as composition effects within the region.[17]

Figure 9

Lack of staff with the right skills and the unemployment rate (in %)

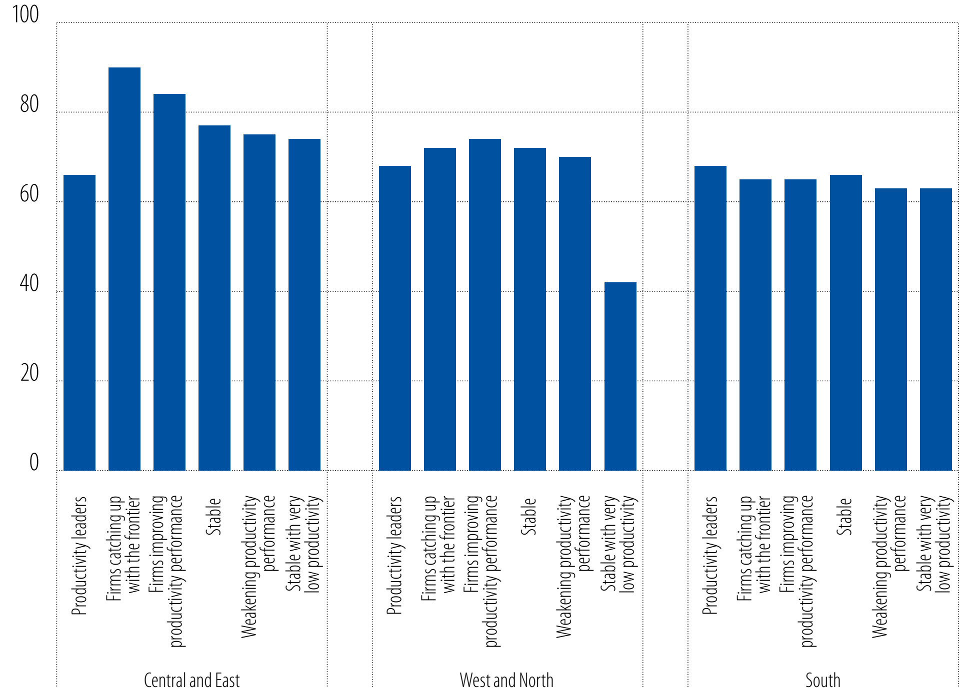


Source: *EIBIS 2019. Eurostat.*
Base: *All firms (excluding don't know/refused responses).*
Question: *Thinking about your investment activities in your country, to what extent is the limited availability of staff with the right skills an obstacle? Is it a major obstacle, a minor obstacle or not an obstacle at all?*
Note: *Shares sum major and minor obstacles.*

To sum up, EIBIS data show that the more dynamic companies in Europe – the growing, more innovative businesses and those developing and deploying new technologies – are facing a more significant skills problem. While this reflects a mix of hiring activities and qualitative differences in skills demand, the gaps faced by these firms are particularly worrying. Those gaps indicate structural shortages that limit firms' ambition and ability to grow and generate costs for firms and the EU economy as a whole.

16 See Chapter 8 for further explanation of firm groups by total factor productivity and estimation procedures.
17 Within the Southern European country group, Italian firms account for a substantial share and show relatively low mentions of unavailability of skills as an investment impediment.

Figure 10
Share of firms reporting skill constraints (%)**, by productivity performance and country group**



Source: *EIBIS 2016-2018, Orbis.*
Note: *Categories refer to the dynamics in firms' productivity performance. They are attributed to firms based on total factor productivity data available from 2011 to 2016. Productivity leaders are in the top quintiles of productivity levels by year in all observations. Firms catching up with the frontier started elsewhere in the distribution but arrived at the productivity frontier. Firms in the third category improved their ranking during the period of observation. Firms in the fourth category are stable (i.e. their last ranking is equal to the first). The firms in the fifth category worsened their position and those in the last position are stable at the bottom of the distribution over the observation period.*

What are the costs of skill gaps?

Firms that do not find the right skills often experience lower production, are unable to respond to business opportunities and fail to support innovation. Missing skills are expected to have a negative influence on productivity as they constrain production and lead firms to adjust recruitment standards downwards, meaning that they hire less productive workers with lower qualifications than required for the job (Bennet and McGuinness, 2009). Shortages have been linked to higher labour costs due to higher spending on wages, recruitment efforts and/or training,[18] and some scholars have argued that workers are in a better bargaining position, potentially demanding an easier pace of work (Haskel and Martin, 1993). Moreover, skill shortages could hamper productivity growth as they inhibit investment in and adoption of new technologies (Foley and Watts, 1994).

Empirical findings on the impact of missing skills on firms have been mixed. Several studies using firm-level data find no clear link between skill shortages and productivity performance (Forth and Mason, 2004; McGuinness and Bennett, 2006). However, Haskel and Martin (1993) conclude that shortages had a negative impact on productivity growth in the United Kingdom. Tang and Wang (2005)

18 Note that training can be a response to shortages as well as a preventive strategy.

find a negative effect on firm performance for small businesses in Canada, and Bennet and McGuinness (2009) conclude that skill shortages weigh on productivity growth in Northern Irish high-tech firms.

We analyse the costs of skill gaps across the European Union, looking at their impact on productivity and investment gaps using information from EIBIS. While our assessment of the productivity impact provides an indication of current costs, we also shed light on how skill gaps can limit firms' future performance through their impact on investment.

Part of the skill gaps firms experience reflect skill mismatches, meaning that productivity could improve if labour were allocated better. The extent of misallocation is one of the factors driving productivity differences within and across countries (Hsieh and Klenow, 2009), and there is evidence that a rising misallocation of resources is one of the culprits behind sluggish productivity growth in the European Union, especially in Southern Europe (Gopinath et al., 2017). Hsieh and Klenow propose a theoretical framework to quantify the costs of that misallocation, based on the idea that the economy as a whole would improve productivity by reallocating production inputs from low to high productivity firms. The research uses the dispersion in marginal revenue products as a proxy for misallocation. Following Gorodnichenko et al. (2018), we use information from the EIBIS on firm characteristics[19] and barriers pertaining to skill shortages and labour market regulation to assess their impact on the dispersion of marginal revenue products of capital and labour and estimate the potential gains from removing distortions.[20]

Potential productivity gains from removing distortions are substantial for firms in the European Union. The potential productivity gains are obtained by assuming that resources would be reallocated smoothly to the average firm in the sample.[21] The firm characteristics considered are firm age, size and employment growth. Distortions in the operating environment are approximated using firms' response about whether they consider the limited availability of skills and labour market regulation to be obstacles (major and minor). Removing a specific set of distortions due to these variables, could raise EU aggregate productivity by about 18%. Focusing exclusively on distortions from skill gaps and labour market policies (but not considering differences due to firm age, size or employment growth), the gains from addressing the frictions would be about 5%.[22]

Removing skill constraints together with improvements in the business environment are particularly promising, as far as productivity gains are concerned, for firms in Southern and Central and Eastern Europe. Firms in Western and Northern Europe are on average more productive than firms in the rest of the European Union. Firms in Western and Northern Europe also operate in a structurally more benign business environment as reflected in higher levels of GDP per capita, better connectivity and business conditions, and fewer firms reporting investment obstacles on average (Figure 11). Comparing firms with relatively similar productivity performance (i.e. in the same productivity quintile[23]), we find that those not experiencing skill constraints are on average more productive than constrained peers in the same country group. To further examine the potential impact of alleviating skill constraints together with improvements in the business environment, we consider a scenario where the skill-constrained firms improve their productivity performance within their productivity peer group, and the companies located in Southern Europe and Central and Eastern Europe operate under similar conditions to firms in Western and Northern Europe. Both groups could improve productivity. Addressing missing skills would deliver a particular improvement to the productivity performance of firms in Central and Eastern Europe, where skill gaps most impede investment (productivity gains would be about 3.7% for Central and Eastern Europe and 1.8% for Southern Europe). The overall EU-wide productivity gains

19 See also Gorodnichenko et al. (2018) for discussion of the theoretical framework and further details of the empirical approach.

20 The marginal revenue of capital is defined at a firm level as the product of the capital share and turnover per fixed asset; the marginal revenue of labour is the product of the labour share and turnover per employee.

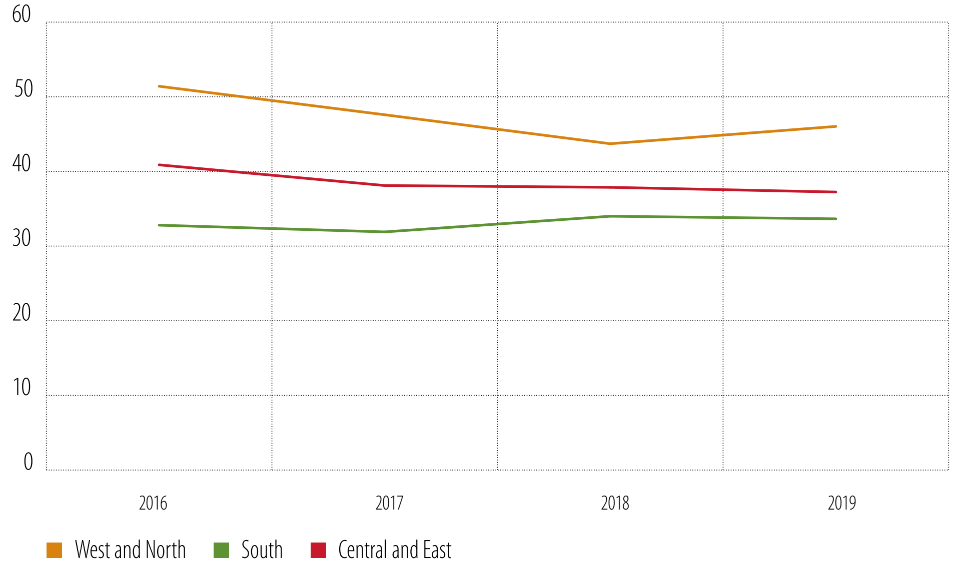
21 Based on EIBIS 2016-2018 data.

22 On the discussion of cyclical and structural determinants of misallocation and the role of institutional factors for Europe in this regard, see Bartelsman (2018).

23 Productivity quintiles, from the bottom to the 4th quintile, while the top 20% of most productive firms are divided into two categories: one referring to frontier firms consisting of the top 5% of the distribution and the other comprising the 81st to 95th percentile just below.

of removing the skill constraints and improving the business environment in Southern and Central and Eastern Europe would add up to about 2%.[24] (Figure 12).

Figure 11
Share of firms not reporting investment obstacles (in %), **by country group**



Source: EIBIS 2016-2019.
Note: Share of firms reporting "not an obstacle" as an average for nine investment impediments (demand, availability of skills, energy costs, digital infrastructure, labour market regulation, business regulation, adequate transport infrastructure, availability of finance and uncertainty).

Firms experiencing skill gaps report underinvestment more often. Beyond limiting firms' current operations, skill gaps can also affect future performance and prospects through underinvestment. For instance, Nickell and Nicolatsis (1997) find that skill shortages reduce fixed capital investment and spending on research and development (albeit temporarily). We examine the effect of missing skills and a set of other investment obstacles on firms' probability of reporting investment gaps using treatment effect estimation techniques.[25]

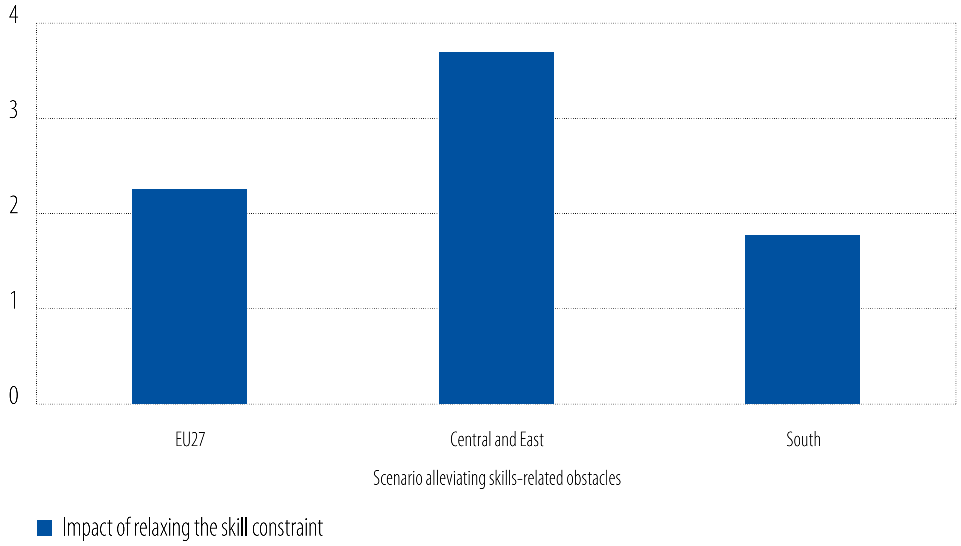
Skills-related obstacles have the third-largest impact on investment gaps. Table 1 shows the average investment gap as a potential outcome if no firm experienced the specific obstacle (POmean) and the average treatment effect for firms facing the obstacle (ATET), or the impact of the obstacle compared to the hypothetical situation in which these firms did not experience this problem.[26] The results indicate that the probability of reporting an investment gap increases by about 4 percentage points for EU firms due to the limited availability of skills. Only the limited availability of finance and uncertainty – which are both integral to investment decisions – show a stronger impact.

24 This is calculated under the assumption that firms in Southern Europe and Central Europe have the same distribution of average productivity values by group. A firm at the technology frontier in Central Europe would be as productive on average as peers in Western and Northern Europe that are not complaining about skills (or labour market obstacles), and similarly for those bringing up the rear.

25 A simple predictive comparison might not be enough to estimate the causal impact of (skills) obstacles because estimates could be driven by cofounding covariates that can affect both experiencing obstacles to investment and investment gaps. For example, a company with very high cash flow is able to invest more in training, and consequently might face a lower skills barrier and show lower investment gaps. Treatment effect estimation techniques can address this bias. For further discussion of the empirical approach, see Pal and Wruuck (2019).

26 Several firm-specific variables are included in the model: profitability (cash flow to total assets), liquidity (cash holdings to total assets), leverage (debt to total assets), size (dummy variables for micro, small, medium and large), age (categories of less than 2, 2-5, 5-10, 10-20 and above 20 years) and industry (dummy variables for manufacturing, services, infrastructure and construction).

Figure 12
Potential productivity gains from closing gaps with peers (in %)**, European Union and country groups**



Source: EIBIS 2016-2018.
Note: The scenario assumes a catching-up within productivity groups. Western and Northern Europe define the benchmark in the second scenario so no separate effects are shown.

Table 1
Effects of investment obstacles on investment gaps, European Union

		Coefficient: investment gap	Robust standard error
Treatment: obstacle=1 vs obstacle=0			
1) Obstacle: demand for products or services	ATET	0.032***	(0.005)
	POmean	0.174***	(0.004)
2) Obstacle: availability of staff with the right skills	ATET	0.039***	(0.006)
	POmean	0.158***	(0.005)
3) Obstacle: energy costs	ATET	0.016***	(0.005)
	POmean	0.181***	(0.004)
4) Obstacle: lack of access to digital infrastructure	ATET	0.002	(0.006)
	POmean	0.187***	(0.003)
5) Obstacle: labour market regulations	ATET	0.025***	(0.005)
	POmean	0.173***	(0.004)
6) Obstacle: business regulations (e.g. licences, permits, bankruptcy) and taxation	ATET	0.026***	(0.005)
	POmean	0.171***	(0.004)
7) Obstacle: availability of adequate transport infrastructure	ATET	0.006	(0.005)
	POmean	0.184	(0.003)
8) Obstacle: availability of finance	ATET	0.101***	(0.005)
	POmean	0.140***	(0.004)
9) Obstacle: uncertainty about the future	ATET	0.043***	(0.006)
	POmean	0.156***	(0.005)
No. of observations		21 752	

Source: EIBIS 2016-2018. European Union refers to EU28.
Note: Regression adjustment estimators run separate regressions for each treatment level. The potential outcomes are predicted for the whole sample, including both treated and untreated units using the two regression lines. The Potential Outcome Mean (POmean) indicates the average investment gap if no company faced the given obstacle. ATET gives the average treatment effect in the sub-sample of firms facing the obstacle, i.e. the impact of facing the given obstacle on investment gaps compared to the hypothetical situation where the same sample of companies did not face that obstacle.

Part of the costs of skill shortages lie in the future. Analysis by EIB economists has shown that investment gaps are not related to capacity concerns but rather to capital quality issues, reflecting firms' concerns that outdated technology reduces their competitiveness (EIB, 2018). This indicates that skill shortages come with additional costs that do not materialise immediately.

Skills are essential if firms are to reap the full benefits of adopting new technologies. Results from the 2018 EIB Digital and Skills Survey show that the limited availability of staff with the right skills is cited by about 40% of EU firms as a main bottleneck to digital adoption (EIB, 2018). At the same time, 63% of firms that have not adopted any digital technology and report the lack of skilled staff as the main barrier to adoption still plan to adopt a digital technology over the next three years. However, a closer look shows that the lack of skills becomes even more important for firms after they have adopted new digital technologies. Mentions of missing skills as a problem are higher for firms that have actually (partially) adopted digital technologies, suggesting that skills are essential to making the most of digital technologies and to staying up-to-date with the latest developments. (Figure 13a)

Skill shortages affect firms' decisions on the purpose of their digital investments and technology adoption. When facing skill constraints, firms are more inclined to invest in digital technologies for automation purposes rather than to develop new products or services. When skills are not a constraining factor, the opposite is true. Figure 13b shows the share of firms naming a particular motivation for their adoption of digital technologies. Companies answering "smarter manufacturing and processes" most likely adopt digital technologies to streamline and improve existing products and processes, whereas firms that give one of the remaining answers are more likely adopting digital technologies to develop new products, processes or markets. The link between skill shortages and the purpose of digital investments and technology adoption is more pronounced among manufacturing firms.

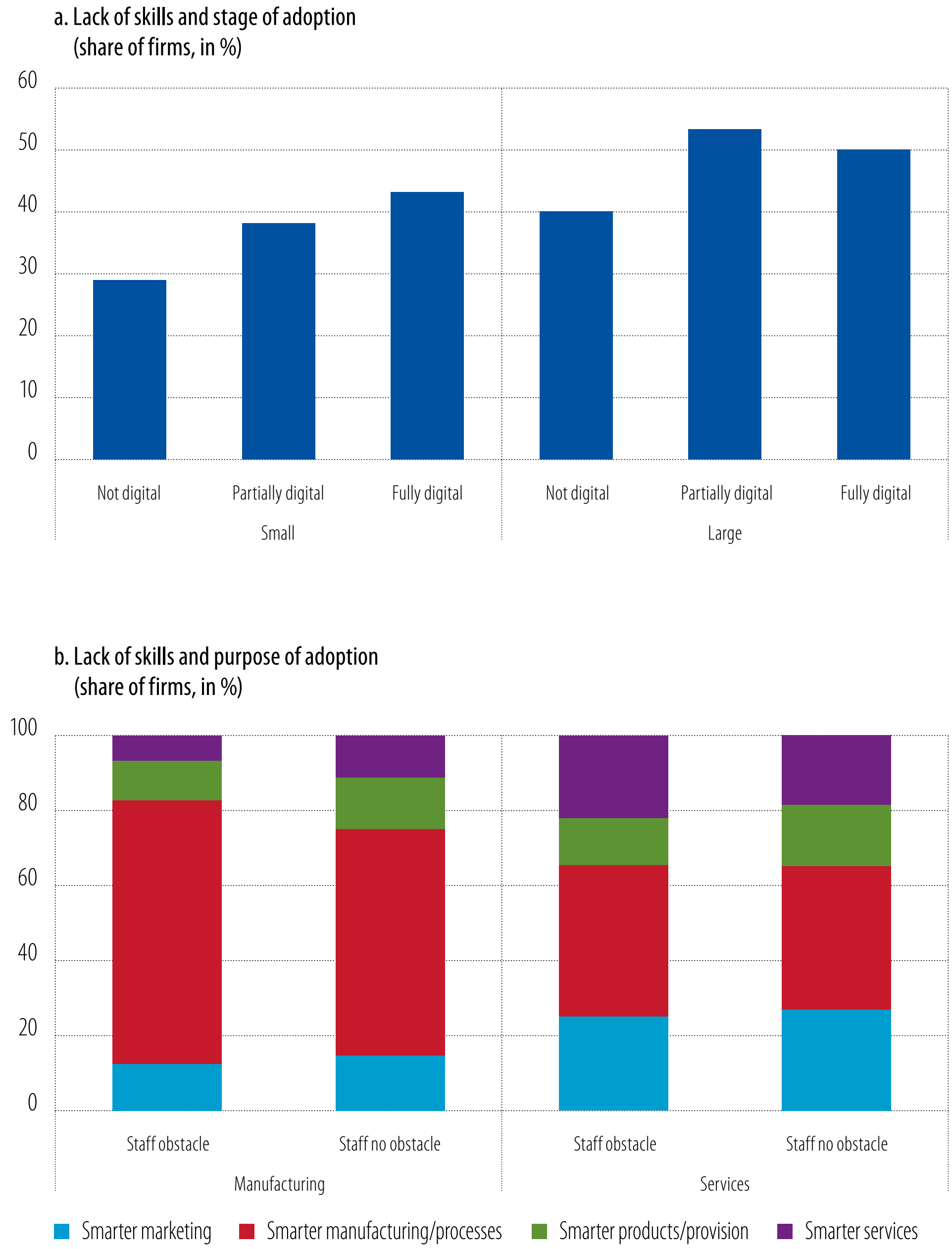
The availability of skills is crucial for digital technologies to create new jobs. Historical evidence shows that the broad availability of human capital has played a key role in technology invention and adoption in Europe. The availability of and complementarities between different types of human capital – inventors and skilled craftsmen – were essential to the onset of the Industrial Revolution in Britain, rather than a scarcity of labour or invention out of necessity (Mokyr and Meisenzahl, 2011). Later on, the availability of human capital proved critical for 19th century Prussia to adopt technology and catch up with the Industrial Revolution (Woessmann, Becker and Hornung, 2010). Human capital has also been essential to integration and positioning in global value chains over recent decades (Grundke et al., 2017 and OECD, 2017). With respect to the current wave of digital transformation, skills can be decisive at three points: i) when firms decide to adopt technology; ii) when they decide on the purpose of that adoption; and iii) for the success of adoption (Figure 14). These factors can feed through the employment effects and hence affect how disruptive new digital technologies are going to be for jobs.

Technological change has transformed work for centuries, on balance for the better but not without friction. Historically, technological change has led to more and better employment (for example with less hazardous working conditions) but change has not always been smooth, not least when accompanied by social hardship (Polanyi, 1944 and Hobsbawn, 2009). At present, concerns abound that "this time it is different," and that the new wave of digital technologies will negatively affect employment. About three in four Europeans think that robots and artificial intelligence will lead to net job destruction.[27] We try to shed light on the potential impact of the ongoing technological transformation by assessing the risk of job automation for the European Union's different regions.

27 Eurobarometer (2017).

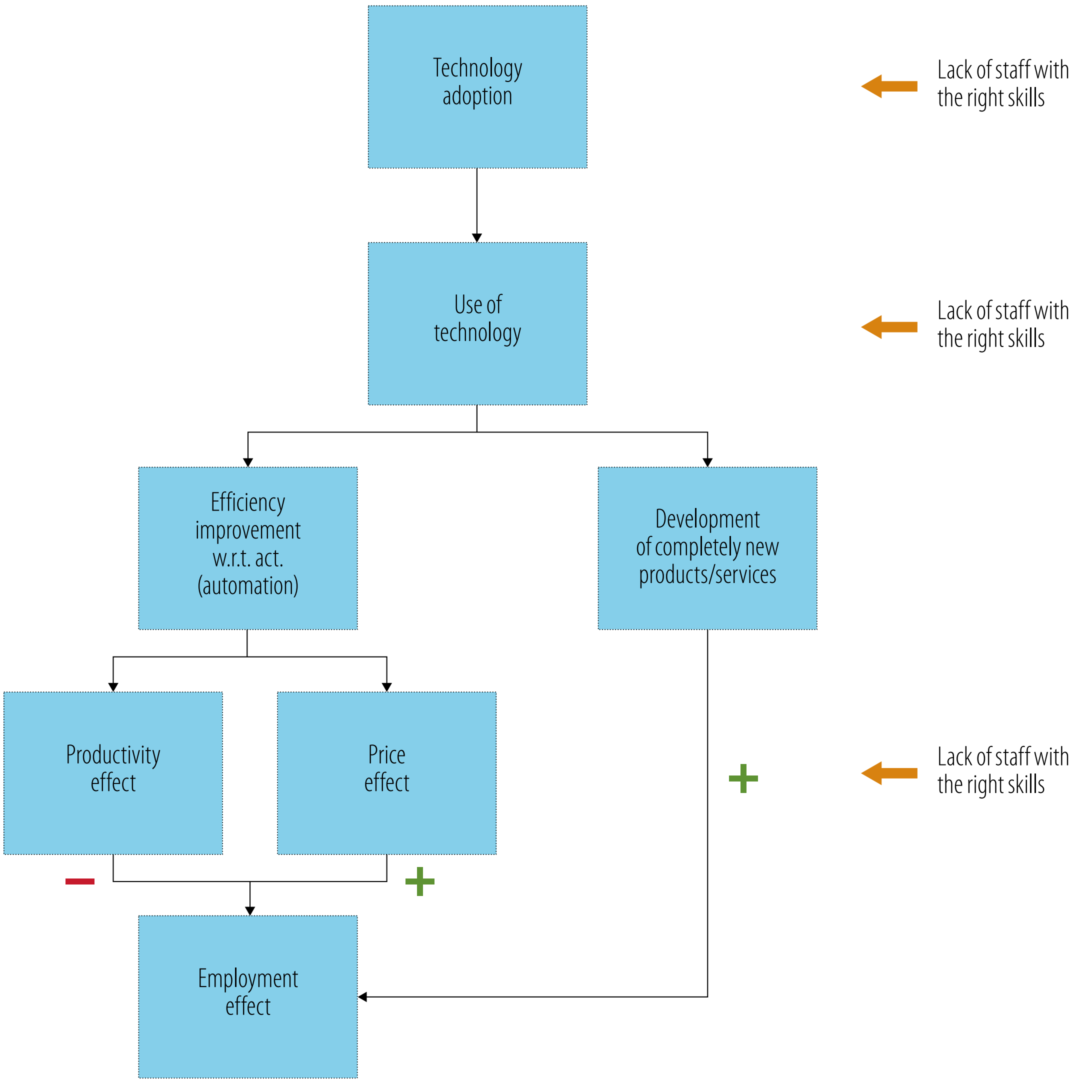
Figure 13

Lack of staff with the right skills and digital adoption



Source: *EIBIS Digital and Skill Survey 2018.*
Base: *All firms (excluding don't know/refused responses).*
Question: *Thinking about your investment activities in digital technologies, which is the main obstacle to adopting digital technologies?*
Question: *Which of the following will be your company's main priority when it comes to investments in digital technologies?*

Figure 14
Lack of staff with the right skills and digital adoption: a schema



Source: EIB Economics Department.

Automation's implications for people and places

Jobs have different automation risks depending on the tasks they cover. The assessment of a job's risk of automation is based on the idea that jobs consist of a number of tasks, some of which are easier to automate than others. Routine tasks are easier to codify and replace with machines, meaning that jobs with mostly routine tasks have a higher automation risk. At the other end of the spectrum is work that requires a lot of social intelligence, interaction and navigation of complex environments, which is difficult to automate. Based on this idea, an emerging body of literature is attempting to quantify automation risks (Box A).

Box A

Assessing job automation risk – an overview

A number of recent studies have attempted to estimate the susceptibility of occupations and jobs at risk of automation. While estimates of the share of jobs at risk vary depending on the methodology used, research suggests that automation holds considerable disruptive potential for the coming decades. Projections of automation are biased in the sense that they are based on tasks considered automatable with current technology. The projections are therefore subject to some uncertainty concerning technological developments and their impact on job tasks and occupations. They also do not represent net employment effects and should best be read as an indication of potential disruption for people and places in the short and medium term.

According to Frey and Osbourne (2013, 2017), close to half of the occupational categories (mostly middle and low-income professions) in advanced economies are susceptible to automation. They estimate that about 47% of employment in the United States is at risk of being automated over the next 20 years. Bowles (2014) applies their methodology to the European Union and concludes that 47% (Sweden) to over 60% (Romania) of the EU workforce will lose their jobs due to automation. Arntz, Zierhan and Gregory (2016) caution on the extent of the wholesale automation of certain occupations and argue that estimates also need to take into account the variation of tasks within occupations and across countries, depending on technology intensity and work organisation. They estimate that an average of 9-14% of jobs in OECD countries are at high risk of being automated, with at least 70% of the tasks being automatable, and that about one-third of all jobs face a smaller (albeit non-negligible) risk of automation.

Two recent analyses (Pouliakas, 2018; Nedelkoska and Quintini, 2018) base their estimates of automation risk on micro-level information about job tasks and skill needs using data from the European Skills and Jobs Survey and PIAAC. Pouliakas finds that 14% of adult workers in the European Union face a very high risk and 40% have a non-trivial chance of automation.[28] According to Nedelkoska and Quintini, 14% of jobs in industrialised countries are highly automatable (probability of automation of over 70%) and another 32% are bound to change substantially (risks of 50-70%), pointing to significant change in job tasks and the way they are carried out.[29]

Existing studies suggest that across the European Union, automation risks tend to be higher for countries in Central and Eastern Europe. In contrast, the shares of jobs at risk tend to be lower in Scandinavian countries, reflecting differences in industrial structure, employment and skill composition, but also work organisation.

More vulnerable workers already face higher risks of automation. Prospects of job automation appear highly contingent on skill levels, with jobs requiring only basic levels of education most exposed (Nedelkoska and Quintini, 2018). By industry, risks are higher in manufacturing and agriculture and lowest in knowledge-intensive services. Younger employees are at higher risk as are (lower-skilled) men, reflecting the industries and occupational profiles they tend to work in. Moreover, relatively static jobs with minimal task changes over time, higher insecurity and lower quality (with lower job satisfaction and fewer promotion and training possibilities) are at a higher risk of automation (Pouliakas, 2018). Altogether, results point to potentially deepening divides among people in the EU labour market.

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28 Jobs at high risk of automation have a median automation probability higher than 70%. Jobs at non-trivial risk/risk of significant change have an automation probability of 50-70%.

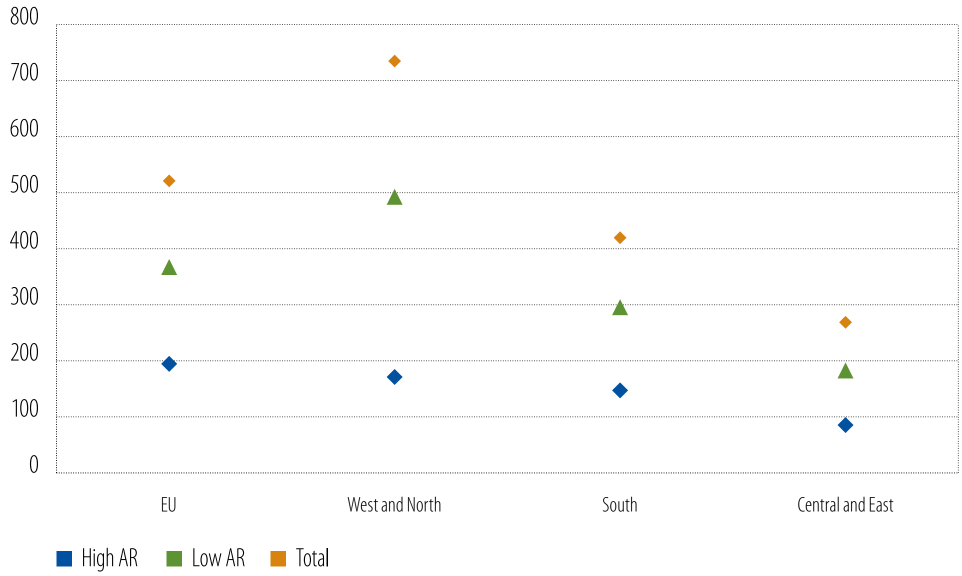
29 The study comprises 32 countries of which 19 are EU members.

We assess the risks of automation across EU regions. Using estimates of mean job automation risks for occupations from Nedelkoska and Quintini (2018) together with information from the EU Labour Force Survey on the occupational shares of job profiles by region, we compute the share of jobs at risk of automation by region.[30] As a next step, we combine the information on the estimated shares of jobs at risk of automation with regional characteristics and firm-level information from EIBIS to shed light on a region's ability to cope with the risks of technological transformation.[31]

Regions with a higher automation risks are concentrated in Central and Eastern Europe. We estimate that 42% to 52% of employment at the regional level is at risk of being automated by 2030. High-risk regions (defined as the 20% with the highest share of jobs at risk of being automated) are concentrated in Central and Eastern Europe, with different regions making up more than 75% of this group at particularly high risk. Six of the ten most exposed areas are located in Romania. In contrast, four of the ten areas with the lowest risk are in Sweden.

High-risk regions have a lower population density. Comparing regions with higher and lower automation risks (above or below the median) indicates that more exposed places in the European Union tend to be less densely populated, and their population is typically poorer and older. Notably, these patterns are visible when comparing the risk of automation across the European Union, within groups of countries and also within the countries themselves for larger Member States (Figure 15).

Figure 15
Population density in NUTS2 regions by automation risk exposure (persons per square kilometre)



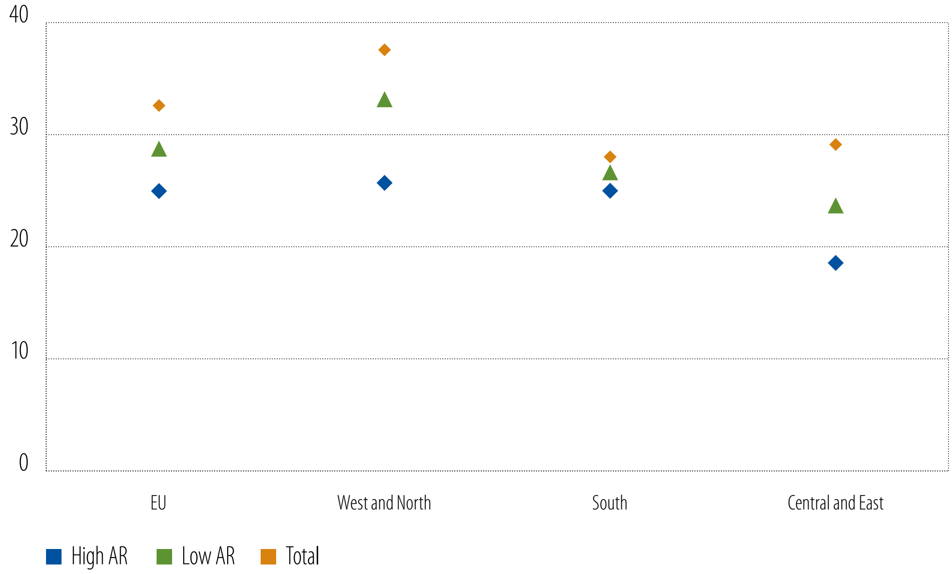
Source: EIB Economics Department calculations, Eurostat.
Note: High AR refers to automation risk that is equal to or above the median level, based on the automation risk calculated for the whole European Union, country groups or selected countries. Low AR refers to the average value of NUTS2 regions with below median level of automation risk, based on the automation risk calculated for the whole European Union and country groups.

30 "Regions" refer to NUTS2 regions according to their 2013 statistical classification. Regional estimates are based on risk estimates for occupation at ISCO 2 digit level based on Nedelkoska and Quintini (2018) and occupational shares in regional employment (averages for 2014-2016) based on data from the EU Labour Force Survey. As a robustness check, regional risks were estimated using occupational risks based on Pouliakas (2018). Due to missing data, a number of regions and Malta are excluded from the analysis. Estimates for risks are derived for 212 regions. Country estimates are used for the Netherlands due to data limitations.

31 For regional analysis for the United States, see Munro et al. (2019).

Figure 16

Share of working age population with tertiary education in NUTS2 regions by automation risk exposure (in %, persons per square kilometre)



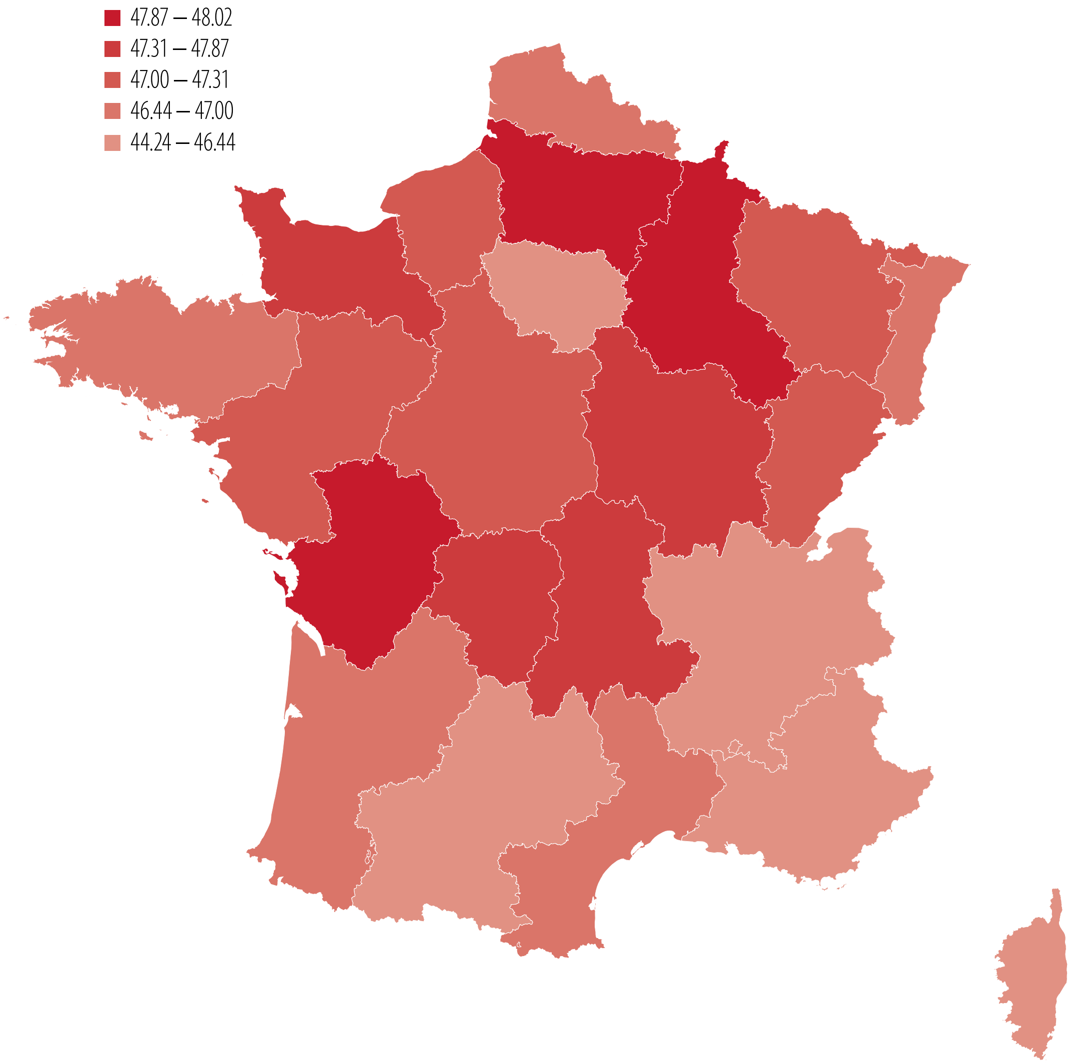
Source: EIB Economics Department calculations, Eurostat.
Note: High AR refers to automation risk that is equal to or above the median level, based on the automation risk calculated for the whole European Union, country groups or selected countries. Low AR refers to the average value of NUTS2 regions with below median level of automation risk, based on the automation risk calculated for the whole European Union and country groups.

The population in low-risk regions is better educated. The share of the working-age population with tertiary education is about 8 percentage points higher in regions with shares of jobs at risk below the EU median (Figure 16). Differences in educational attainment also exist within country groups and are most pronounced in Western and Northern and Central and Eastern Europe. The same pattern can be seen within Member States, despite differences in the percentage of people with tertiary education, and when looking at younger, highly educated individuals at an early stage of their careers.[32] The differences in skill composition likely reflect lower tertiary education costs for people already living in denser, more urban areas, which often feature (clusters of) tertiary education institutions as well as (young) people moving to these places to be educated. Higher occupational attainment can also be seen in higher employment rates in regions with lower automation risks. In contrast, regions with higher shares of jobs at risk tend to feature more difficult labour market conditions compared to the EU average as well as within the Central and Eastern Europe and Southern Europe country group. Similarly, regions with high automation risk exposure tend to have higher long-term unemployment rates compared to the EU average and within the Central Europe and Southern Europe group. For Southern Europe, differences between regions with high vs low automation risk are particularly pronounced. For example, in Italy and Spain, long-term unemployment rates are about 3 percentage points higher in regions with high exposure to automation risk compared to low-risk regions, suggesting that job automation could perpetuate already difficult local labour market conditions.

Capital regions typically face lower automation risks. Among the larger EU countries, France has the largest regional discrepancies, with the Île-de-France region facing the lowest risks (Map 1). The French case shows a pattern that also exists in other Member States, with the capital regions typically having the lowest share of employment at risk. This is the case for 12 out of 13 countries with at least five NUTS2 regions, with the only exception being Romania where the capital region has the second lowest risk.

32 Aged 30-34 with tertiary education.

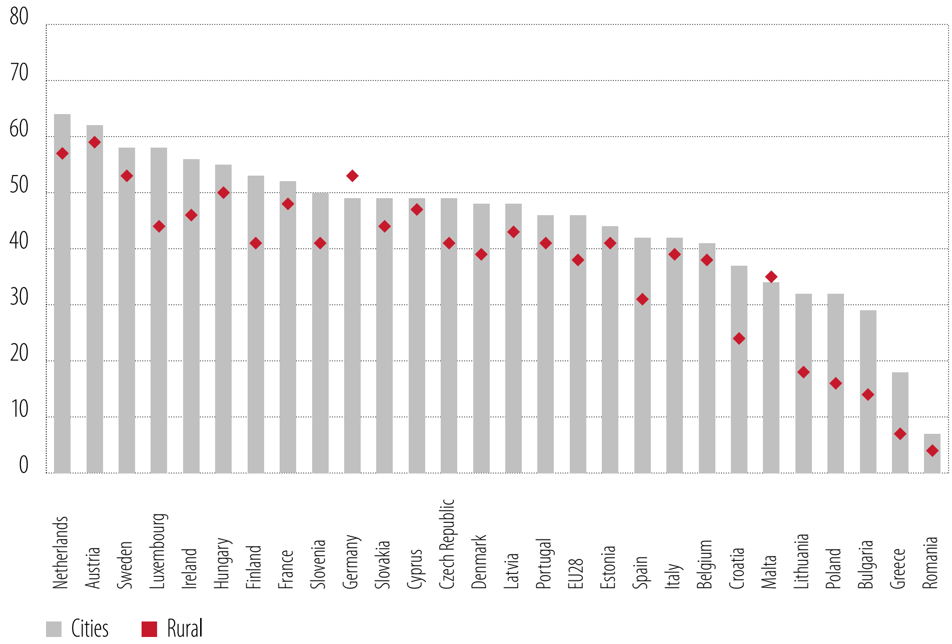
Map 1
Regional automation risks for France



Source: *EIB Economics Department calculations.*
Note: *Share of jobs at risk of automation by NUTS2 region. Outermost regions not displayed.*

Automation is likely to have a more severe effect on regions already under pressure. Analysing regional automation risk suggests that technological changes over the next few years could widen spatial divergences in two ways: i) among regions within countries and ii) among country groups in Europe. Less densely populated and poorer places with structurally more difficult labour market conditions appear more exposed to task replacement and changes associated with automation. In contrast, capital regions and places with a more educated workforce are less susceptible. This could further widen regional polarisation as part of the population adapts by moving to places with better job prospects. However, incentives to move are lower for those with skillsets no longer in demand as they are unlikely to find better jobs elsewhere, and opportunities to update their skillsets are often more limited (Figure 17). Moreover, increasing divergences in housing costs between rural and thriving urban areas in recent years have made moving more costly.

Figure 17
Training participation rates by level of urbanisation (%)



Source: *Adult education survey, 2016.*
Note: *Training refers to non-formal training activities, i.e. outside of schools, colleges and universities.*

Enhanced skill formation and a high quality business environment are key to strengthening regions' capacity to adapt to automation risks. Analysis of automation risks focus on the potential disruptive effects of technological change. For net effects on employment, complementarity and productivity effects also need to be taken into account.[33] The scale and location of the compensating effects cannot be predicted at this point.[34] However, to benefit from the upside, regions need to foster conditions to spur job creation and support skills upgrading. Workers' qualifications are crucial to this process as they determine regions' innovative potential and capacity to adopt new technologies and hence the possibility for firms in these places to become more productive[35] and create jobs that require skills complementary to new technologies. Place-sensitive strategies for territorial development (taking specific regional conditions such as geographical position, links with neighbouring regions, etc. into account) can contribute to fostering local investment and innovation.

Country group results point to convergence challenges in Europe. Projections give an indication of countries' and regions' risk exposure within a certain time period but do not indicate how fast changes will materialise. However, timing matters if regions are to compensate for automation as well as manage the scale of disruption, how long it lasts and where it is felt. This is particularly true given the speed and breadth of the ongoing digital transformation, which differentiates it from previous waves of technological change. In this situation, the late adoption of digital technologies will cost Southern and Central and Eastern Europe but also the European Union as a whole, because slow adoption reduces the potential advantages in scale that could be realised with the single market. Slow adoption can thereby reduce incentives for innovation in the European Union, making it harder to keep up with global competition.

33 Automation will increase demand for jobs requiring skills complementary to technology, for example machine programming. Higher productivity effects can raise employment via aggregate demand.

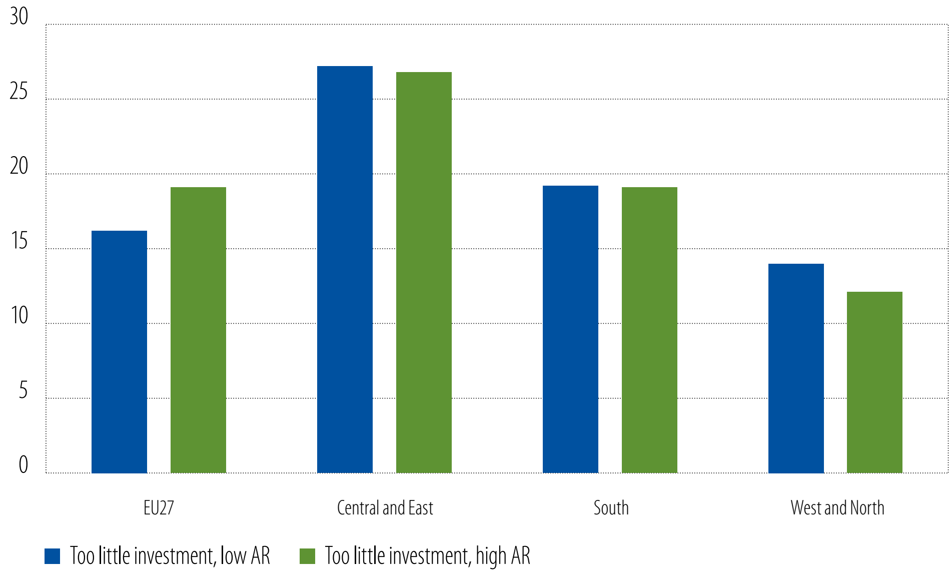
34 At a regional level, automation's impact may depend on not only the specific location of regions, their connectivity and national policies but also trends in the way work will be carried out.

35 For further analysis of the impact of institutional conditions and human capital on regional convergence and productivity growth, see European Commission (2019).

Furthermore, deepening divergences between places that thrive on digital transformation and those lagging behind challenge social cohesion within the bloc.

Firms' activities and investment decisions will drive the speed of automation. EIBIS results suggest that the gaps between Western and Northern Europe and the other two country groups may be widening. Regions with higher automation exposure have a higher share of firms reporting underinvestment (Figure 18). This difference appears mostly driven by divergences across country groups, with more companies reporting underinvestment in Southern and Central and Eastern Europe for both high and low automation risk regions. Similarly, we find a higher share of firms in both groups facing finance constraints.[36] At the same time, firms in both country groups operate in a structurally more challenging business environment. In particular, Southern European firms appear most constrained by both business and labour market regulation in comparison to the rest of Europe, with limited variation of automation risk. For firms in Central and Eastern Europe, labour market regulation is less of a concern but business regulation and skills pose bigger obstacles. Similarly, a recent assessment of sustainable development conditions finds persistent structural inefficiencies in labour markets in Southern Europe while countries in Southern and Central and Eastern Europe tend to underperform on human capital development and institutional quality compared to peers in Western and Northern Europe (European Commission, 2019).

Figure 18
Share of firms reporting underinvestment by automation risk exposure (in %)**, European Union and country groups**



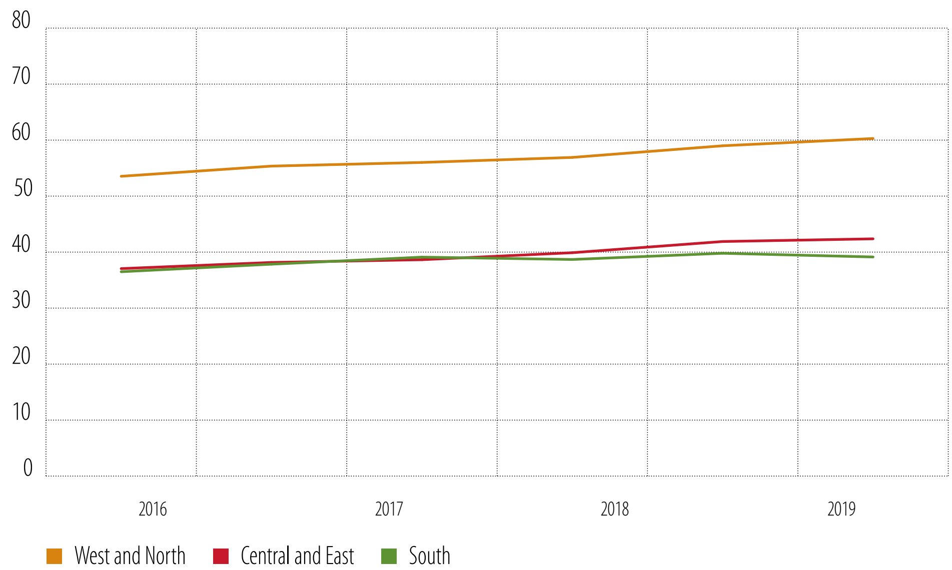
Source: *EIB Economics Department calculations, EIBIS 2016-2018.*
Note: *The bars show the shares of firms reporting underinvestment split by degree of automation risk for the European Union and the three country group regions respectively.*

Whether firms will invest more in labour-saving or labour-augmenting technologies will depend on the obstacles they face in their business environment. The combination of not being able to invest enough due to a more challenging operating environment and the limited availability of skills raises the risk of: i) delaying investment in new technologies or their development, ultimately leading to lower productivity and competitiveness; and/or ii) investing in new technologies that are more labour-replacing than labour-augmenting, impacting inclusiveness. Here, constellations differ by country groups due to starting conditions and current obstacles.

36 See Chapters 5 and 6 on financing conditions.

Firms in Western and Northern Europe are in a better starting position for realising employment creation effects. Here, the operating environment is more favourable and the existing skills base facilitates investment in the adoption of digital technologies earlier. EIBIS data indicate that firms in the region currently have an edge in digital adoption (EIB, 2018). Similarly, the share of firms that do not plan to invest in digital technologies over the coming years is lowest here (less than 5% compared to about 10-15% for the rest of the European Union).[37] At the same time, the broader skills base, including the availability of digital skills (Figure 19), and opportunities for skill development play a stronger role as an enabler for the adoption of digital technologies and emergence of new employment requiring complementary skillsets (McKinsey, 2018). Skill shortages, particularly in terms of talent that complements technological change, also occur and may even be (temporarily) higher because more firms are already looking for this talent. However, companies seeking it are also in a relatively favourable position for bridging gaps due to the ability to pay higher wages and the attractiveness of places for immigration, both globally and within the common labour market.[38] Moreover, a higher share of existing workplaces already feature a greater emphasis on information and communication technology (ICT), meaning that current employment facilitates the acquisition and further development of skills required to work with technology. Correspondingly, the five countries with the highest share of people in the labour force without any digital skills are all located in Southern or Central and Eastern Europe while the top five in terms of advanced digital skills are all in Western and Northern Europe. (European Commission, DESI, 2019)

Figure 19
Digital skills development, by country group



Source: *European Commission, Digital Economy and Society Index.*
Note: *The graph shows the evolution of the human capital component in the Digital Economy and Society Index (DESI). Higher values indicate a stronger human capital base to support digitalisation. The index component captures the availability of digital skills at basic (50%) and advanced level (50%) using a set of indicators to assess the availability of basic digital skills, digital skills above the basic level, basic software skills, ICT specialists, female ICT specialists and ICT graduates. For further information on the indicator and components, see European Commission, Digital Economy and Society Index.*

More routine job tasks and labour scarcity combined with a shrinking workforce make investment in labour-saving technologies relatively attractive in Central and Eastern Europe. Demographic projections indicate that Central and Eastern Europe will be strongly affected by ageing and workforce shrinkage

37 According to the EIBIS skills and digitalisation survey, about 60% of firms in the manufacturing sector have implemented at least one digital technology, while adoption rates are below 60% for the rest of the European Union.

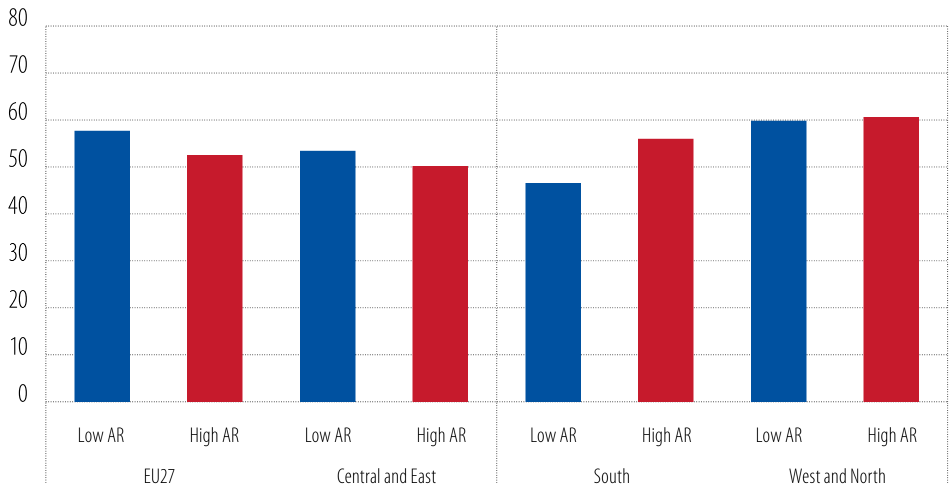
38 For further discussion on intra-EU mobility flows, see Brutscher et al. (2019) and the European Commission (2019b).

(IMF, 2019), adding to the attractiveness of investing in labour-saving technologies. Along these lines, EIBIS data show that firms in the region already consider automation more attractive when finding that the skills of their current workforce are not fully adequate.[39] At the same time, current shortages of high-skilled labour and the lower technological intensity of jobs, coupled with barriers to acquiring new skills or updating existing ones, make it more difficult to create new jobs based on technological advances.

Southern Europe risks seeing a delay in technology adoption. Countries in the region have the highest share of firms that do not plan any investment in digital technologies in the next few years (15% compared to less than 10% in the rest of the European Union, according to the EIBIS special survey digitalisation and skills 2018). In the region, the combination of several adverse factors – years of weak economic activity following the financial crisis, regulatory barriers, a relatively high share of the workforce with low skill levels, in particular digital skills and a lower share of jobs that make use of these skillsets – risks delaying technology adoption or making it (more) divisive.

Different approaches to developing human capital may accentuate current divergences. Companies invest in their workforce to increase productivity. Their willingness and ability to do so across the European Union also reflects differences in operating environments, with the share of firms investing in training higher in regions with lower automation risk. This is again driven by country group differences, with both Southern and Central and Eastern Europe having lower shares of firms investing in training regardless of the risk of automation. Notably, in Central and Eastern Europe the share of firms investing in training is lowest in regions with relatively high automation risk. This suggests that people in the most exposed locations also have fewer opportunities to update their skills, ultimately making the creation of new jobs requiring skills complementary to technology less likely.

Figure 20
Share of firms investing in training, by automation risk exposure (in %)**, for the European Union and country groups**



Source: *EIBIS 2016-2018.*
Note: *Unweighted shares of firms reporting any investment in training.*

39 According to the EIBIS special survey on digitalisation and skills, about 43% of firms in Central and Eastern Europe consider automation to be an option for responding to internal skill gaps compared to 30% and 40% in Southern and in Western and Northern European countries, respectively. At the same time, firms in the region are less likely to address gaps with additional training (68% compared to about 80% for countries in the rest of the European Union).

Firm training: what role for adjustment?

Firms' investment in their workforce varies widely, with the lowest shares of firms investing in training all located in Southern and Eastern Europe.[40] According to EIBIS, in recent years the share of firms not investing a single euro in training was above 60% in Greece, almost 50% in Bulgaria and about 40% in Romania and Italy. While small firms across the European Union are less likely to invest in training, this is particularly the case for small companies in Southern Europe (Table 2). Here, finance constraints also appear to play a stronger role in limiting training investment.[41] Average training investment per employee differs substantially, ranging from below EUR 100 in several Central and Eastern European countries and Greece to higher than EUR 300 in the majority of countries in Western and Northern Europe.

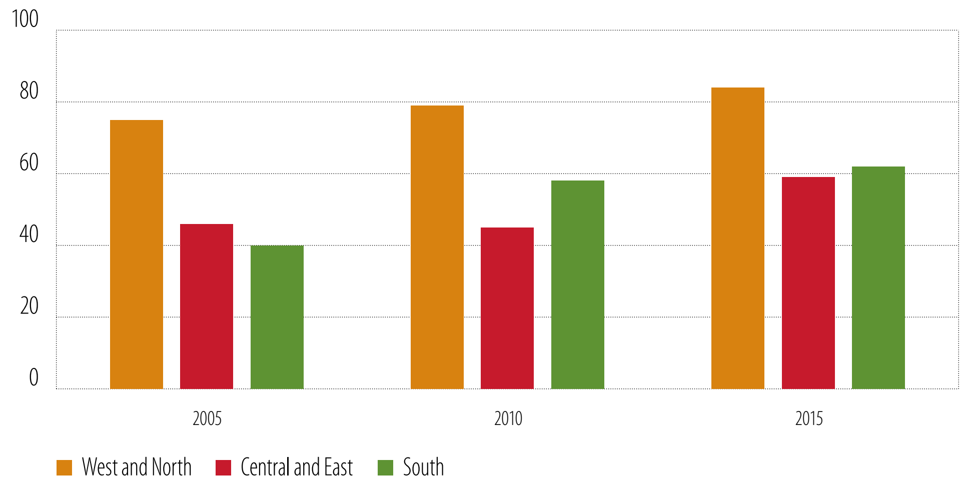
Table 2
Share of firms not investing in training (in %)**, by EU region and firm size**

Area	5-49 employees	50-249 employees	250-employees
Western and Northern Europe	36.4	19.7	23.5
Southern Europe	48.9	28.5	24.8
Central and Eastern Europe	43.2	23.8	22.9

Source: EIBIS 2016-2019.

More EU firms invest in their workforce than 15 years ago, but country group differences persist. The share of firms providing training in the European Union grew steadily but slowly, from about 65% in 2005 to 73% in 2015.[42] Complementarities between innovation and training are one factor behind higher training rates. New training methods (for example via online courses) might have lowered the costs for some types of training provided by firms. However, gaps between the country groups remain (Figure 21).

Figure 21
Share of firms providing training (in % of all enterprises)**, by EU region**



Source: CVTS.
Note: Group averages exclude Croatia and Ireland due to missing data for 2005-2010.

40 For a more extensive discussion of obstacles to firm training, see Brunello and Wruuck (2019).

41 Brunello et al. (2019) examine the impact of finance constraints on EU firms' training investment using data from EIBIS and Orbis. Finance constraints have a negative effect on firms' training investment in the European Union and for Southern European and smaller firms in particular.

42 Longer-term comparison based on the Continuing Vocational Training Survey (CVTS) for EU28.

Differences in firms' training investment across countries reflect economic institutions, industrial structure, innovation activities and the relative supply of skills. In the European Union, countries with higher R&D investment and a higher share of the population with tertiary education also tend to have fewer firms not investing in training, suggesting complementarities with other types of investment as well as public investment in human capital. For example, Sweden, one of the countries with relatively high shares of training in the EU comparison,[43] is similarly among the top spenders on R&D (3.3% in 2017) and 37% of its population has a tertiary education. In comparison, in Italy the percentage of firms conducting no training is about 40%, R&D investment is 1.4% of GDP and the percentage population with a tertiary education stands at 17%.[44] Similarly, across the European Union low R&D expenditure and low tertiary education tend to be accompanied by a higher share of firms not providing training.[45]

Higher product market competition tends to favour training. In theory, higher competition in product markets has two contradictory effects on the provision of training. On the one hand, it lowers the returns per unit of output that a firm can appropriate from training. On the other, lowering barriers increases the number of firms on the market, raising output, profits and gains from training and therefore incentives to invest in the workforce. Empirically, there is some indication that greater competition is associated with higher training investment (Autor, 2004 for the United States; Heywood et al., 2017 for the services sector in Germany; Bassanini and Brunello, 2011). Stricter regulation of product markets is associated with a higher share of firms not providing training.[46]

Labour market regulation and employer-employee relationships affect the levels of training by firms and who the beneficiaries are. While results on the overall impact of minimum wages on training provision are mixed, there is some evidence of a positive union effect on training in Europe (Green, 1993; Dustmann and Schonberg, 2009). Non-standard work (not only reflecting digitalisation but also regulatory changes) has been linked to more limited training opportunities for individuals on these types of contracts (Brunello and Wruuck, 2019). For Europe, the training incidence gap between non-standard and standard workers is about 10 percentage points (ILO, 2016). Striking a balance between flexibility and protection, and incentives for firms to train and employees to participate, is delicate. On the one hand, lower firing costs could reduce firms' incentives to train (Acemoglu and Pischke, 2000). On the other, stricter employment protection could give rise to dual labour markets with temporary workers less likely to receive training (Bratti, 2018).

Structural and institutional differences are at the heart of country (group) differences in firms' training efforts, as they determine costs and benefits. At the same time, there are some commonalities across the three country groups. It is typically the more productive firms that also invest more in their workforce (Table 3).[47] Firms that choose not to provide training mostly do so because they do not see the need for it, which can be due to lack of returns.[48] Furthermore, companies with more stagnant jobs (higher shares of routine task work) see less need for training than those with jobs that are more intensive in cognitive and non-routine tasks (18% vs 26%).[49] More innovative firms and companies adopting innovation are also more concerned about not having invested enough in their workforce, suggesting that firms in a better position to utilise skills and where skill needs evolve faster might also be more willing to provide training.

43 Above 75% of firms providing training on multi-year average.

44 Tertiary education shares for 2018, total population, 15-64 years.

45 Based on cross-country correlations between the share of firms in EIBIS providing no training and the share of the population with tertiary education (-0.49) and R&D investment relative to GDP (-0.46).

46 Based on cross-country correlations between the share of firms in EIBIS providing no training and the strictness of product market regulation (OECD).

47 Higher values in the bottom category appear to be driven by Belgian firms with relatively high spending per worker.

48 This is by far the most cited reason for not providing training by firms across the European Union, with more than 80% stating existing qualifications correspond to current needs.

49 For EU manufacturing and services. "Routine" includes both manual and cognitive routine work. Based on the EIBIS 2018 special module on digitalisation and skills, see EIBIS (2018) for further description of the sample.

Table 3
Training spending per employee by productivity group

Average spending per employee	Central and Eastern Europe	Western and Northern Europe	Southern Europe
Top productivity performers	117	330	207
2nd quintile	94	309	161
3rd quintile	88	203	150
Bottom productivity performers	69	288	150

Source: EIBIS 2016-2018, Orbis.
Note: Limited data availability for some countries in Orbis.

Training investment can increase firm productivity, either by itself or in combination with other investment. Research by EIB economists indicates that higher training investment intensity is associated with higher labour productivity. In addition to a direct effect, training investment has a positive effect in combination with investment in software and databases (see Chapter 3). This finding appears quite intuitive, as the introduction of new software and databases often requires the acquisition of new skills to use and leverage those tools. Brynjolfsson et al. (2018) also provide evidence that new technologies often require additional investment in the beginning to obtain the full benefits and point out that some of the complementary effects only materialise over a longer period. For instance, investment in the acquisition of new databases may be more productivity-enhancing if the firm in question also makes a further investment in training on how to utilise the resource, so putting employees in a better position to use it to develop new products or processes.

A high quality business environment is crucial for firms' willingness and ability to train. Moreover, the combination of private and public high quality investment in human capital is the basis for adaptive systems that enable skills to develop faster to changing needs. EIBIS results suggest that companies regard private and public human capital investment as complements rather than substitutes. Asked about priority areas for public investment, firms that invest in training themselves also consider public investment in training and higher education to be more important compared to non-training peers, pointing to potential synergies between public and private investment in human capital.[50]

Education and training systems tend to change slowly, putting them at odds with short to medium-term risks of displacement and higher (re)training needs due to automation. Educational systems also need to adapt to changing technological requirements to be able to foster the development of new skills (such as social, creative and analytical skills). While that adjustment is happening, near to mid-term change in skills demanded will already be affecting much of the workforce. A large part of the skill adjustment will therefore need to be encouraged through lifelong learning systems. Projected retraining needs are considerable and are likely to go beyond gradual upskilling (Box B).

50 26% of training firms prioritise professional training and higher education for public investment compared to 18% of firms not investing in training. Source: EIBIS 2017.

Box B

Thriving in a digital world – what does it take? [51]

As technology changes the demand for certain skills and jobs, individuals will need to be increasingly mobile in the labour market and acquire new or different skills to reduce the risk of being replaced or let go. At the same time, they may be able to benefit from the new job opportunities brought about by technological change. Meanwhile, governments will need to support workers in their occupational transitions through education and training investments, helping facilitate the transition of workers whose positions are at high risk of being automated to new and better-quality jobs.

By assessing the skills distance between occupations, analysis in the Skills Outlook 2019 (OECD, 2019) shows that not all occupations at high risk of automation require the same training effort for workers to transit to safer occupations. Some occupations may be close to each other in terms of skill requirements while facing different risks of automation. In those cases, small but targeted retraining efforts (shorter than six months) may be sufficient to help workers move to more secure occupations and avoid the risk of being made redundant due to automation. Other workers, however, have skills that are rather distant from those of occupations that are not at high risk of automation, and may therefore need moderate or even major retraining efforts to avoid the risk of being displaced by automation and technological change, while endorsing at worst moderate wage reductions and limited skills excesses. It is estimated that more than half of occupations (54%) at high risk of automation will require workers to make either moderate (less than one year) or major (more than one year) training efforts for them to be able to transit to jobs that are not at high risk of automation (OECD, 2019).[52] Results differ substantially across countries.[53] In particular, in countries where workers' skills vary widely, such as the United Kingdom or France, occupations tend to be more distant from one another in their skills requirements and mobility between occupations appears more complex. As a consequence, the training efforts required to switch between occupations appear larger (Bechichi et al., 2019). In this case, strengthening the participation of workers in high quality adult learning is therefore particularly important. In countries characterised by relatively small differences in skills and generally low skill levels, such as Greece or Italy, workers may find new employment after only minimal retraining. In the longer term, however, the development and adoption of new technologies aimed at maintaining or increasing countries' competitiveness and growth will require larger investments in education and training for all.

The exposure of different European countries to the risk of automation varies considerably, as does the share of employment in occupations with a high risk of automation that would require a major training effort to avoid that risk (Figure B1). In Belgium, for instance, 0.4% to 1.8% of workers will need to undergo major training to move to safer occupations, depending on whether it is assumed that all workers in these occupations are at high risk (upper bound) or only some of them are, given, for example, industry structure and other structural and individual features (lower bound).[54] These shares increase considerably in other countries, however. In the Czech Republic, by contrast, up to 5.9% of workers will likely need major (re)training to prevent automation from making them redundant.

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51 Prepared by Elena Crivellaro (Centre for Skills, OECD), Stéphanie Jamet (Directorate for Education, OECD) and Mariagrazia Squicciarini (Directorate for Science, Technology and Innovation, OECD). This box is based on research for OECD (2019), OECD Skills Outlook 2019 - Thriving in a digital world.

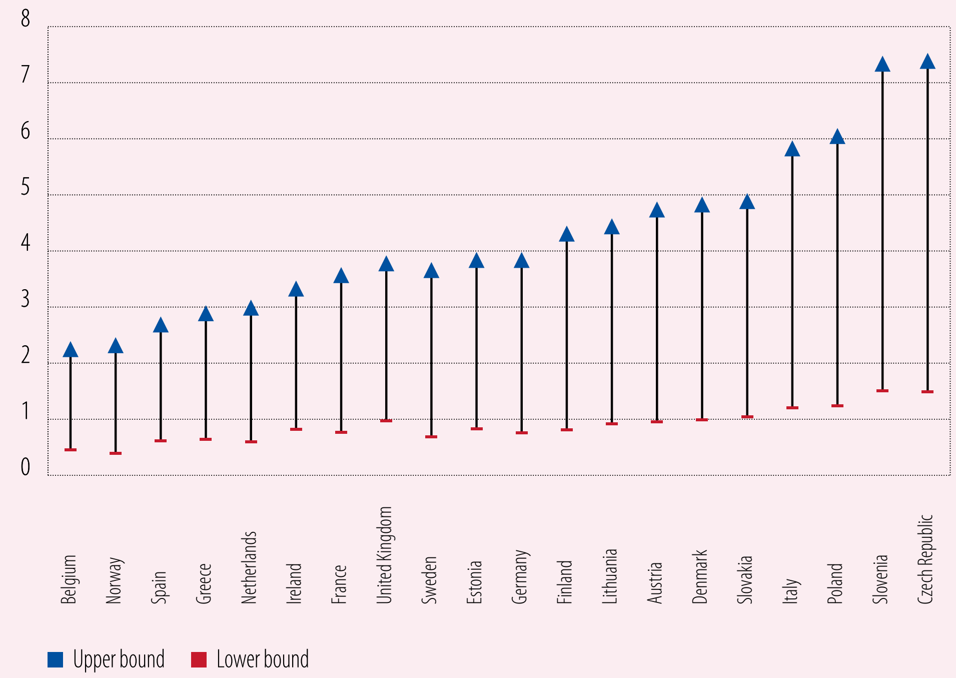
52 This result holds for the whole set of countries included in the analysis, namely Australia, Austria, Belgium, Canada, Chile, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Lithuania, Ireland, Israel, Italy, Japan, Korea, the Netherlands, New Zealand, Norway, Poland, the Russian Federation, Singapore, Slovakia, Slovenia, Spain, Sweden, Turkey, the United Kingdom and the United States.

53 Certainly, opportunities for workers to change occupation depend on several country characteristics, including geographical location of economic activity, industry structure and dynamics, institutional barriers, labour market flexibility and skills distribution.

54 Arntz, Gregory and Zierahn (2016); Nedelkoska and Quintini (2018).

Figure B.1

Share of employment in occupations at high risk of automation (in %, for which a major training effort is needed to transition to lower-risk occupations)



Source: *EIB staff calculations based on Nedelkoska and Quintini (2018) and Frey and Osborne (2017).*

Note: *For the lower bound estimate, only workers in jobs currently at high risk of automation are considered while for the upper bound estimate, all workers currently employed in occupations at high risk of automation are considered. The proportion of workers in jobs at high risk of automation in an occupation is taken from Nedelkoska and Quintini (2018). The risk of automation of the occupation of origin is computed based on estimates by Frey and Osborne (2017). Occupations of destination considered are those with a low or medium risk of automation that a worker can move to with moderate wage reduction and limited skills excesses.*

Some countries are better prepared to face the challenges brought about by digitalisation and new technologies than others (OECD, 2019). Only a few countries in the European Union (such as Belgium, Denmark, Finland, the Netherlands and Sweden) have been able to equip their workforces with the appropriate digital and foundation skills needed to thrive in a digital world. Conversely, individuals in Greece, Italy, Lithuania and Slovakia often seem to lack the necessary foundation skills that are key to flourishing in the digital world. The formal and informal training systems of these countries appear to some extent inadequate to meet the challenges posed by the digital transformation and to enable people to improve their skills. Moreover, these countries also lag behind in terms of their ability to navigate and thrive in the digital era. For instance, only 36% of individuals in Italy can make complex and diversified use of the Internet, compared to 58.5% on average across the OECD and 79.1% in the Netherlands.

As adults will need to reskill and upskill throughout their careers to keep up with changes in economies and societies (including in labour markets) traditional education systems need to evolve into effective lifelong learning systems. Nonetheless, participation in training by low-skilled adults, those most likely to be affected by the changes ahead, is more than 24 percentage points below that of high-skilled adults on average across the European countries included in the analysis.[55]

55 These are Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Lithuania, the Netherlands, Poland, Slovakia, Slovenia, Spain, Sweden and the United Kingdom.

By adapting the education curricula to changing skills requirements and by providing more effective training to teachers, countries could reap the benefits of the new learning and teaching possibilities offered by technology. In this context, technology could potentially play an important role in making education and training systems more efficient, flexible and adaptable to individual needs, independently of their location. More flexible and targeted learning opportunities (e.g. micro-credentials or nano-degrees) as well as the development of online resources are examples of how technology could help to deliver new educational content. However, challenges still exist in recognising the skills acquired through these new learning paths and in making skill acquisition "certified" and recognisable.

Since the digital transformation is affecting different individuals, sectors and firms, the policy response must be holistic and coordinated. Countries may need to put in place a comprehensive digitalisation policy package that joins up policy on education, the labour market, tax, research and innovation, housing and social protection to ensure a cohesive and whole-of-government approach that will fully realise the potential of the digital transformation and address its challenges.

Providing the opportunity to retrain is key to the European Union's transition in the digital era and to mitigating social costs. Firms can help bridge some of the gaps and support skills development by providing an environment to incentivise and support learning and by financing training activities. With employers sponsoring the majority (about 70%) of job-related training activities in the European Union, they are a key part of the solution.[56] They can help ensure that skills are upgraded smoothly in line with changing needs, and in a best case scenario can increase productivity while limiting disruption to people who otherwise may suffer larger wage losses from involuntary unemployment and then have to retrain and find a way back into the labour market. However, firms' willingness and ability to do this is contingent on their operating environments. Static firms with jobs requiring few task changes are unlikely to drive the retraining efforts needed in the short to medium term with a view to adapting skillsets to changing needs. Moreover, (prospects of) greater occupational mobility might affect traditionally successful training models such as apprenticeships that were more geared towards lifelong careers. In the short term, bolder steps may be required to limit the costs of disruption and support lifelong learning on a broader basis. Investing in skills will put EU firms in a better position to innovate, create employment and contribute to human capital formation now and in the future.

56 In turn, the majority of adult training activities (79%) are job-related. Source: Adult Education Survey, 2016. The relatively high share of employer-sponsored activities may also reflect the general affordability of training, which can be prohibitive for individuals.

Conclusions

Missing skills are a key obstacle for EU firms, hampering investment and technology adoption. Moreover, skill gaps limit individuals' employment prospects, leaving them more vulnerable to the impact of technological change. The limited availability of skills entails substantial costs in terms of lower productivity today and lower job creation in future digital transformation. For the people of Europe, skill gaps risk deepening inequalities as those not possessing the right skills, and with limited opportunities to acquire them, face greater difficulties in adapting to changing job requirements and successfully transitioning between jobs. Moreover, skill gaps may deepen divergences across country groups by affecting the speed of technological transformation and its effects on employment.

Failing to act on the challenge of missing skills could deepen divisions between people and places with negative implications for competitiveness and inclusiveness in the European Union. While current employment levels are at record highs, future employment developments and opportunities to reap the benefits of digitalisation for firms and individuals will ultimately depend on the ability of the European Union and Member States to draft policies that help workers adapt to changes and develop the skillsets needed to thrive in a changing world of work. Strengthening human capital in the European Union is a common challenge that needs to be addressed now to avoid widening divergences.

More innovative companies as well as digital and dynamic firms are particularly affected by skill gaps. Skill constraints are typically linked to lower productivity. Missing skills tend to affect the firms driving economic dynamism the most. The type of firms more often affected by skill gaps also suggest that there is a qualitative component to current gaps and a need for skills to adapt.

Support for innovative and dynamic firms can help to speed up the skills adaptation. Targeted support for these firms by the European Union and Member States must not be to the detriment of lower-skilled workers.[57] In fact, employment creation by these firms can help to incentivise skills development. It needs to be coupled with enhanced opportunities for learning and acquiring new skills to help deal with shortages faster and move more people into quality jobs. Supporting training by innovative and dynamic firms could have positive spillover effects.

Addressing skill constraints requires short and long-term measures to address shortages of critical skills and to foster an environment that allows for the smooth reallocation of skills. In practice, short- to medium-term measures to mitigate shortages of some skills could include better access to (re)training opportunities. Bottlenecks for high-level digital talent could be eased by facilitating the immigration of people with the relevant qualifications, as experts in these areas tend to be more mobile.[58] Bringing in top-level skills needs to go together with better options for developing the local talent pool, such as through new educational programmes in areas such as artificial intelligence or the increased use of online courses, and sound business conditions. Ultimately, it is the combination of a good business environment and a high quality skill base that enables successful hubs to emerge, and attracts but also keeps top talent that can often choose a location and employer depending on where they can learn.[59]

Smooth reallocation requires people to be able to move and adapt their skills in line with changing needs throughout Europe. An integrated labour market and support for learning mobility – for example by enabling study or work experience abroad – contributes to better matching between demand and supply and helps to foster productivity growth across the European Union. At the same time, labour mobility in the European Union does not come without challenges. Large-scale emigration can add to the current shortages experienced by firms and come with longer-term costs related to slower convergence, potentially aggravating the risk of a multi-speed Europe. Moreover, it might dampen incentives for (early) human capital investment as some of the gains may accrue elsewhere, discouraging education and

57 See Aghion et al. (2018) for discussion.
58 The case of Singapore's recent programme to attract talent in frontier technologies is one example.
59 See, for instance, Tambe, Ye and Capelli (2019) on learning opportunities and choices for switching jobs.

result in sub-optimal levels overall. This ultimately comes at a cost for Europe as a whole, as high quality education provides the foundation for developing skillsets, enabling a smooth transition to work and lifelong learning.

New digital technologies hold considerable disruptive potential for jobs in the coming years and will affect people and places unevenly. Policies can help to mitigate the geographic impact of digitalisation. Strategies to enable places to cope with the risks of job automation and benefit from the upside of digitalisation need to focus on improvements to the business environment together with a supply of high quality skills to limit further regional polarisation. Similarly, making improvements to the business environment and strengthening the skills base can help countries to catch up.

Digital technologies can be better exploited to limit inequalities in learning. While the benefits of digitalisation have been highly concentrated in some regions and cities, digital technologies also hold the potential to bridge geographical divides and facilitate access to educational programmes and training for individuals and teachers where access is more limited. However, information must be provided on how to fully leverage the benefits of digital technologies for learning, by not only training teachers to use digital technologies as part of their teaching but also providing guidance and quality assurance for online adult learning programmes.

Expanded efforts to boost lifelong learning are urgently needed. The European Union can support this process through economic policy coordination and financing. Lifelong learning needs are likely to rise over the next few years but current goals are unlikely to be met and participation is lowest among those who may be the hardest hit by changing demands.[60] There is no silver bullet to boost participation in lifelong learning, as many of the factors limiting provision and participation are structural and reflect country-specific conditions. However, the European Union has the tools to develop the holistic responses needed by leveraging economic policy coordination and identifying critical obstacles and ways to tackle them. In addition, dedicated instruments to equip people and businesses to better deal with the disruptive effects of digital transformation could be considered, for instance to help firms implementing new technologies to improve skills development.

Policies need to offer broad support to lifelong learning and step up efforts to address inequality of opportunity in education systems at an early stage. With automation, many workers will need to adapt to changing workplaces and potentially switch industries and occupations. Policies to facilitate this process are urgently needed to avoid high levels of technological unemployment and provide workers with prospects. This involves efforts by private and public institutions to identify the skills needed, to find ways to develop them, and to provide an environment that makes the investment worthwhile. While retraining opportunities and lifelong learning will be vital to enabling workers already in the labour market to cope with risks from job automation, efforts to boost adult learning need to go together with investment and targeted measures addressing the accessibility and quality of education.

Strengthening the access to and the quality of education at an early stage is key to tackling unequal learning opportunities. It provides a foundation to facilitate learning later in a person's working life by fostering the development of crucial cognitive and social skillsets at the very beginning. As such, education helps generate innovation and allows individuals and societies to adapt to changing environments. Improving the quality of public education and focusing on policies that increase opportunities for children from disadvantaged backgrounds are therefore essential to creating a more inclusive European Union now and in the future.

60 By 2020, 15% of the core working age population should participate in continuing training, but by 2018, only 11.1% across the EU had done so.

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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" (i.e. 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 of these is 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 (i.e. Northern Europe, Southern Europe or Central and Eastern Europe). Second, to deal with outliers, we set negative implied depreciation differentials equal to zero.

Corporate infrastructure database

To analyse corporate infrastructure investment activities in more detail, we assembled a novel micro-dataset of infrastructure firms. All firms were selected from the Bureau van Dijk Orbis database, a commercial database of firm balance sheet and profit-and-loss data.

We identified the firms to be included in the data using a two-stage approach. First, we searched the web for the main infrastructure firms in Europe by country/sector. This was to be sure that we had included the most important infrastructure firms in the dataset. In a second step, we complemented the list of firms with all those firms that fall into one of the detailed six-digit NAICS codes related to infrastructure activities.[3] Among all firms identified in this way, we kept only those that (i) were listed as active in the Orbis database; (ii) reported financials in at least one of the last two years (2016–18); and (iii) had a minimum of 49 employees.

This search strategy left us with around 10 000 infrastructure companies overall, which are relatively well distributed across the six main sectors: power, water, transport, ICT, education and health as described in Table 1 below. The sector with the fewest observations is education. This is why, for some of the data-intensive analyses, we do not report separate results for this sector.

About 60% of infrastructure firms in our sample are located in the group of other EU countries, 25% in the periphery region and 15% in the cohesion countries. The median size of firms is around 150 employees, with very little variation across sectors. Total fixed assets for the typical infrastructure firm amount to between EUR 3 million in the education sector and EUR 44 million in the power sector (Table 2).

3 Hydroelectric Power Generation, Fossil Fuel Electric Power Generation, Nuclear Electric Power Generation, Solar Electric Power Generation, Wind Electric Power Generation, Geothermal Electric Power Generation, Biomass Electric Power Generation, Other Electric Power Generation, Electric Bulk Power Transmission and Control, Electric Power Distribution, Natural Gas Distribution, Water Supply and Irrigation Systems, Water and Sewer Line and Related Structures Construction, Oil and Gas Pipeline and Related Structures Construction, Power and Communication Line and Related Structures Construction, Rail Transportation, Line-Haul Railroads, Short Line Railroads, Pipeline Transportation of Crude Oil, Pipeline Transportation of Natural Gas, Pipeline Transportation of Refined Petroleum Products, All Other Pipeline Transportation, Air Traffic Control, Other Airport Operations, Other Support Activities for Air Transportation, Support Activities for Rail Transportation, Port and Harbour Operations, Marine Cargo Handling, Navigational Services to Shipping, Wired Telecommunications Carriers, Wireless Telecommunications Carriers (except Satellite), Satellite Telecommunications, All Other Telecommunications, Colleges, Universities, and Professional Schools, General Medical and Surgical Hospitals, Psychiatric and Substance Abuse Hospitals and Specialty (except Psychiatric and Substance Abuse) Hospitals.

Table 1
Distribution of firms in the final sample

Sector	Number of Firms	Share of Firms (%)
Power	1 941	19.04
Water	1 222	11.99
Transport	2 030	19.92
ICT	1 199	11.76
Education	258	2.53
Health	3 542	34.75
Total	10 192	100.00

Table 2
Descriptive statistics

	Employees		Total fixed assets (EUR)		Share from		
	mean	median	mean	median	Cohesion	Periphery	Other EU
All Sample	835	150	470m	7.3m	19%	24%	57%
Power	949	147	1.1bn	44m	19%	18%	63%
Water	539	117	260m	6.1m	39%	25%	36%
Transport	948	125	340m	2m	14%	44%	42%
ICT	1 643	134	1.2bn	9m	15%	16%	69%
Education	943	132	87m	3.5m	5%	31%	64%
Health	550	196	33m	6.2m	16%	20%	64%

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 entails 12 500 completed interviews every year. 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.

Using a stratified sampling methodology, the EIBIS General Module is representative across all 28 Member States of the European Union and applies to four firm size classes (micro, small, medium and large) and four sector groupings (manufacturing, services, construction and infrastructure) within countries. Firms have to have a minimum of five employees in order to 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 people 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 third wave of the survey took place between April and August 2018. The fourth wave of the survey took place between April and July 2019.

The EIBIS General Module is intended to complement 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 ECB/EC SAFE survey by focusing on the link between firm investment and investment finance decisions.

Table 3
EIBIS at a glance

28	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 country.
12 672	European firms participated in the last wave of the survey, compared to 12 483, 12 338 and 12 355 in the previous waves of the survey.
803	US firms participated in the last wave of the survey.
9 867	of all firms in the pooled sample responded for at least two consecutive waves.
87%	of firms surveyed in 2019 agreed to be contacted again for next year's survey.

The EIBIS is a very powerful instrument built according to the highest scientific standards. In order 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.

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, at a country level and for most countries at a country-industry-group and country-size-class level.

In a forthcoming EIB working paper (Brutscher and Coali, forthcoming), we assessed the data quality of EIBIS. We did this in two steps: first we benchmarked the sampling frame from which all survey respondents are drawn, the Bureau van Dijk Orbis database, against two other databases to see how well it captures the (relevant) business population.

In a second step, we then compared the final EIBIS sample against random draws of firms from the same sampling frame. We did this on the basis of the financial information included in the sampling frame. The purpose of this exercise was to assess whether and to what extent firms' (un-)willingness to participate in the survey may have led to a selection bias.

Overall, the results are very positive. A comparison of the Bureau van Dijk Orbis dataset with the Eurostat Structural Business Statistics (SBS) for the relevant sector/size classes showed coverage ratios (i.e. 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 three – Cyprus, Greece and Luxembourg – does the coverage ratio fall below 50%.[4]

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.

A comparison of the Orbis database with the CompNet database also suggests a good coverage of Orbis. 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 final outcome is a wide range of indicators at the country-sector-size-class level.

To assess the coverage of the EIBIS sampling frame, we reproduced the same country-sector-size-class level indicators using the Orbis database (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 Orbis and the CompNet database being very similar.

Having a sampling frame that covers a high percentage of the population of interest is necessary for the EIBIS survey results to closely reflect what is happening in the non-financial corporate sector in the European Union. It is not a sufficient, however. 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.

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.

More information on both the EIBIS General Module and the Add-on Module can be provided upon request to eibis@eib.org.

Start-up and scale-up survey add-on module

In 2019, the Add-on Module surveyed 1 100 start-ups and scale-ups in the EU27, the United Kingdom and United States. Eligible respondents were Chief Executive Officers, Financial Managers or Heads of Accounts.

The survey was administered by telephone (in the local language) and took on average less than 20 minutes to complete. The fieldwork started in April 2019 and continued until July 2019. Firms had to be listed on the Crunchbase Database, have been founded between 2008 and 2018, and still be active.

In the EU27 499 start-ups and scale-ups were interviewed, in the UK this figure was 120, while 483 start-ups and scale-ups were interviewed in the United States. Survey answers from the Add-on Module on Start-ups and Scale-ups in this report are aggregated using firm weights based on the Crunchbase Database.

Municipality survey add-on module

In 2017, the EIBIS Add-on Module surveyed 555 municipalities in Europe on their infrastructure investment activities and associated barriers.

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 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 April and August 2017. As part of the survey, 555 municipalities were interviewed in all 28 Member States, split across the following countries and country groupings (regions).

Table 4
Number of interviews per country/country grouping

France: 36	Other Northern Europe (Austria, Denmark, Finland, Ireland and Sweden): 92
Germany: 30	Other Southern Europe (Cyprus, Greece, Malta and Portugal): 58
Italy: 30	Other Central Europe (Czech Republic, Hungary, Slovakia and Slovenia): 67
Spain: 30	South-East Europe (Bulgaria, Croatia and Romania): 56
Poland: 30	Baltics (Estonia, Latvia and Lithuania): 45
United Kingdom: 35	Benelux (Belgium, the Netherlands and Luxembourg): 46

The sample frame from which municipalities were randomly selected was a comprehensive list of European cities. 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 10 and 35 (depending on the size of the country).[6] The survey results can thus be interpreted as reflecting the views of larger municipalities in each country.

Sector-specific answers were aggregated into an infrastructure aggregate using country-specific sector weights based on public investment shares by sector. 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 2017 EIBIS technical report. Detailed results of the survey are published in a separate publication entitled "EIBIS 2017: Municipality Infrastructure Investment Activities." Both publications are available at www.eib.org/eibis.

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.

6 The sample was generally provided at a ratio of 5:1 (for each completed interview).

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 Organisation (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 was produced in collaboration with ECOOM (The Centre for Research & Development Monitoring).

The EU Industrial R&D Investment Scoreboard

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 in order 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 2018 edition of the Scoreboard comprises the 2 500 companies investing the largest sums in R&D in the world in 2017/18. These companies, based in 46 countries, each invested over EUR 25 million in R&D for a total of EUR 736.4 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 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 2018 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: http://www.iri.jrc.ec.europa.eu/web/guest/scoreboard.html.

Investment in climate change mitigation

Investment in climate change mitigation comprises renewable energy, networks, energy efficiency, transport infrastructure, agriculture land use/land use change and forestry, and research and development. It includes investments that would be economically and financially viable without placing any special value on greenhouse gas abatement, as well as those that would be unattractive if not for the climate imperative.

Renewable energy

Data from the International Energy Agency (IEA) and Bloomberg New Energy Finance (BNEF) are the basis for the estimates of investment in renewable energy presented in this chapter.

IEA estimates are based on analysis of annual capacity additions and unit investment costs, derived in part from surveys with industry, IEA Technology Collaboration Programmes, the International Renewable Energy Agency (IRENA) and other organisations. Investment does not include operating and maintenance expenditures, financing costs, research and development spending, mergers and acquisitions or debt and equity market transactions. Investment outlays are counted in the year that an asset becomes operational, not in the year when the investment decision was made. Thus, the investment for a specific year actually reflects spending carried out in previous years too.

BNEF estimates are based on disclosed deal values, or BNEF estimates based on comparable transactions. Investment outlays are counted on the date of financial close. The estimates include all biomass and waste-to-energy; wave and tidal; geothermal and wind generation (>1 MW); hydro (1–50 MW); biofuels (>1 million litres/year); and all solar projects (<1 MW counted as distributed capacity).

Networks

Investment in electricity networks includes transmission, distribution and grid-scale battery storage. The data reflect three drivers: investment in new infrastructure to accommodate new demand; investment to replace ageing infrastructure; and the investment required to integrate renewables into the power system. Network investment to accommodate new demand is calculated based on the commissioning of new transmission and distribution lines and on the analysis of data provided by the 2016 NRG Expert Transmission and Distribution Database. The applied unit investment costs are based on past capital expenditures and data from industry surveys. Investment in asset replacement assumes an average lifetime of 40 years for assets already in operation. Unit replacement costs are derived from costs of new infrastructure. The investment costs of transmission and distribution networks required for renewable integration are based on literature reviews. The analysis of investments in the digitalisation of the electricity grid is based on analysis of NRG, BNEF and MarketsandMarkets. Investment in grid-scale electricity storage is based on the capacity deployment reflected in the US Department of Energy's Global Energy Storage Database. Investment in pumped-hydro storage – the largest component of global storage investment – is included in the hydropower data of WEI 2018.

Energy efficiency

There are no official data on investment in energy efficiency, and estimating it presents some unique challenges. Energy efficiency is typically a component of a larger investment. For example, when a piece of machinery is replaced, the new machinery might have a number of enhancements, including lower energy consumption. Energy efficiency investments are made by many agents – both public and private – across many sectors, including households and enterprises. Dedicated financing for energy efficiency is in its infancy. This means that for the majority of investments, the source of financing does not provide a clear-cut distinction between energy efficiency and other aspects of the investment.

Two broad approaches to estimating energy efficiency investment have been taken by the IEA. The bottom-up approach calculates the additional cost for a given country of the 25% most efficient appliances over and above the average cost of appliances in a given category. For example, in the area of residential lighting, energy efficiency investment would be estimated as the number of high efficiency light bulbs purchased times the cost difference between a high efficiency bulb and a regular bulb.

The top-down approach estimates how much would have been spent on energy if aggregate energy intensity remained fixed from one year to the next. This is the monetary value of the energy efficiency savings. Combined with an assumption about the payback period of energy efficiency investments, this yields an estimate of how much would have been invested to yield the observed reduction in energy use. In comparison with the bottom-up approach, the top-down approach has the advantage of requiring less data, but has two disadvantages. Firstly, energy intensity is not energy efficiency, and to the extent that reductions in energy use resulted from structural shifts to lower-energy activities, the top-down approach would overestimate efficiency investment. Secondly, there is inevitably some overlap between the top-down measure of energy efficiency and the other categories of climate change mitigation investment used in this report. For example, switching from fossil fuels to renewable energy has a large impact on aggregate energy intensity. Improvement in vehicle efficiency is also hard to distinguish in the aggregate data from reductions in energy consumption due to investment in transport infrastructure.

Bottom-up estimates of investment in energy efficiency are not available prior to 2014, with a top-down methodology being used in past publications to estimate previous years. Imputed energy savings are calculated based on changes in aggregate energy intensity. The savings are smoothed out using a three-year moving average. Investment is assumed to be proportional to the smoothed out energy savings, and the model is calibrated to agree with the most recent bottom-up estimate.

Transport infrastructure

Climate change mitigation investment in transport infrastructure is estimated based on OECD International Transport Forum data on capital formation in rail and inland waterways. Missing data where extrapolated is based on the ratio to GFCF.

The statistics are based on a survey of total gross investment (defined as new construction, extensions, reconstruction, renewal and major repair). Member countries supply data in current prices. OECD reports that despite the relatively long time series, complexities with regard to data definition and coverage have rendered international comparisons difficult. The indicators such as the investment share of gross domestic product (GDP) depend on a number of varying factors, such as the quality and age of existing infrastructure, the maturity of the transport system, the geography of the country, and the transport intensity of its productive sector. The OECD therefore advises caution when making comparisons of investment data between countries, and instead would encourage studying the evolution of individual countries or aggregates over time.

Forestry

Available data on GFCF in forestry are taken from Eurostat, Statistics Explained: Forests, forestry and logging. Missing data are estimated by assuming that the ratio of forestry to GFCF remains constant.

Research and development

The chapter uses four sources of information on R&D.

- OECD survey data for government R&D. These data are available up to 2013 for most countries and for some countries in 2014. Climate change mitigation R&D is assumed to be composed of the following top-level categories in the database: energy efficiency, renewable energy, hydrogen and fuel cells, other power storage technologies, and other cross-cutting technologies. In addition, carbon capture and storage (which is under fossil fuel technologies in the database) is included in the analysis. These data refer to government expenditure at a national level and do not include EU programmes.
- IEA data on corporate R&D spending on clean energy up to 2017, with state-owned enterprises (partly overlapping with public R&D) up to 2016.
- BNEF estimates of public and corporate R&D.
- EIB financing of R&D in manufacturing sectors, including automotive, chemicals and other manufacturing.

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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.
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.
ATT	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).
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.
B2B	Business to business: trade conducted via the internet between businesses.
B2C	Business to consumer: trade conducted via the internet between businesses and consumers.
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.
Basic firms	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).
Benelux	Belgium, the Netherlands and Luxembourg.
Beveridge curve	A graphical representation of the relationship between unemployment and the job vacancy rate, with the number of unfilled jobs expressed as a proportion of the labour force.
BFAVAR	Bayesian factor vector autoregressive model.
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.
Born digital	Young firms that are digital from day one, with a business model that is centred on one or more digital technologies.
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 start-ups, usually in exchange for convertible debt or ownership equity.
CAGR	Compound annual growth rate.
Capex	Capital expenditures.
Capital cost	A cost deriving from, or forming part of, capital expenditure on a project.
Carbon intensity	The ratio of GHG emissions divided by activity, e.g. GHG emissions/GDP.
CCI	Credit condition indicator.
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 (e.g. steel, cement and refining) and fossil fuel power.
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.
CET1 ratio	Common Equity Tier 1 Ratio: regulatory ratio computed for banks in order to assess their capacity to withstand major shocks. Core Tier 1 capital divided by risk-weighted assets. The ratio must be above a level determined in the so-called Basel III package.
CESEE	Central, Eastern and South-Eastern Europe.
CFC	Consumption of fixed capital.
CMU	Capital Markets Union: European Commission action plan to establish the building blocks of an integrated capital market in the EU by 2019.
COFOG	Classification of the functions of government.
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.
Co-patents	Patents with multiple applicants or inventors.
Cross-country citations (CCC)	An index representing the relative intensities of citations between the citing country and the cited country.
Crowdfunding	The practice of funding a project or venture by raising small amounts of money from a large number of people.
CSPP	Corporate Sector Purchase Programme.
CVTS	Continuing Vocational Training Survey: an enterprise survey conducted every five years to collect information on continuing vocational training in enterprises, forming part of the European Union's statistics on lifelong learning.
DDM	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.
De-meaning	Subtracting the sample mean from each observation so that they are 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.
Dominance analysis	A method that enables a researcher to break down the total predicted variance of a regression model in order to investigate the relative importance of each predictor within the model.
Drones	Powered, unmanned aerial vehicles that can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload.
DSM	Digital Single Market.
DWL	Deadweight Loss: a cost to society created by market inefficiencies.
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.
EED	Energy Efficiency Directive: a set of binding measures to help the EU reach its 20% energy efficiency target by 2020.
EFB	European Fiscal Board.
EIB	European Investment Bank.
EIB Digital and Skills Survey 2018 (EIBIS add-on module)	In 2018, the EIB conducted a survey of 1 700 firms in manufacturing and services in the European Union and the United States on the back of the EIB Investment Survey (EIBIS).
EIBIS	European Investment Bank Investment Survey.
EIF	European Investment Fund.
Employee stock options	A type of equity compensation granted by companies to their employees and executives. Rather than granting shares of stocks directly, the company gives derivative options on the stock instead.
EMTF	Effective marginal tax rate.
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, e.g. energy/GDP.

Energy only markets	Electricity markets that rely solely on the price signals from the day-ahead (wholesale) market.
Entrepreneurship	The process of designing, launching and running a new business.
EPEC	European PPP Expertise Centre.
EQI	European Quality of Government Index.
Erasmus+	EU programme to support education, training, youth and sport in Europe.
ERP	Equity risk premium: the excess return that investing in the stock market provides over a risk-free rate.
ESD	Energy Service Directive.
ESRB	European Systemic Risk Board.
ETS	EU emissions trading system.
EU	The 28 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.
EU-LFS	EU Labour Force Survey.
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	Factor augmented vector autoregressive model.
FCI	Financing condition index. 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).
FDI	Foreign Direct Investment.
Fintech	Financial technology: computer programs and other technology used to support or enable banking and financial services.

FiT	Feed-in tariffs: guaranteed payments made to households or businesses generating electricity from renewables for a predefined period.
Frontier firm	See "Leader firm".
FUII	Financing Union for Investment and Innovation.
Fully digital	Firms that have fully implemented at least one of four digital technologies in recent years (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.
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.
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.
GHG	Greenhouse gases.
GNP	Gross national product: the total value of goods produced and services provided by a country during one year, equal to the gross domestic product plus the net income from foreign investments.
HGEs	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.
HICP	Harmonised index of consumer prices.
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).
Hollowing out	The process by which the shares of total employment in high-ranked and low-ranked jobs in terms of wages have expanded relative to middle-ranked jobs over time.
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.
ICE	Internal combustion engine (usually driven by burning fossil fuels, e.g. oil or petrol).
ICT	Information and communications technology.
IEA	International Energy Agency.
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 Municipalities Survey captures urban transport, social housing, ICT, health, education and the environment.
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).
Innovative firms	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.
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; organisation and business process improvements (including restructuring and streamlining).
Internal finance	In the EIB Investment Survey (EIBIS), internal finance consists of internal funds or retained earnings (e.g. cash, profits).
Investment intensity	Investment expenditure per employee.
IPO	Initial public offering.
IPP	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.
IRENA	International Renewable Energy Agency.
IRR	Internal rate of return.
ISCED	International Standard Classification of Education: a statistical framework for organising information on education.
KIS	Knowledge-intensive sectors.
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).
Laggard firm	A firm that is not leading in terms of productivity and is not a leader firm (see definition of "Leader firm").
Large companies	Firms with at least 250 employees.
LCOE	Levelised Cost of Electricity: the unit cost of a generating asset over its lifetime.
Leader firm	The top 5% of the median number of firms in terms of total factor productivity (TFP), by industry, but across time.
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.
LIFE	"L'Instrument Financier pour l'Environnement" programme (the EU's funding instrument for the environment and climate action).
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.
Lighthouse investment	Investments that are ten times the average funding volume in a metropolitan area in a given year.
Low-carbon economy	An economy based on low-carbon power sources (i.e. not based on fossil fuels).
LPs	Limited Partners.
Low-technology manufacturing sectors	Sectors with NACE codes 1–18 and 31–32.
LULUCF	Land use, land-use change and forestry sector.
M&A	Mergers and acquisitions are transactions in which the ownership of companies is transferred 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.
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.
NAICS	North American Industry Classification System.
NAIRU	Non-accelerating inflation rate of unemployment: the specific level of unemployment that is evident in an economy that does not cause inflation to rise.
NAWRU	Non-accelerating wage rate of unemployment: the level of unemployment at which wage growth might be kept stable.
NBER	National Bureau of Economic Research.
NEET	Young person who is "Not in Education, Employment or Training".
NFCs	Non-financial corporations.
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".
OECD	Organisation for Economic Co-operation and Development.
Old	Firms more than ten years old.
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.

Partially digital	Firms that have partially implemented at least one of four digital technologies in recent years (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.
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.
PE	Private equity.
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.
PIM	Perpetual inventory method: used to estimate stocks of capital using investment flows. It is based on the idea that stocks constitute cumulated flows of investment, corrected for retirement and efficiency loss; it is calculated by type of assets, thus differentiating (at least) by categories such as dwellings, buildings, infrastructure, machinery, equipment, weapons and intellectual property products.
PISA	Programme for International Student Assessment.
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	Public-private partnership; purchasing power parity.
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, e.g. machinery and equipment.

PSM	Propensity score matching.
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 (i.e. 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, e.g. in the area of personal services. The result of RBTC would be greater job polarisation.
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.
Salton index	An index capturing the number of collaborative patents between countries i and j, normalised by the square of the product of the total patent count of both countries.
Scale-up	Start-ups 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.
Serial entrepreneur	An entrepreneur who continuously comes up with new ideas and starts new businesses.
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).
Skill-biased technological change (SBTC)	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.
Skill categories	Classification of staff based on their responses to the question: Thinking about all the staff you employ, could you estimate what proportion is mostly engaged in "routine" tasks/"manual" work?
Slack	The discrepancy between the volume of work desired by workers and the actual volume of available work. It describes the unmet demand for paid labour in the population.
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.
Southern Europe	Cyprus, Greece, Italy, Malta, Portugal and Spain.
SPV	Special purpose vehicle.
Start-up	A young firm with high growth ambitions.
Support processes	Processes supporting production, e.g. lighting, ventilation and compressed air production.
Tangible investment	Investment in, for example, land, business buildings and infrastructure or machinery and equipment, as defined in the EIB Investment Survey (EIBIS).
Tech sector	In the EU Industrial R&D Investment Scoreboard, the tech sector refers to electronic and electrical equipment; technology hardware and equipment; software and computer services.
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.
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.
VAT	Value added tax.
VC	Venture capital: a type of private equity focused on start-up companies with high growth potential.
WACC	Weighted average cost of capital.
WEF	World Economic Forum.
WEF Infrastructure Quality Score	Question from the World Economic Forum's Global Competitiveness Report: How would you assess general infrastructure (e.g. 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.
WGI	World Governance Indicators.
Young	Firms less than ten years old.

INVESTMENT REPORT
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The EU bank

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