

EXECUTIVE SUMMARY

Research and innovation (R&I) and their impacts on the economy and social prosperity: opportunities and risks

Economic growth has returned to Europe, but sluggish productivity growth, which largely depends on R&I, continues to hold back more robust growth ...

After years of economic and political crisis, resilient economic growth has returned to Europe, unemployment is falling and Europe is ready to set the foundations for its future. In order to solidify the recovery and ensure higher levels of prosperity, it needs to address its sluggish productivity growth, which has remained flat for almost a decade, and ensure that economic prosperity is widely shared and leads to a more cohesive society.

... a phenomenon that is common to other advanced economies, but is particularly acute in Europe and hinders its ability to bridge the productivity gap compared to the United States.

In recent years, despite the rise and emergence of many new technologies which hold the promise of large productivity gains, these gains have yet to fully materialise. This phenomenon, common to several advanced economies, and notably the United States and Japan, is particularly acute in Europe, although there are large differences across the Member States. Europe's labour productivity gap compared to the United States has not been bridged and remains nearly 12% lower, driven primarily by insufficient progress in particular segments of the economy, notably its inability to substantially increase its productivity levels in high-tech sectors and knowledge-intensive services that continue to be less productive and less present in Europe.

While R&I are crucial for new and better job creation, new technologies can increasingly, and more quickly, affect job and wage polarisation and income disparities.

While R&I spur the creation of new and better-quality jobs, and while overall employment rates remain high in Europe, the rise of new technologies, such as robotics and artificial intelligence, and the increase in task automation have led to some polarisation in the labour market. There has been a fall in the number of medium-routine jobs, estimated at around 9% in the European Union, and there is pressure on wage dispersion in several countries. This leads to market-led rising inequality, which increased more than 5% percent between 2007 and 2013. The broader development and implementation of many of these new technologies generates a risk of fast-paced and large-scope destruction of routine tasks with an accompanying risk of rising inequality, notably if new innovation-related jobs mainly benefit the smaller segments of the population. Overall, this trend in job and wage polarisation is likely to continue, if not accelerate, should divergences in innovation and productivity growth continue to grow across companies, sectors and countries, bringing consequences for greater inequality and the economic, social and political consequences associated with it.

These phenomena, while not new, seem to suggest deep changes in innovation dynamics ...

Against this backdrop, understanding the role and economic impacts of R&I is crucial, as they are the main drivers of productivity and economic growth, notably for advanced economies, and affect job-creation patterns and the demand for skills as well as overall income distribution and inequality.

Changes in the innovation landscape

... that are largely driven by long-term socio-economic forces, such as demographical changes in an ageing population, climate change, globalisation and digitalisation ...

Understanding the role and impact of innovation in our economies and societies primarily requires understanding the main forces shaping those innovations. Changing demographics, in an ageing population, climate change, the rise of globalisation and notably with digitalisation and digital technologies, that are merging the digital and physical spheres, are drastically altering the nature, mechanisms and impacts of the innovation process.

... that lead to faster pace, deeply transformative and increasingly science-based and complex innovations resulting in a higher concentration of benefits in particular firms, hindering innovation diffusion ...

Innovation, notably of the most disruptive type, is increasingly linked to the exploitation of synergetic elements stemming from the convergence of several technologies, very often enabled by digitalisation and more science and technology rich than recent digital innovations, such as application developments. These upcoming innovations, which bring the digital and physical spheres closer together, are based on several technologies that are not easy to master or to obtain off the shelf. To fully reap the benefits of innovation, a change in business models is needed, which usually requires the investment of substantial economic, and at times financial, capacity. Many disruptive innovations are being introduced quickly on to the market, bringing about complete game-change scenarios into increasingly converging industries and markets. This gives rise to new global superstar companies, notably in the United States, that are leading in all the market

capitalisation rankings. More precisely, among the top 15 largest global companies by market capitalisation, two – i.e. Facebook and Alibaba – did not even exist a decade ago, while others have since multiplied their market capitalisation by eight to twelve times, e.g. Apple or Amazon. Many of the benefits from innovations are being concentrated more and more in ‘winner takes most’ markets and industries, where innovation diffusion across firms tends to slow down. More precisely, recent research by the Organisation for Economic Co-operation and Development (OECD) has shown that productivity grew by a robust 30-40% among the most productive companies in the manufacturing and business-services sectors, from 2001 to 2013, respectively, while in the remaining companies, the rise in productivity was well below 10%.

... and that can explain recent trends in productivity and inequality and shed some light on future trends.

These changes in the nature of innovation are likely to be behind many of the productivity and inequality patterns currently observed and, beyond potential statistical mismeasurements, they are responsible for two facts. These are: the general slowdown in the impacts of recent innovations which may not be disruptive enough to support productivity increases; and, second, for the sharp increase in the differences in productivity growth across firms, within and across sectors, which suggests a slowdown in innovation dissemination.

A new way of analysing innovation performance is needed

Traditional analyses of R&I performance must become attuned to cater for the changing nature of innovation dynamics and the new ways through which innovation is spurring productivity growth and generating socio-economic impact ...

These changes in the innovation landscape are affecting how we analyse and assess R&I performance, notably in relation to how R&I is carried out and what determinants influence their ability to maximise socio-economic impacts. High-quality socio-economic innovation impacts are sought. Analyses should increasingly attempt to capture how R&I ecosystems deliver those innovation impacts and should aim to examine proxies for the speed of innovation diffusion while identifying bottlenecks which impede that diffusion.

... because, while we have yet to acquire a full understanding of all the drivers of innovation creation and innovation diffusion in this changing context ...

Currently, there are a number of empirical limitations in properly accounting for the impact of innovations. For example, there are no specific indicators that can be used to directly track and monitor innovation quality and innovation diffusion per se, although there are some good analytical proxies, such as high-growth transformational entrepreneurship or the dispersion of productivity growth across firms and sectors. Moreover, our understanding of the drivers and bottlenecks that influence the impacts and ability of high-quality innovation to accrue and diffuse must be further refined.

... there are, however, a number of factors which go beyond the traditional science and technology metrics, which are very important to provide a more nuanced picture ...

Notwithstanding these limitations, which bring a degree of uncertainty to the analysis of innovation performance and policy formulation, there is a set of factors that drive R&I performance. Investment in high-quality research, skills development, ICT or economic competences result in the production of high-quality scientific and technological outputs and innovations, and also enhance the ability to absorb technologies and innovations developed elsewhere, thereby facilitating the diffusion of innovation.

Moreover, innovation eco-systems that facilitate the flow of knowledge across innovation agents also help to improve the innovation quality and diffusion. Finally, good framework conditions for innovation are crucial to enable and foster innovation creation and diffusion; from effective regulation frameworks to well-functioning markets that facilitate the (re)allocation of resources to innovative and productive activities, or the availability and demand for risk capital that can finance high-risk projects, both at the inception and scale-up phases, of innovative projects.

... such as the analysis of: the role and impact of intangible assets, the development and deployment of a country's scientific excellence, the capacity of an economy to engage in transformational entrepreneurship¹ or the role of framework conditions, such as regulation, competition or access to risk capital, to spur innovation.

These factors have been and continue to be crucial to ensure high-impact innovation. However, in

1 Transformational entrepreneurship concerns those new businesses which, from the onset, have the ambition to become big and provide "disproportionately large contributions to net job creation" (Haltiwanger, 2014) and which invest more in R&D, proportionally, than older ones (Surowiecki, 2016). Very often, transformational entrepreneurship is opposed to subsistence entrepreneurship, the ambition of which is to gain some measure of financial independence, but not to scale up and grow in large numbers (Schoar, 2010).

the current context of fierce change in innovation dynamics, there are a number of aspects that are particularly important and which require a fresher and more nuanced analysis in order to get the correct picture of innovation performance:

- ▶ The importance of combining several types of innovation-prone assets to spur the creation and adoption of innovations, from R&D to ICT investment, to skills development or managerial and organisational skills changes. a 'silo approach', focusing solely on, for example, R&D or ICT performance in isolation may not provide a good basis for understanding the complexity of the innovation process.
- ▶ The enhanced role of skills and their development to support innovation and ensure the broader ability of a country to contribute to and benefit from innovations.
- ▶ Developing an upgrade of a country's science base is critical to spur and speed up scientific excellence and to nurture the development and adoption of disruptive innovations and technological performance.
- ▶ Knowledge flows and creating the conditions for stronger knowledge flows are increasingly important to support the building up of scientific excellence and its fast diffusion and transformation into innovations.
- ▶ Innovation-led entrepreneurship. While traditional indicators of entrepreneurship remain important, it is particularly important to monitor transformational entrepreneurship given that it deeply disrupts existing markets through innovation and is responsible for the creation of many new jobs.
- ▶ In the context of rapid change, where access to competitive factors, such as data, is rapidly shifting, framework conditions that allow for disruptive innovations to accrue, scale up and diffuse, are gaining in importance. This is particularly relevant in relation to: the availability of risk capital for innovation and entrepreneurship at all stages; regulations that enable (and do not hinder) innovation diffusion across sectors; well-functioning markets that allow for the rapid and frictionless reallocation of resources; and a level playing field through effective competition policy.

The EU's research and innovation performance

The Report presents a dedicated, nuanced and fresh analysis of R&I performance that defines a number of findings. Overall, Europe remains a global research and innovation powerhouse ...

Overall, Europe is a global R&I powerhouse and the leading economy in terms of public investment in R&D and the number of researchers. It is a front runner in terms of scientific productions, including high-quality publications² (nearly one-third of all high-quality publications worldwide are European), albeit not at the very top level³. More precisely, the EU accounts for one-fifth of the world's R&D investment, and 23% of the global public R&D. Moreover, with more than 1.8 million researchers, the EU is the economy with largest number of researchers, ahead of China and the United States, with 1.6 million and 1.3 million researchers, respectively.

... although it fails to invest as much as other economies, notably the United States, in business R&D, education and skills development, ICT and economic competences ...

Notwithstanding its public R&D investment capacity and scientific performance, Europe lags behind the United States, Japan South Korea and even China in private and overall R&D investment levels. In this respect, the EU accounts for less than one-fifth of the world's business R&D investment, in contrast to the United States or China which account for 28% and 24%, respectively. Business R&D intensity in the EU stands at 1.3% compared to almost 2% for the United States and nearly triple that for South Korea, at almost 3.5%. Also, in comparison to the United States, Europe trails behind in ICT investment which hinders its ability to reap the benefits of digitalisation, education or economic competences⁴.

... a trend that has been widening ...

This investment gap, notably for private R&D investment, has been widening in recent years, providing evidence of challenges that are hindering Europe's ability to bridge the investment gap in intangible assets. More precisely, while business R&D intensity held up well during the financial and economic crisis of 2007–2012, growing at around 2.5% on average annually, since then the annual growth rates have fallen to around 0.5%, well below the 2% in the United States and 3% in China.

... and is coupled with relatively weaker knowledge flows among stakeholders ...

In addition, and even if they have been rising over time, knowledge flows among stakeholders, which are partially influenced by, and the result of, lower investment levels among them, tend to be lower in Europe compared to the United States.

While on the rise, the share of open access publications, which help to spread excellence and knowledge diffusion, remains low in Europe (around 30%) compared to the United States (35%), as is the number of public-private co-publications, an indicator of science-based public-private co-operation, where Europe's score is half (30 public-private co-publications per million population) that of the United States (63.4). On a positive note, Europe is capitalising on the globalisation of science by tapping into international knowledge pools, as nearly half of its publications are the result of international collaborations.

... that affect Europe's technological and innovation output and results in it failing to capitalise sufficiently on its scientific capacity and scientific excellence.

These lower investment levels in many relevant assets for innovation and the somewhat lower

² High-quality publications are measured as the number of top 10% highly cited publications.

³ Excellent publications are measured as the number of top 1% highly cited publications.

⁴ Economic competences encompass brand equity, organisational capital and training.

knowledge flows among different stakeholders translate into Europe's limited ability to capitalise on its strong and excellent scientific base to spur technological development and innovation.

Despite being anchored in fields where Europe performs strongly, the proportion of patents in the economy, notably in emerging technology fields such as big data or the Internet of Things, is lower than in other economies and has been declining over time. Nonetheless, Europe's performance in patents in quantum computing and telecommunication is promising, linked to its strong scientific position in these areas. Europe also lags behind the United States and Japan in terms of the share of employment in knowledge-intensive activities in business industries, a broad proxy for innovation performance, where Europe gathers around 14% of the jobs in this category against 16-17% for the United States and Japan.

Moreover, weaker framework conditions for innovation and innovation-led entrepreneurship ...

More stringent labour and goods market conditions in Europe than in the United States and other advanced economies are hindering Europe's ability to effectively reallocate resources towards more innovative and productive activities. These rigidities lead to companies sinking in significant financial resources which can be regarded as unproductive and that do not exit the market at the necessary or expected speed. In this regard, the OECD estimates that around 16% to 19% of all available capital is sunk into unproductive companies in Italy and Spain. As a result, and even if the relationship between competition and innovation is far from linear, Europe's level of competition is continuously perceived to be lower than that of the United States, even if in the latter there has been an overall visible increase in the concentration of sales, employment and R&D in recent years.

This situation seems to persist despite significant progress in undertaking deep structural reforms in several Member States, a process that has

nonetheless recently lost momentum. Despite progress, Europe's market continues to be fragmented, notably in areas such as digital technologies, the provision of capital or services, which hinders the ability of companies to mobilise and scale up innovations quickly. Finally, while access to finance has drastically improved in Europe, leaving behind the worst periods of the financial crisis, risk capital, notably for growing and scaling up practices, continues to be very scarce, and at a fraction of that available in the United States.

... result in lower transformational entrepreneurship levels, despite a good performance in more traditional entrepreneurship indicators ...

With weaker framework conditions and a narrow capacity to translate its scientific excellence into technological performance and innovation, Europe appears capped in its ability to foster transformational entrepreneurship. The creation and scale-up of new companies that grow into global giants, and which seem to be reaping many of the innovation benefits across the world, is rather limited in Europe. While Europe scores relatively well on traditional entrepreneurship indicators, the gap with the United States is very large in both the number and relative importance of rapid high-growth companies, such as the unicorns, which are disrupting existing markets and largely reaping the benefits of innovation. More precisely, recent estimates point out that there were 20 private companies valued at US\$ 1 billion or more in Europe, while there were 106 in the United States and 50 in China.

... and affect Europe's ability to support the faster structural change of its economy towards more productive and innovative activities. This, in turn, influences its capacity to invest in intangible assets.

As a result of Europe's lower entrepreneurship and innovation capacity, its structural change towards a more knowledge-based economy able

to support higher productivity levels and larger investments in intangible assets is not progressing at the required speed. On average, the share of knowledge-intensive activities⁵ in the value added of the European economy grew by less than 0.5% annually from 2000 to 2015. As a result, in 2015, less than 50% of the European value added was produced in one of these sectors, while in the United States or South Korea the share was above this threshold. Decisive policy and strategy actions will be necessary to escape from this vicious feed-back loop.

However, this aggregate analysis masks large differences across the Member States ...

This aggregated analysis of Europe's R&I performance masks important national differences in terms of its capacity to support productivity growth at the current level of economic prosperity, investment and performance dynamics in the EU economies.

... and while the innovation divide persists in Europe, it is now more nuanced, notably for investment patterns ...

Overall, R&I tend to play a different role in spurring productivity growth depending on the stage of economic prosperity in the country concerned. While for some lower- and middle-income countries R&I can improve productivity, thanks to factors such as foreign direct investment (FDI), investment in infrastructure or the better functioning of markets, in the long run, research, innovation and entrepreneurship are key to spur productivity and growth.

The scientific and innovation divide in Europe used to be clearly divided between north and south and west and east. Although that division is still present, it is becoming much more nuanced, notably in terms of investment levels, where certain

countries have made significant progress to catch up and others have not. More precisely, Slovakia, Bulgaria, Poland and the Czech Republic have significantly increased their R&D investment intensity over the past decade. In some cases, e.g. the Czech Republic, this has allowed for a strong convergence towards the EU average. On the other hand, countries like Romania, Portugal and Spain have exhibited disappointing R&D investment-intensity records. It should be noted that in some countries, much of the progress has been driven by public efforts, e.g. Poland, and very often supported by European funding. This, of course, can cast doubts about the longer-term sustainability of these investments. It should not be overlooked that some countries building their R&I capacity have used their public R&I investments to improve not only their scientific capacity but, often to a lesser extent, technological output as well.

... although significant challenges in transforming investment into scientific and technological outputs still persist in restructuring systems.

However, this divide remains much more pronounced in terms of scientific and technological outputs than in terms of innovation. When it comes to scientific excellence, for example, the regional rankings continue to be solidly led by countries like the United Kingdom, the Netherlands, Denmark and Belgium, while Central and Eastern European Member States continue to significantly trail behind with values often as low as a third of the leading countries in the share of highly cited publications. This reflects the lower efficiency of the national R&I systems in the laggard countries in transforming R&D investment into scientific and technological output. While it is too early to clearly identify the real causes behind these proportionally weaker results, they may hint at particular bottlenecks which need to be addressed through tailored structural reforms to improve the quality and efficiency of the underlying national R&I systems.

5 Knowledge-intensive activities are defined as those in high-technology manufacturing, medium-high-tech manufacturing and knowledge-intensive services.

Policy implications⁶

Against the backdrop of the deep process of transformation in the nature and dynamics of innovation, and bearing in mind that robust evidence is still not always at hand, the analysis in this Report of Europe's R&I performance leads to a set of policy implications. Europe needs to:

1. Boost its investment in intangible assets

Enhancing public investment in R&I and other intangible assets can help bridge Europe's current investment gap compared to other economies. Active labour market policies aimed at developing the skills needed for a changing economy will contribute not only to spurring innovation but also to mitigating the risks associated with potential job losses which might be brought about by task automation. While Member States benefit from different fiscal spaces for public investment, those able to do so should invest more in intangible assets. In addition, this will bring spillover benefits to other countries. Member States that have experienced low or even declining public R&I investments should make it a priority to cement the basis of future growth on such investments. In addition, the leveraging of business R&D investment, an area in which Europe particularly lags behind, is critical. The right framework conditions for private companies to innovate must be in place.

2. Urgently rethink public support for R&I, notably for market-creating breakthrough innovations

Europe lacks sufficient investment in market-creating disrupting innovations, where private capital shies away. Supporting bot-

tom-up transformative innovative projects can bridge this gap. In addition, public R&D investment will benefit from moving away from supporting specific fields towards more comprehensive mission-oriented policy approaches that maximise the impacts of public R&D and galvanise private investment. Policy experimentation in these fields can help achieve more robust evidence about the impacts of these changes in public R&D funding.

3. Improve the conditions for speeding up knowledge creation and diffusion by opening up national science and innovation systems

Supporting investment in R&I and other intangible assets improves the economy's absorptive capacity and its ability to diffuse knowledge. Measures to open up science and innovation systems within Europe, and to the world, will support faster and stronger knowledge flows. Initiatives to build up the conditions for open science, thanks to the opportunities offered by digital technologies, and for open innovation, including through stronger science-business links, are critically important.

4. Ensure innovation-friendly regulations and innovation-demand policies that support transformative innovation and innovation diffusion across sectors

It is crucial to develop innovation-friendly regulations that facilitate the smoother adoption of innovations, notably in relation to the myriad of opportunities that digital technologies offer, across all sectors of the economy and specifically in relation to highly regulated sectors such as education, health or transportation. In addition, innovation-demand policies, such as public procurement or

⁶ The views expressed in this publication are the sole responsibility of the authors and do not necessarily reflect the views of the European Commission

the empowerment of consumers to develop consumer-based innovations will be critical. These actions will speed up the creation of benefits from innovation.

5. Rethink competition policy in a digitised economy

While sufficient evidence is still unavailable, it appears that changes in the innovation dynamics are leading to a higher concentration of innovation benefits and to the creation of potential monopolies or dominant positions in relation to the access and use of key new resources, such as data, and notably big data. This may have implications for ensuring a level playing field with equal opportunities for transformative innovations.

6. Complete the internal market in all sectors to support the rapid scale-up of European innovation

Europe's ability to scale up innovations is being hindered by an incomplete internal market, notably in strategic areas such as digital or services. Achieving that internal market in all areas is crucial to give innovations 'born in Europe' the opportunity to scale up and become global players.

7. Boost sufficient access to risk capital in Europe to support innovation

Risk and patient capital, while recovering, remain very low in comparison to the United States. Public efforts to invest and leverage private risk capital are crucial. Initiatives like the Capital Markets Union or the creation of a pan-European Venture Capital 'Fund of Funds' aiming at making European capital markets deeper, broader, better integrated and with greater capacity to leverage business resources will help bridge this gap.

8. Strengthen the pace of structural reforms and improve framework conditions for the creation, growth and orderly exit of firms, to unlock resources from unproductive companies

Continuing structural reforms that allow markets to react better and faster to the changes that innovations bring to the markets and which facilitate the entry, as well as the orderly exit of firms, will help reallocate resources towards the most innovative and productive companies, avoiding the negative lock-in of resources in unproductive and zombie companies.

9. Raise R&I capacity across the EU

Bridging the innovation divide in Europe in order to build the foundations of sustained growth across all Member States and regions will require renewed efforts to sustain investments in R&I and other intangible assets. It will also require the design, implementation and evaluation of the necessary accompanying reforms to boost the quality, efficiency and institutional capacity in R&I. The mobilisation of national and European resources towards these activities will bring scientific excellence and impactful innovation performance.

10. Europe must capitalise on the increasingly global innovation landscape by opening up its science and innovation to the world

As the global R&I landscape has changed profoundly with the rise of new innovation poles, Europe needs to ensure that it capitalises on all the new knowledge that is created around the world by building strong R&I partnerships and supporting the strengthening of R&I capacity in other countries, so that global knowledge can quickly expand and more countries can contribute to and benefit from global progress.

Avenues for future analysis

The current analysis has unveiled a number of areas where there is a lack of sufficiently robust evidence to underpin policy decisions. These include:

- ▶ How can public R&D investment better leverage private R&D investment? What role is there for mission-led public R&I to increasingly mobilise public and private R&D investments?
- ▶ How can investment in intangible assets support innovation and innovation diffusion and what mechanisms are in place at the microeconomic level?
- ▶ How can synergies between R&I, ICT, skills and social policies be best ensured for more impactful innovations with a wider sharing of benefits in society?
- ▶ How is the current level of innovation concentration, notably in the United States, affecting the creation of a level playing field where incumbents and new entrants can compete fairly? What role is there for regulation and competition policy, notably in relation to data use?
- ▶ How do labour and market regulations affect skills development and innovation diffusion in a digitised economy?
- ▶ How can R&I policy instruments best support the diffusion of innovation?

These are areas where we will continue to work to shed more light and reduce the uncertainty that the current changes in innovation dynamics are creating for the purpose of policy formulation.

The current Report presents profound insight into several of these areas in Part II.