

III. Digitalisation of the euro area economy and impact on resilience

This section examines how the ongoing digital revolution affects markets functioning and macro-economic outcomes, in particular the capacity of euro area Member States to withstand shocks. In product markets, the digital revolution is expected to strengthen cross-border production and trade, increase the share of tradable services in total output as well as to lower administrative burdens and capital costs of starting and operating a business. Nevertheless, increased knowledge flows from technologically advanced economies to developing economies may change existing comparative advantages, thereby potentially adversely affecting Member States' economic resilience if they are not accompanied by adequate structural reforms and investments. In labour markets, the digital revolution is expected to have an impact on employment composition, work organisation, wage setting and contract types. While these labour market developments may improve economic resilience, increased labour market polarisation, skills mismatch and a higher structural unemployment are important risks triggered by the skills-biased nature of digital technologies. In financial markets, digital payment systems and FinTech credit are likely to strengthen the capacity to withstand shocks as they broaden funding sources. The increased role of data and technology in the financial sector value chain and product mix also puts new requirements on regulators and supervisors that will need skills and expertise in this field if they are to implement their mandates effectively, supporting the opportunities emerging from digitalisation, while mitigating risks that may occur.

Given the potentially ambiguous impact of digitalisation, policies are needed to ensure that product, labour and financial markets function smoothly and efficiently and that Member States have the capacity to withstand macroeconomic shocks in an increasingly digital economy. It is also essential to promote wide-reaching innovation and investment. For the euro area, different rates of transition to the digital economy could prove a significant risk to convergence and macroeconomic stability. Due care is needed to ensure that the uneven distribution of the legacy of the crisis across the euro area does not hinder the smooth transition, as factors such as high indebtedness could limit Member States' capacity to adjust and innovate. ⁽⁸³⁾

III.1. Introduction

This section explores how the different dimensions of the ongoing digital revolution ⁽⁸⁴⁾ could impact euro area Member States' economies, including their growth potential and their capacity to convergence and withstand shocks. ⁽⁸⁵⁾ This analysis is based on a literature review rather than a rigorous analysis using, for instance, a dynamic general equilibrium model.

Digital technologies affect all dimensions of economic activity, not only in their specific new sectors, but also as they impact most existing activities, given their nature as general purpose technologies. However, understanding their net impact on growth and economic resilience is not straightforward. For instance, the main question remains unanswered whether digital technology will be able to foster a major revival in productivity growth. Even so, while digitalisation could lead to an increase in the demand for high quality jobs on the one hand, on the other, they can also create or strengthen monopoly power and impact income distribution and job opportunities, especially for the low-skilled.

For Member States in a currency union the potentially asymmetric nature of these effects risks being amplified, especially in the absence of adequate shock absorption tools, as these countries have fewer adjustment channels. This challenge is particularly significant as the ongoing transition towards the digital economy starts in a context where initial conditions in terms of digital

⁽⁸³⁾ This section was prepared by Raffaele Fagnoli and Eric Meyermans. The authors wish to thank Peter Kerstens, Werner Roeger and Lucia Vergano for useful comments.

⁽⁸⁴⁾ In this section "ongoing digital revolution" refers to the process whereby a broad range of socio-economic activities are being digitalised. Digitalisation should be distinguished from digitisation, with the latter referring to conversion of analogue information streams into digital bits, while the former refers to the way socio-economic interactions are restructured around digital communication and media infrastructures.

⁽⁸⁵⁾ Strengthening resilience entails acting on three elements: i) reducing the economies' vulnerability to shocks; ii) increasing their shock-absorption capacity; and iii) increasing their ability to reallocate resources and recover from the shocks. See, for instance, European Commission (2017), 'Economic resilience in EMU. Thematic discussions on growth and jobs. Note for the Eurogroup', September 2017.

infrastructure and skills vary strongly across euro area countries.

This section starts by briefly describing the key characteristics of the ongoing digital revolution that are relevant for this analysis. Sub-section 3 highlights relevant differences across the euro area Member States in the use and development of new digital technologies, and the challenges these may create for lagging countries to catch-up with the leaders and for the latter to be able to stay on the frontier of global innovation.

Sub-section 4 examines how the digital revolution affects product markets, in particular in terms of transformation of existing comparative advantages, location of production and international competition, thereby creating both new opportunities and challenges for economic resilience and potential growth. Special attention is paid to ongoing developments in global value chains (GVCs) and e-commerce.

Sub-section 5 explores the effects of the digital revolution on labour markets' notably on the composition of employment, wage setting and contract types as well as on total employment which is mainly driven by income and substitution effects.

Sub-section 6 briefly examines the consequences of technology-enabled innovation in financial services (i.e. FinTechs) on the financial sector. Here the focus is on digital payment systems, FinTech credit and virtual currency schemes. While FinTech firms are still facing national barriers to scale up services across the Single Financial Market they have a strong potential to strengthen Member States' economic resilience but also may pose new systemic risks. The last sub-section draws some policy conclusions, while recognising that there are still significant unknowns in this area.

Digitalisation also has a significant impact on public finance as the ongoing digital revolution erodes traditional corporate revenue sources. In turn, further digitalisation increases the opportunities to exploit the disconnection between where value is created and where taxes are paid. This affects tax revenues, with the effects unevenly distributed within and beyond borders. ⁽⁸⁶⁾

⁽⁸⁶⁾ Such loss of public revenue may occur when, for instance, digital companies operating in Europe have little or no physical presence

However, the analysis of fiscal transmission mechanisms falls beyond the scope of this section. ⁽⁸⁷⁾

Furthermore, secure network and information systems are essential to keep the online economy running. ⁽⁸⁸⁾ However, in a stronger digitally-connected economy, activities may become even more subject to cyber-risks making it more pressing to implement without further delay measures to mitigate such risks. ⁽⁸⁹⁾ Putting in place strong prevention detection, containment, recovery and repair mechanisms will help maximise benefits of digitalisation and minimise the risks from cyber-attacks. Nevertheless, an in-depth analysis of the impact of cyber-risks on economic resilience falls beyond the scope of this section. ⁽⁹⁰⁾

The macro-economic developments considered involve 'unknown-unknowns' making the subsequent analysis incomplete and potentially subject to major revisions if new information becomes available.

III.2. The ongoing digital revolution: from automation to artificial intelligence

The analysis in this section starts from the recognition that information and communication technology is a general purpose technology, therefore impacting the economy and society through multiple channels. ⁽⁹¹⁾ So far, the impact of

in Europe, or when new forms of work in the on-demand economy are subject to lower effective social security contributions. See also OECD (2015), Addressing the Tax Challenges of the Digital Economy, Action 1 2015, Final Report.

⁽⁸⁷⁾ On 21 March 2018, the European Commission proposed new rules to ensure that digital business activities are taxed in a fair and growth-friendly way in the EU. Two distinct legislative proposals were made aimed at i) reforming corporate tax rules so that profits are registered and taxed where businesses have significant interaction with users through digital channels and ii) introducing an interim tax which covers the main digital activities for which the mismatch between the place of taxation and value creation is the starkest (until the comprehensive reform has been implemented).

⁽⁸⁸⁾ See, for instance, High Level Group of Scientific Advisors (2017), 'Cybersecurity in the European Digital Single Market', Scientific Opinion 02, available at https://ec.europa.eu/research/sam/pdf/sam_cybersecurity_report.pdf

⁽⁸⁹⁾ As has been taken into consideration in the European Commission's Digital Market Strategy and its FinTech Acton Plan.

⁽⁹⁰⁾ See, for instance, High Level Group of Scientific Advisors (2017), *op cit*.

⁽⁹¹⁾ Generic features of a general purpose technology are that it can be used in a broad range of applications, that it has a wide scope for improvement and elaboration, and that it shows a strong complementarity with existing or potential new technologies. See, for instance, David, P. and G. Wright (2003), 'General Purpose

the digital revolution has come in two waves.⁽⁹²⁾ At its onset in the mid-1980s, the digital revolution was mainly characterised by automation of tasks that could be codified and by the physical fragmentation of the different stages of the production process such as in the case of global value chains.

In recent years, the digital revolution has entered a second wave, driven by a wide range of potentially disruptive technologies. Most of these are directly enabled by digital technologies or their development is driven by innovations in fields such as the low-carbon and circular economy⁽⁹³⁾ and key enabling technologies (KETs).⁽⁹⁴⁾

Building on digital innovations unleashed by the first wave, the second wave seems characterised by more pervasive and accelerated innovation trends which have the potential to further affect the economy by reshaping markets, production, business models, work organisation and public administration.

The digital revolution considered in this section is based on many innovations, which significantly differ in terms of stage of development, timeframe for widespread adoption, and their possible transmission channels on economics and social aspects. Even the understanding of their scope and potential impact is currently very diverse.

The overall impact of these technologies on the economy depends on their combination and interactions. Against this background, classifying the emerging technologies according to the sector of application, economic impact or technological features is not straightforward, and even the concept of a 'single' ongoing digital revolution is open to question. McAfee and Brynjolfsson (2017) have recently proposed a classification based on

the identification of three major ongoing 'revolutions', i.e. machine learning, digital platforms and crowd-sourced collaboration.⁽⁹⁵⁾

Machine learning embodies big data⁽⁹⁶⁾ and smart algorithms⁽⁹⁷⁾ in combination with strong computational power allowing for statistical pattern recognition which in turn enable computers to perform complex non-routine tasks. Examples of machine learning include language recognition and medical applications, as well as applications to hire workers or forecast demand for a particular service.⁽⁹⁸⁾

Digital platforms bring together buyer and seller who do not know each other before entering the platform.⁽⁹⁹⁾ They generate, accumulate and control an enormous amount of data that might constitute important inputs for other actors.

Crowd-sourced collaboration facilitated by digital platforms allows a single entity to engage resources spread across the world. For example, crowd funding is a way of financing businesses or any other activity from a variety of sources via digital platforms.⁽¹⁰⁰⁾

III.3. Differences across Member States, within a still fragmented Digital Single Market

Several factors continue to generate differences across the euro area Member States in terms of

Technologies and Surges in Productivity: Historical Reflections on the Future of the ICT Revolution', in David, P and M. Thomas (Eds., 2003), *Economic Future in Historical Perspective*, Oxford University Press.

⁽⁹²⁾ See, for instance, McAfee, A. and E. Brynjolfsson (2017), *Machine, Platform, Crowd: Harnessing Our Digital Future*, W.W. Norton & Company

⁽⁹³⁾ Including the circular economy, clean energy and low carbon economy initiatives underpinned by digitalisation like digital road solutions supporting the move towards zero emission mobility.

⁽⁹⁴⁾ KETs cover micro-/nano-electronics, nanotechnology, photonics, advanced materials, industrial biotechnology and advanced manufacturing technologies such as bio-based products, smart vehicles, sustainable construction and smart grids. See for instance http://ec.europa.eu/growth/industry/policy/key-enabling-technologies_en

⁽⁹⁵⁾ McAfee, A. and E. Brynjolfsson (2017), op cit.

⁽⁹⁶⁾ While no universal agreed definition exists, "big data" can be understood as "large routinely or automatically collected datasets, which are electronically captured and stored. It is reusable in the sense of multipurpose data and comprises the fusion and connection of existing databases for the purpose of improving performance." See, Gesundheit Österreich Forschungs- und Planungs GmbH (2016), 'Study on Big Data in Public Health, Telemedicine and Healthcare', Final Report

⁽⁹⁷⁾ In the absence of an explicit knowledge of the rules that govern tasks, smart algorithms allow to infer the tasks to be carried. For more details on such algorithms, see, for instance, Domingos, P. (2016), *The Master Algorithm : How the Quest for the Ultimate Learning Machine Will Remake Our World*, Ingram Publisher Services.

⁽⁹⁸⁾ See, for instance, The Economist, March 31 2018, Special Report on Artificial Intelligence in business.

⁽⁹⁹⁾ On two-sided digital platforms, which are the most common type of platforms, an intermediary brings together the two sides of a transaction whereby the volume of the transaction depends on the structure (and not only on the overall level) of the fees charged by the platform. See, for instance, Rochet, J and J. Tirole (2006), 'Two-Sided Markets: A Progress Report', *The RAND Journal of Economics*, Vol. 37, No. 3, pp. 645-667

⁽¹⁰⁰⁾ See, for instance, Yin X., Liu W., Wang Y., Yang C., Lu L. (2014), 'What? How? Where? A Survey of Crowdsourcing'. In: Li S., Jin Q., Jiang X., Park J. (eds), *Frontier and Future Development of Information Technology in Medicine and Education*, Springer.

their use and development of new digital technologies, and the speed at which they realise the full potential of the digital economy.⁽¹⁰¹⁾ Without being exhaustive, this section highlights briefly differences among euro area Member States in terms of digital performance, investment and other relevant macro-economic conditions, and how these affect key areas for the functioning of the Digital Single Market.

III.3.1. Digital performance divide

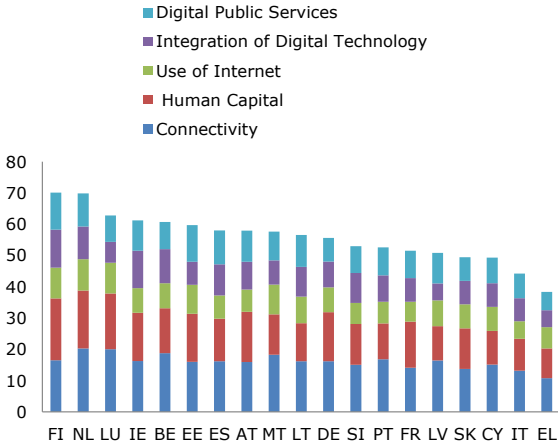
Graph III.1 shows the Digital Economy and Society Index (DESI) which covers Member States' performance in terms of the different dimensions of the digital economy.⁽¹⁰²⁾ The DESI indicator suggests that the variation across Member States is biggest in terms of human capital and integration of digital technology, while their ranking is comparable across other dimensions.

Further available evidence shows that R&D expenditures by the ICT sector continue to differ strongly across Member States in 2015 (Graph III.2). The highest levels (as percent of GDP) are recorded in Austria, Germany and Finland, and the lowest in Cyprus, Latvia and Lithuania.⁽¹⁰³⁾

III.3.2. Sluggish digital investment

To build the physical digital infrastructure, to produce new "intelligent" machines and to integrate new technologies in the production process significant and well-designed investment is needed.⁽¹⁰⁴⁾ However, aggregate data on investment do not seem to capture an increase in the rate of investment arising from the digitalisation process.⁽¹⁰⁵⁾

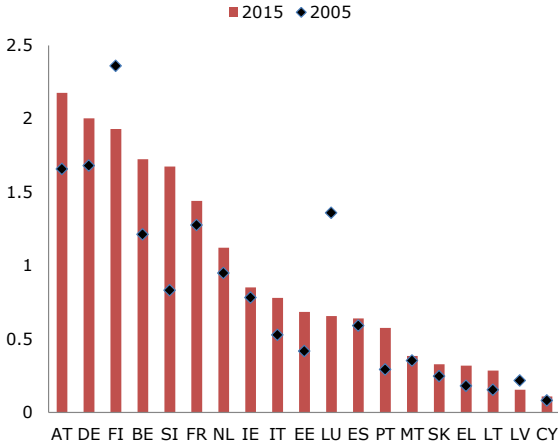
Graph III.1: The Digital Economy and Society Index (DESI) - 2018



(1) The Connectivity dimension measures the deployment of broadband infrastructure and its quality. The Human Capital dimension measures skills ranging from basic skills (that enable individuals to interact online and consume digital goods and services) to advanced skills (that empower the workforce to take advantage of technologies for enhanced productivity growth). The Use of Internet dimension measures the depth of online activities ranging from consumption of online content (music, games, etc.) to modern communication activities such as online banking. The Integration of Digital Technology dimension measures the digitisation of businesses. The Digital Public Services dimension measures the digitisation of public services.

Source: European Commission

Graph III.2: ICT sector's business expenditures on R&D (% of GDP)



Source: 2018 PREDICT Dataset.

Besides the sluggish cyclical investment recovery, the downward trend of business investment in non-residential assets across the euro area, experienced since early 2000, and the marginal increase in R&D investment (as a percent of GDP), which are the investments directly related to innovation, is at odds with the view that

⁽¹⁰¹⁾ In this section, 'digital economy' refers to the full range of our economic and social activities supported by the internet and related information and communication technologies.

⁽¹⁰²⁾ DESI is a composite indicator tracking the evolution of Member States' performance based on 30 indicators covering five dimensions: connectivity, human capital, use of internet, integration of digital technology and digital public services.

⁽¹⁰³⁾ The 2018 PREDICT dataset shows that in 2015, ICT sector's business expenditures on R&D was 3.3% of GDP in South Korea, followed by Japan (2.6%), Taiwan (2.4%) and US (2.0%).

⁽¹⁰⁴⁾ For instance, the Roland Berger Strategic Consultancy estimates that in order to become a leader in the Industry 4.0 revolution, Europe would need an average of additional 90 billion investment per year over the next 15 years.

⁽¹⁰⁵⁾ In 2017 total investment (as share of GDP) in the euro area was on average still about 0.8 percentage point below of the average level for the period 1995–2004 and well below the pre-crisis peak.

digitalisation could generate sizeable new investment.

However, recent research suggests that innovation does not only arise from investment in R&D activities but also from investment in intangible assets.⁽¹⁰⁶⁾ While tangible investments have suffered more from confidence and uncertainty shocks triggered by the financial and sovereign debt crisis, intangible assets have proved more resilient to cyclical conditions, maintaining their upward structural trend.⁽¹⁰⁷⁾

Although this type of investment could keep increasing in the future, their scalable nature and their strong potential for synergies and spill-overs suggest that intangible investment might not drive aggregate investment up since, as in the case of R&D investment, it is mainly only the leading firms that are enjoying a high rate of return on their intangible assets.⁽¹⁰⁸⁾

Indeed, investments in innovation are mostly concentrated in a small group of highly productive firms at the technological frontier while a large number of firms far from this frontier are trapped in a bad mix of low profits and low productivity and therefore are not willing or capable to invest more – as suggested by, for instance, Andrews et al. (2016).⁽¹⁰⁹⁾

Digital investment concentration could support the view that there is little scope for large investment opportunities in developed countries as digital innovation lacks the same revolutionary features of

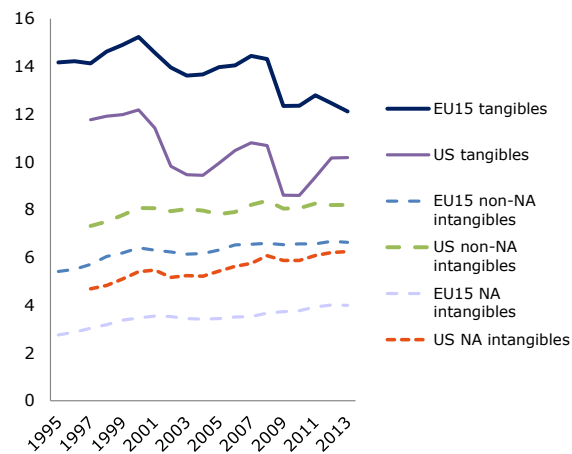
the old waves of technological innovation which gave raise to massive investment in physical capital in the last two centuries.⁽¹¹⁰⁾

Nevertheless, in the medium/long term, when digital technologies will be more mature and enjoy a much broader diffusion a higher rate of digital investment could follow as their adoption would be easier and profitable even for less advanced firms. Therefore, an increase of digital investment as well as its impact on the aggregate investment rate will depend on the speed of diffusion of digital technology in the coming years.

III.3.3. Other macro-economic factors

Other macroeconomic and structural differences may also affect the diffusion of digital technologies. For example, high public and private indebtedness levels, uncertainty over future regulation and economic outlook remain important factors that could hold back investments in digital technologies and their uptake. In turn, if protracted, the low investment levels could have an adverse feedback effect on the diffusion of digital technologies and hence on overall productivity growth and resilience.

Graph III.3: Investment in tangible and intangible assets, Eu 15 vs US



(1) Business sector non-residential GFCF by asset type, (% of business sector GVA).

Source: European commission, European Economy Discussion Paper No. 47.

Public finances may also have an impact on the diffusion of digital technologies. Indeed, while tax

⁽¹⁰⁶⁾ Corrado et al. divide intangibles investment into three broad categories: i) computerised information (software and database); ii) innovative property (scientific R&D, design, financial innovations) and iii) economic competencies (workforce training, improvements in organisational structures, marketing and branding. See Corrado, C A, J Haskel, C Jona-lasinio, and M Iommi (2016), “Intangible Investment in the EU and US Before and Since the Great Recession and Its Contribution to Productivity Growth”, *EIB Working Papers* 2016/08.

⁽¹⁰⁷⁾ Thum-Thysen A., et al. (2017) 'Unlocking Investment in Intangible Assets', *European Economy, Discussion Paper No.47*.

⁽¹⁰⁸⁾ Scalable means that firms can easily increase the return on their intangible without additional new investment. The synergies and spill-overs imply that, as in the case of R&D, most innovative firms benefit more from investment in intangibles than laggards. In addition, leaders might be most effective in assimilating knowledge from intangible investment undertaken by rivals, and in combining intangibles in a way that laggards cannot. For more details, see, for instance, Haskel, J, and S Westlake (2017), *Capitalism Without Capital The Rise of the Intangible Economy*, Princeton University Press.

⁽¹⁰⁹⁾ Andrews, D, Criscuolo, C and P Gal (2016), “Mind the Gap: Productivity Divergence between the Global Frontier and Laggard Firms”, *OECD Productivity Working Papers*.

⁽¹¹⁰⁾ See Cowen, T (2011), *The Great Stagnation: How America Ate All the Low-Hanging Fruit of Modern History, Got Sick, and Will (Eventually) Feel Better*, The Penguin Group.

revenues may suffer from the difficulties of taxing digital activities at the national level, public spending on areas such as education and lifelong learning, innovation, public digital infrastructures and cybersecurity are vital for reaping the full benefits of the digital economy. Hence, improving the overall composition of public finances would help to allow Member States to release more resources for investment in the digital economy. The creation of a fair taxation system that establishes a direct connection between the place where value is created and where taxes are paid and that reflects changes in working conditions could support the objective of securing sustainable public finances.

The demographic structure of a country could also hinder the integration of digital technologies into the production processes, if older workers have a lower propensity to acquire the skills necessary to meet the evolving needs of the labour market. ⁽¹¹¹⁾

Finally, regulations not directly related to the ICT sector, but with a direct impact on the functioning of markets may also act as a barrier to further digital development. For example, empirical research ⁽¹¹²⁾ suggests that overly strict employment protection legislation may deter firms from innovating in risky technologies and from investing in digital equipment (installing PCs, servers and extensions) because of higher costs in shedding workers if the project has to be closed down. ⁽¹¹³⁾

⁽¹¹¹⁾ Older employed persons may have a lower incidence of training for various reasons such as the period for amortisation of the investment in their skills is too short, because they are often perceived as being less adaptable, or because training contents and training forms are not in accordance with their training preferences such as training-on-the-job rather than participation in formal training courses. See, for instance, Thomas Zwick, T. (2015), 'Training older employees: what is effective?', *International Journal of Manpower*, Vol. 36, No. 2, pp.136-150.

⁽¹¹²⁾ See, for instance, DeStefano, T., De Backer, K. and L. Moussiégt (2017), 'Determinants of Digital Technology Use by Companies', *OECD Science, Technology and Innovation Policy Papers* No. 40 and Bartelsman, E., P. Gautier and J. de Wind (2016), 'Employment protection, technology choice, and worker allocation', *International Economic Review*, Vol. 57, No. 3, pp. 747-826.

⁽¹¹³⁾ Nevertheless, such effect may reduce in the future as cloud computing allows firms to access such infrastructure without making the initial costs. For the impact of product market regulation on ICT development, see, for instance, Conway, P., Janod, V. and G. Nicoletti (2006), 'Product Market Regulation in OECD Countries: 1998 to 2003', *OECD Economics Department Working Papers* No. 419.

III.4. Product markets: competition and information

From the first industrial revolution until the early-1990s, the volume of international trade between countries was to a large extent driven by the cost of transporting goods, while its composition reflected countries' comparative advantages. Innovations drove up productivity in developed industrialised economies which consolidated their comparative advantages in capital- and knowledge-intensive products. In this setting the slow and limited flow of knowledge favoured industrial concentration and specialisation across those euro area Member States which industrialised first.

Since the early 1990s, however, ICT innovations have contributed to dramatic changes in trade patterns by accelerating and broadening knowledge flows. In turn, falling communication and transport costs have led to a fragmentation and outsourcing of certain stages of the production process increasing the share of intra-industry trade in total trade better reflecting comparative advantages across countries and locations. Trade flows started to depend less on relative production costs of final goods and services but more on relative productions costs of intermediate goods along the value chain. ⁽¹¹⁴⁾

The ongoing digital revolution is expected to bring further changes in the organisation of production, such as more intense automation and data exchange in manufacturing and stronger service intensity.

These transformations have the potential to affect the existing comparative advantages of countries, including euro area Member States. The less innovative are more vulnerable to changes in international trade flows due to the risk of being cut out from the reshaping of global value chains.

III.4.1. Industry 4.0 and global value chains

Assessing the impact of the ongoing digital revolution on global value chains is not straightforward as it depends on two contrasting factors, i.e. fragmentation and centralisation of the production process.

⁽¹¹⁴⁾ The same factors triggered the development of regional value chains across EU Member States, in particular between old and new euro area Member States.

The convergence of the different technologies underlying the Industry 4.0 revolution⁽¹¹⁵⁾, could make complex and fragmented global value chains more efficient by reducing coordination costs. For example digital technologies allow smart factories to manage more efficiently complex logistic, distribution and production networks, including by widening offshoring opportunities.⁽¹¹⁶⁾

However, global value chains will continue to face other significant costs associated with production fragmentation. Such costs include long lead-time, low flexibility, instability in supply chains, unsatisfactory quality standards of foreign suppliers, cultural differences and communication problems.

In the future, these costs could exceed the benefits of fragmentation which in turn may decrease as emerging technologies, such as machine learning and robotics have the potential to replace or at least bundle together tasks that today are performed by low/medium skilled workers and outsourced across the global value chain. This would lower labour input costs and reduce the gains of locating labour-intensive stages of the production process in low-wage countries, potentially being a driver for significant reshoring.⁽¹¹⁷⁾

In addition, the application of technologies such as the developments of 3D printing could also further reduce production costs and favour small scale fragmented 'microproductions'. Moreover, as the use of 3D printers for certain manufactured goods increases the scope for tailoring the product according to customer preferences, the production of these goods is also likely to move closer to customer markets. This would then provide strong incentives for euro area firms to keep or move back production close to European markets, favouring the expansion of local value chains.⁽¹¹⁸⁾

These developments could favour those Member States already integrated in EU regional value chains, in particular those with relative comparative advantages in knowledge intensive stages of production would likely benefit from such reshoring. At the same time, the growing importance of customer market access and the relatively low factor price differential across euro area Member States could also lead to some concentration of manufacturing activities in fewer regions.⁽¹¹⁹⁾

III.4.2. An increasing share of tradable services

The new ways in which services are produced, distributed and consumed due to the digital revolution is likely to result in a higher share of tradable services in the economy and also impact economic resilience and potential growth, as the following examples illustrate.

New digital technologies tend to further increase the share of the pre- (such as design, R&D, finance, organisation) and post- (such as marketing, post-sales) production services in a product's value added, which blurs the distinction between manufacturing and service operations in the production process. They also open the way to a new form of fragmentation, this time in the service activities of the production process, for instance by means of digital devices such as 'telerobotics' and 'telepresence'.⁽¹²⁰⁾

At the same time, new digital technologies tend to strengthen the ongoing ICT-driven process of knowledge flows from technologically-advanced economies to developing economies that have the necessary network infrastructures and human capital needed for technology adoption.⁽¹²¹⁾ On balance, these ongoing developments exert additional pressure on those euro area Member States which had their comparative advantages in

⁽¹¹⁵⁾ The concept of Industry 4.0 also referred as smart factories or digital industry is about changes in the production process and along the value chain arising from the adoption of different technologies such as cloud computing, internet of things, artificial intelligence, robotics, big data, 3D printing.

⁽¹¹⁶⁾ Christopher, M and M. Holweg (2011) 'Supply Chain 2.0: Managing supply chains in the era of turbulence', *International Journal of Physical Distribution & Logistics Management*, Vol 41, No. 1.

⁽¹¹⁷⁾ Foerstl, K., Kirchoff, J.F. and L. Bals., (2016), 'Reshoring and insourcing: drivers and future research directions', *International Journal of Physical Distribution & Logistics Management*, Vol. 46, No 5.

⁽¹¹⁸⁾ Vyas, N. (2016), 'Disruptive technologies enabling supply chain evolution', *Supply Chain Management Review*, pp. 36-41.

⁽¹¹⁹⁾ As suggested by the New Economic Geography theory. See, for instance, Krugman P. and A. Venables (1990), 'Integration and the Competitiveness of Peripheral Industry', in C. Bliss and G. de Macedo (eds), *Unity with Diversity in the European Community*, Cambridge University Press/Centre for Economic Policy Research, pp. 56–75.

⁽¹²⁰⁾ Such devices allow labour services to be provided by workers without the need for their physical presence. See, for instance, Baldwin, R. (2016), *The Great Convergence: Information Technology and the New Globalization*, Harvard University Press.

⁽¹²¹⁾ Hallward-Driemeier M. and G. Nayyar (2018), 'Trouble in the Making? The Future of Manufacturing-Led Development', The World Bank Group.

the capital and knowledge intensive-stages of production.

Furthermore, digitalisation could also lead to an increase in cross-borders trading of previously non-tradable goods and services, such as certain types of business services, education and health care services. In turn, such developments create opportunities for euro area firms to diversify their sales markets. At the same time they may trigger productivity increases linked to the fact that firms open to international competitions are usually under a stronger pressure to innovate. Both these effects have a strong potential to strengthen the capacity of euro area Member States to absorb and recover from shocks.

Against this background, euro area countries with a more competitive and developed service sector seem better suited to benefit from the large increase in trade opportunities arising from higher tradability of services. While this would be a welcome development, it also runs the risk of strengthening the divergence with lagging euro area Member States.

III.4.3. The geographical location of digital services

New digital technologies that significantly lower fixed costs, such as cloud computing ⁽¹²²⁾, and/or the marginal cost of producing and delivering digital products at global scale such as digital platforms, make it easier for small actors to start a "global" business. ⁽¹²³⁾ In turn, the lower start-up costs and lower costs of operating a business, beyond increasing opportunities for SMEs, may strengthen an economy's capacity to recover when hit by an adverse shock. Nevertheless the magnitude of the shock can get bigger as small firms and 'start-ups' would be more at risk of exiting the market as they have weaker buffers to absorb shocks.

Several factors such as lower marginal costs in the provision of digital products, the increased share of digital services and strong knowledge flows, could give rise to a larger geographical dispersion of

economic activity. On the other hand, knowledge spillovers are likely to continue playing a key role - and possible even more - in attracting economic activities in highly innovative and concentrated regional clusters and cities. Indeed, smaller firms and individuals carrying out digital businesses and knowledge-intensive activities have stronger incentives to concentrate around regional innovative clusters with a view to benefitting from the innovations produced in the surrounding environment by larger enterprises and public research centres, but also to benefit from interactions with other innovative firms operating in adjacent parts of the value chain.

Overall, an increase in the share of value added concentrated into few innovative and more productive regional clusters and cities can be observed. ⁽¹²⁴⁾ In turn, this could lead to larger regional inequalities within and between countries, which would make Member States more vulnerable to shocks, while hindering the convergence process of those Member States lagging behind in digital transformation.

III.4.4. E-commerce

One immediate and very visible aspect related to the impact of ICT technologies on the economy is the rise of e-commerce. ⁽¹²⁵⁾

Available data shows that both the share of enterprises having an e-sales department and the turnover related to e-sales is increasing. While the share of turnover from e-sales remains still limited in the euro area ⁽¹²⁶⁾, it has doubled from 3% to 6% between 2011 and 2017 (See Graph III.4). In most countries, the majority of e-sales transactions take place between companies.

⁽¹²²⁾ Others are, for example, increasing automatization of certain pre-market services such as consultation and marketing, easier access to financial resources through crowdfunding and venture capital,

⁽¹²³⁾ Lund S. and J.Mankyla (2016), 'How Digital Trade is Transforming Globalisation', McKinsey&C, E15 Expert Group of the Digital Economy, Think Piece.

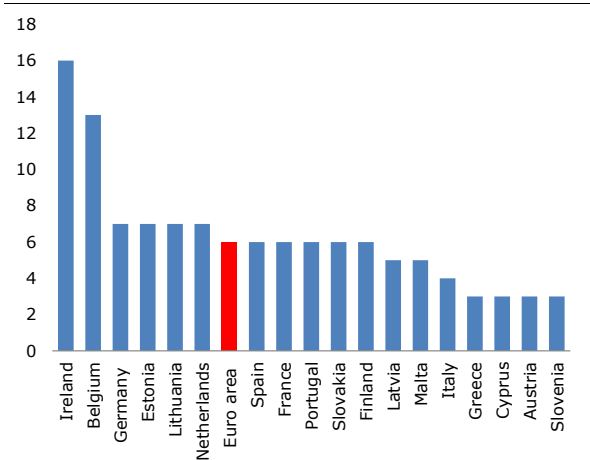
⁽¹²⁴⁾ See for instance Kolko, J (2010), "Urbanization, Agglomeration, and Coagglomeration of Service Industries", in Glaeser, E. L. (editor), *Agglomeration Economics*, The University of Chicago Press, pages 151-180.

⁽¹²⁵⁾ E-commerce can be defined as the sale or purchase of goods or services through electronic transactions conducted via the internet or other computer-mediated networks.

⁽¹²⁶⁾ Mainly due to barriers hindering the well-functioning of the Single Digital Market. A well-functioning Single Digital Market is built on trust between consumers and suppliers, affordable high-quality cross-border parcel delivery, absence of unjustified geo-blocking and limited VAT related burdens when selling across borders. See, for instance, European Commission (2015), 'A Digital Single Market Strategy for Europe', SWD (2015) 100 final; and European Commission (2017), 'A Connected Digital Single Market for All', SWD (2017) 155 final.

E-commerce can have a strong impact on the functioning of the market economy as it provides consumers easier access to a wider range of different products often sold at lower prices than in physical stores. Consumers and firms also profit from the business opportunities arising from the reduction of searching and in general of transaction costs, which allows them to explore markets without the constraint of geographical proximity. In turn, this may make demand for goods and services less vulnerable to idiosyncratic shocks.

Graph III.4: **Enterprises' turnover from web sales (% of total turnover)**



(1) Data for Luxembourg are not available.
Source: Eurostat, E-Commerce Statistics, Dec. 2017.

While the bulk of e-commerce still takes place through firms' own websites or applications, a growing share of transactions is likely to take place via digital platforms in the future, since this allows for further reductions of transactions costs compared to both traditional off-line commerce and on-line bilateral exchanges.

However, as the economy of digital platforms is based on network effects ⁽¹²⁷⁾, their developments could lead to market concentration and market dominance.

In certain sectors where production is concentrated in oligopolistic markets, the direct interaction between large on-line retailers and large producers can lead to a concentration of the producer surplus between these two agents. In addition, while online marketplaces theoretically expand market access

⁽¹²⁷⁾ Network effects imply that the larger the number of users on a platform, the larger the benefits it produces for all users, so that more users are attracted towards the platform.

opportunities for a large set of even small producers, they could also cause sales concentration across a fewer number of firms compared to what occurs with physical marketplaces as filtering criteria can lead to 'superstar effects'. ⁽¹²⁸⁾

As network effects generate positive externalities for users, stronger competition in the platform market would not necessarily be welfare enhancing, in particular for consumers, as this would reduce the network effects and the benefit they generate. ⁽¹²⁹⁾

Large firms and retailers seem to have benefitted most from e-commerce. ⁽¹³⁰⁾ However this may not necessarily be due to the nature of e-commerce per se, but to the more general abilities of large enterprises to profit from digital innovation, at least in a first phase. In this respects, countries where the share of large firms is bigger are in principle more fit to profit from e-commerce - at least in a transitional phase.

The overall macroeconomic impact of e-commerce remains ambiguous and difficult to assess at least in the short to medium run as the following examples illustrate.

⁽¹²⁸⁾ I.e. most popular products benefit from being in the top-ranking and keep attracting a larger share of buyers. However other authors argue that e-commerce, also favour long tail products - i.e. less popular products which attract a limited number of buyers because on-line marketplace can afford keeping such products on-sale while physical store cannot, due to space constraint. The final outcome of these two effects is somehow ambiguous, see, for instance, Brynjolfsson, E., Y. Hu, and M. Smith (2010), 'Long Tails Versus Superstars: The Effect of IT on Product Variety and Sales Concentration Patterns', *Information Systems Research*, Vol. 21, No. 4, pp. 736-747.

⁽¹²⁹⁾ See, for instance, Caillaud, B. and B. Jullien (2003), 'Chicken & egg: Competition about intermediation service providers', *Rand Journal of Economics*, Vol.3 4, No. 2, pp. 309-328. The emergence of the platform economy calls for a new competition policy approach looking at dynamic effects on innovation, market competition, long term consumer welfare, product variety, data portability. See, for instance, Coyle, D. (2018), 'Practical competition policy implications of digital platforms', Bennett Institute for Public Policy working paper no: 01/2018. Moreover, platforms operate under conditions of lively oligopolistic competition as the pace of technological progress has caused a relatively high birth and death rate of leading platforms in the last fifteen years. See for instance Evans P. and A. Gawer (2016), 'The rise of Platform Enterprises, A global survey', *The Emerging Platform Economy Series* No. 1, The Centre for Global Enterprise

⁽¹³⁰⁾ The share of large enterprises with e-sales department accounts is 44% while only 18% of small enterprises have e-sales department. This is also reflected in a larger share of turnover that large enterprises obtain from e-sales. Eurostat: E-commerce statistics December 2017.

First, while e-commerce may change the composition of consumption (e.g. more digital goods and services will be consumed), it also can foster an increase in total consumption, as it reduces trade and distribution costs, allowing all sectors and economic agents to benefit from lower retail prices. ⁽¹³¹⁾

Second, cross-sectorial shocks can materialise giving rise to temporary adjustment costs, which might lead to more persistent distributional effects. In fact, while there is evidence that traditional retailers also can profit from e-commerce opportunities by moving part of their business model on line, the sector could however be confronted with shrinking profit margins and, as a consequence, a number of existing retailers might be pulled out of the market. This may be reinforced by a shift of business opportunities from retailers to producers, as e-commerce lowers the barriers for the latter to operate on retail markets.

In this respect, Member States whose economic structures facilitate a swift reallocation of resources across sectors will be more resilient to absorb these shocks and avoid high transitional unemployment which could reduce on the positive aggregate impact of e-commerce on consumption.

Finally, e-commerce may also have a direct impact on reducing the costs associated with the changing of the prices of goods and service, i.e. so-called menu costs. ⁽¹³²⁾ Although these costs may be small, macroeconomic theory suggests that even small menu costs in an environment characterised by monopolistic competition may give rise to important business cycle fluctuations. ⁽¹³³⁾ As such, a further expansion of e-commerce could contribute to reducing business cycle fluctuations.

Nevertheless, available evidence ⁽¹³⁴⁾ seems to suggest that the impact of lower menu costs via e-commerce on business cycle fluctuations has been insignificant, so far.

III.4.5. Digitalisation, the price level and inflation

Digitalisation affects inflation in a direct way via its impact on the price of ICT goods and services that are part of the HICP basket. But this effect is small. For example, while prices for information processing equipment fell by more than 80% between 2001 and 2017 its weight in the HICP price index is only 0.5%. Furthermore, digitalisation also may pose important challenges for the measurement of inflation, as new goods and services are developed at an intensive pace, the quality of existing goods and services changes, and new types of product outlets emerge, as well as substitution effects from price changes. ⁽¹³⁵⁾

Digitalisation also affects the general price level in an indirect way. First, as e-commerce strengthens competition, the market power of sellers decreases. In addition, digital platforms also reduce transaction costs thereby creating additional room to lower prices. These effects induce a one-off decrease in prices – although as e-commerce is only gradually progressing, these decreases may be dragged out over time giving rise to lower inflation over that period. ⁽¹³⁶⁾

Nevertheless, in markets where sellers have strong market power, the information obtained about consumers (via, for instance, their browsing behaviour) can be used for price discrimination. Therefore, prices would not necessarily decrease. ⁽¹³⁷⁾ In addition, monopoly power on two-sided digital platforms may limit price flexibility if

⁽¹³¹⁾ See, for instance, Cardona M. et al. (2015), 'The Macro-economic impact of e-Commerce in the EU Digital Single Market', *European Commission JRC Technical Reports*.

⁽¹³²⁾ Nevertheless, Blinder (1991), 'Why are Prices Sticky? Preliminary Results from an Interview Study', *The American Economic Review*, Vol. 81, No. 2, pp.89-96 reports that "menu costs" is one of the factors that may trigger price stickiness, along with coordination failures (e.g. firms may be hesitant to be the first to change prices), service (e.g. the service provided such as delivering on time is also an important dimension of competitiveness) and contracts (e.g. firms' room for manoeuvre may be limited by implicit or explicit contracts).

⁽¹³³⁾ See, Mankiw, G. (1985), 'Small Menu Costs and Large Business Cycles: A Macroeconomic Model of Monopoly', *Quarterly Journal of Economics*, 100, pp. 529-537.

⁽¹³⁴⁾ See, for instance, Gorodnichenko, Y., Sheremirov, V. and O. Talavera (2015), 'Price setting in online markets: does IT click?', *Federal Reserve Bank of Boston Working Papers* 15-1.

⁽¹³⁵⁾ See, for instance, Hausman, J. (2003), 'Sources of Bias and Solutions to Bias in the Consumer Price Index', *Journal of Economic Perspectives*, Vol.17, No. 1, pp. 23–44

⁽¹³⁶⁾ Nevertheless, greater ease of price comparison online can already be a sufficient reason for brick-and-mortar retailers to speed up the lowering of their prices i.e., the so-called Amazon effect. See, for instance, Charbonneau et al. (2017), 'Digitalization and Inflation: A Review of the Literature', *Bank of Canada Staff Analytical Note* No. 2017-20.

⁽¹³⁷⁾ See, for instance, Shiller, B. (2014), 'First-Degree Price Discrimination Using Big Data', Department of Economics, Brandeis University.

intermediaries try to capture rents by raising fees for suppliers. ⁽¹³⁸⁾

The digital revolution may also foster stronger cross-border price convergence as it facilitates price arbitrage. ⁽¹³⁹⁾ In addition, global value chains expanding under the impulse of innovations in communication technology may make domestic inflation more responsive to developments in value chain partners. ⁽¹⁴⁰⁾

Digitalisation is also expected to increase productivity, which may lead to price decreases. If, in addition, the productivity gains are associated with employment losses (in the short- to medium turn), decreases in aggregate demand may put additional downward pressure on prices (in the short- to medium turn).

Finally, the effectiveness of monetary policy could also increase if monetary authorities get real time data at their disposal which may be facilitated by a more digital economy. ⁽¹⁴¹⁾ A more credible and effective monetary policy would help reduce the volatility of the economy and hence favour investment and growth.

III.5. Labour markets in the digital age

III.5.1. Employment composition and work organisation: automation and machine learning

Jobs are a coherent bundle of tasks which encompass routine tasks (that can be fully codified) ⁽¹⁴²⁾ as well as non-routine tasks requiring creativity, problem-solving and interpersonal skills. During the first wave of the digital revolution,

computers replaced mainly routine tasks while complementing non-routine tasks. ⁽¹⁴³⁾

Automation of routine tasks is expected to continue, and this is more likely to happen in specific areas. MGI (2017) ⁽¹⁴⁴⁾ estimate that about 5 percent of occupations can be fully automated with currently known technologies. ⁽¹⁴⁵⁾ Examining job profiles in 32 OECD countries, Nedelkoska and Quintini (2018) estimate that 14% of existing jobs have a probability of 70% or more to be automated. This includes primarily jobs requiring a low skill level such as food preparation assistants, assemblers and cleaners. As much as 32% of existing jobs, however, face a lower but still very high probability of automation of between 50 and 70%. This includes mainly jobs performing codifiable tasks in manufacturing such as machine operators and drivers. Instead, jobs requiring a high level of education, in combination with strong social interaction, creativity, problem-solving and personal care are estimated to have less than 30% chance of automation. This concerns about 26% of jobs. ⁽¹⁴⁶⁾

The expected employment impact of machine-algorithms that use big data to infer the tasks to be carried out is more ambiguous. On the one hand, they have the potential to replace non-routine tasks such as driving a car. On the other hand, they have the potential to complement knowledge workers such as the Internet of Things which may give rise to new forms of interaction between workers and machines.

At the same time, increased demand for knowledge workers may generate important local job-multiplier effects. For instance, Goos et al. (2015) estimate that for each high-tech job between 2.5

⁽¹³⁸⁾ The risk of market dominance on two-sided digital platforms could be limited by measures such as promoting the use of common standards. See, for instance, Rochet, J-C and J. Tirole (2006), 'Two-Sided Markets: A Progress Report', *The RAND Journal of Economics*, Vol. 37, No. 3, pp. 645-667

⁽¹³⁹⁾ At least, if barriers such as unjustified geo-blocking get effectively removed. See for instance the Commission's proposal to address unjustified geo-blocking, adopted by the Council in February 2018, at <http://data.consilium.europa.eu/doc/document/PE-64-2017-INIT/en/pdf>

⁽¹⁴⁰⁾ As argued in, for instance, Auer, A., Borio, C. and A. Filardo (2017), 'The Globalisation of Inflation: The Growing Importance of Global Value Chains', *CESIFO Working Paper* No. 6387.

⁽¹⁴¹⁾ Nevertheless, this will then call for carefully filtering and analysing large amounts of information. See, for instance, Sinclair (2015), 'What big data could do for economic forecasts', *World Economic Forum*.

⁽¹⁴²⁾ Levy, F. and R. Murnane (2004), *The New Division of Labor: How Computers are Creating the Next Job Market*, Princeton University Press.

⁽¹⁴³⁾ In line with the fall in the price of ICT equipment. See Autor, D. and D. Dorn (2013), 'The Growth of Low-Skill Service Jobs and the Polarization of the US Labor Market', *The American Economic Review*, Vol. 103, No. 5, pp. 1553-1597.

⁽¹⁴⁴⁾ McKinsey Global Institute (2017), 'A Future That Works: Automation, Employment, and Productivity'

⁽¹⁴⁵⁾ Focussing on jobs (rather than tasks), Frey, C. and O. Michael (2017), 'The future of employment: How susceptible are jobs to computerisation?' *Technological Forecasting and Social Change*, Elsevier, Vol. 114(C), pp. 254-280 estimate that about 47 percent of total US employment could be automated over about the next decade or two, whereby especially workers in transportation, logistics, office and administrative support workers, and production are at risk. Nevertheless, occupations labelled as high-risk occupations often still contain a substantial share of tasks that are hard to automate. See, for instance, Arnt et al (2016), op cit.

⁽¹⁴⁶⁾ See, for instance, Nedelkoska, L. and G. Quintini (2018), 'Automation, skills use and training', *OECD Social, Employment and Migration Working Papers*, No. 202.

and 4.4 jobs are created outside high-tech employment.⁽¹⁴⁷⁾ Such jobs are mainly for workers carrying out low-skilled tasks such as cleaning and gardening, which could in part offset the fall in demand for these jobs as identified by for instance Nedelkoska and Quintini (2018).

In addition, the digital platforms will give rise to new forms of work organisation whereby firms outsource tasks as in the case of the on-demand economy⁽¹⁴⁸⁾ or global value chains⁽¹⁴⁹⁾; while work organisation within firms will become more flexible through the use of digital devices such as virtual work places.⁽¹⁵⁰⁾

Such increased flexibility may then create opportunities for new types of employment which are more flexible, such as independent professionals⁽¹⁵¹⁾, or for other digital innovations such as telerobotics and telepresence that reduce significantly the need for physical presence to perform tasks.⁽¹⁵²⁾

Finally, digitalisation may also affect the composition of labour supply as it provides new opportunities for workers who face difficulties accessing the labour market. For example, digital innovations may enhance the functional capacities of certain people with disabilities, allowing them to perform tasks they otherwise would not be able to carry out. They also may provide parents digital platforms to better combine family and work responsibilities. Cloud-computing may reduce the barriers that the self-employed face to start their

own businesses as they no longer need to make heavy investments in ICT equipment.⁽¹⁵³⁾

These changes in employment composition and work organisation also are likely to impact economic resilience. For example, it is to be expected that a better-skilled labour force and more flexible work arrangements may improve an economy's capacity to absorb and recover from shocks.

Nevertheless, the increased flexibility of work organisation (mediated by digital platforms) may also carry downward risks if it results in an excessive job rotation within as well as between enterprises, which may adversely affect workers' incentives and opportunities to acquire firm-specific skills – and hence may lower productivity and capacity to withstand shocks.

Moreover, the hollowing out of the middle class due to the tasks-biased technological progress carries the risk that it may deprive the economy of a stable source of consumer spending and tax base. Furthermore, if the new organisational methods entail the diffusion of freelance work and this represents the only source of income, employees may be more at risk of income volatility (compared to workers with a standard contract) which may trigger precautionary savings.

Finally, if social security arrangements and taxes are different for employees and freelance workers, unchanged regulations in combination with a strong rise in freelance work may create new rigidities in job changes and pose important fiscal challenges.

III.5.2. Functioning of labour markets: skill mismatches and skill shortages

As discussed above, the digital revolution is expected to change the employment composition significantly and increase the mismatch between current skills and occupations and the new skills and job openings. For example, the European Centre for the Development of Vocational Training projects for the 2015-2025 period a strong growth in the demand for the high-skilled and elementary occupations, and a notable decrease in

⁽¹⁴⁷⁾ See, for instance, Goos, M., Konings, J. and E. Rademakers (2016), 'Employment Growth in Europe: The roles of innovation, local job multipliers and institutions', *KU Leuven VIVES Discussion Paper* No. 50.

⁽¹⁴⁸⁾ On-demand platforms link individuals with contingent or freelance tasks. Employers may have an incentive to engage in such platforms as the labour services resourced via a digital platform constitute a variable cost which makes it easier to maximise profits. In addition, it also facilitates the outsourcing of non-essential tasks (such as cleaning). Employees may participate in such platforms because it provides them more flexibility and opportunity to balance private and working life and this flexibility may be an incentive for some to enter the labour market. It may provide also additional income for those who already have a steady job. See, for instance, Microsoft (2018), 'The Future Computed Artificial Intelligence and its role in society'.

⁽¹⁴⁹⁾ See previous sub-section.

⁽¹⁵⁰⁾ See, for instance, Microsoft (2018), *op cit.*

⁽¹⁵¹⁾ Independent professionals (iPros) are self-employed without employees who are flexible and innovative and operate in high-value, high-knowledge professional sectors. See, for instance, Leighton, P. (2015), 'Future Working: The Rise of Europe's Independent Professionals (iPros)'.

⁽¹⁵²⁾ As discussed in the previous sub-section.

⁽¹⁵³⁾ See, for instance, Abadie, F. et al. (2016), 'The labour market implications of ICT development and digitalisation', Chapter 4 in European Commission (2016), *Employment and Social Developments in Europe report.*

the demand for mid-level skilled occupations. ⁽¹⁵⁴⁾ See Chart III.5. This may then pose important challenges which call for the adaptation of adequate learning and training systems.

At the same time, new digital tools may enhance skill matching. More particularly, digital platforms, such as on-demand and online talent ⁽¹⁵⁵⁾ platforms, lower significantly the cost to match employers with employees, while e-learning facilitates the capacity of employees to acquire and regularly update their skills. ⁽¹⁵⁶⁾

While still limited in size ⁽¹⁵⁷⁾, these digital platforms have a strong potential to strengthen job-matching. This may then also have a feedback on wages. On the one hand, while lower search costs may increase employees' job search intensity, it may also increase their reservation wage, as employees expect to receive more job offers as the cost to post a job vacancy decreases. In turn, a higher reservation wage may make employees more reluctant to accept a job offer and raise wages thereby putting upward pressure on equilibrium unemployment. On the other hand, the lower search cost may increase labour supply that may put downward pressure on wages.

At the same time, the ongoing digital revolution will also increase the ability of employers to monitor employee productivity – especially when

transactions are made on a digital platform. This could bring wages better in line with productivity, thereby lowering equilibrium unemployment and creating better incentives to raise productivity.

III.5.3. Total employment: income and substitution effects

The ongoing digital revolution will affect the demand for and supply of labour via several channels.

The displacement effect. First, the digital revolution is expected to increase productivity so that less labour is required to produce the same output level. ⁽¹⁵⁸⁾

The income effect. At the same time productivity increases may be translated into higher real wages and permanent income. ⁽¹⁵⁹⁾ This may then increase aggregate demand and in turn the demand for labour.

The expectations effect. The income effect may get reinforced if well-functioning financial markets allow agents to bring forward expected future productivity gains.

The labour supply effect. Real wage increases may induce a higher labour supply, limiting the upward pressure on wages.

The reallocation effect. Initially, prices are likely to fall and wages to rise in the sectors experiencing digitalisation but the additional income may be spent on a variety of goods and services raising employment in these sectors. ⁽¹⁶⁰⁾ In turn, this increased demand for goods and services in the other sectors may induce additional investments in these sectors, giving an additional boost to labour demand.

⁽¹⁵⁴⁾ Of course, in these projections the impact of digital revolution is only one of the many factors affecting future labour demand. Other factors include globalisation, demographic change and greening of the economy.

⁽¹⁵⁵⁾ Online talent platforms have the potential to lower search costs for both employers and employees - thereby improving job matching. See, for instance, McKinsey Global Institute (2015), 'A Labor Market that Works: Connecting Talent with Opportunity in the Digital Age'.

⁽¹⁵⁶⁾ In addition, skill matching can be spurred by lifelong-learning strategies and well-functioning labour markets along flexicurity principles in combination with a cross-border recognition of skills that facilitate cross-border mobility of workers, as foreseen in, for instance, in European Commission (2016), 'A New Skills Agenda for Europe. Working together to strengthen human capital, employability and competitiveness', SWD(2016) 195 final.

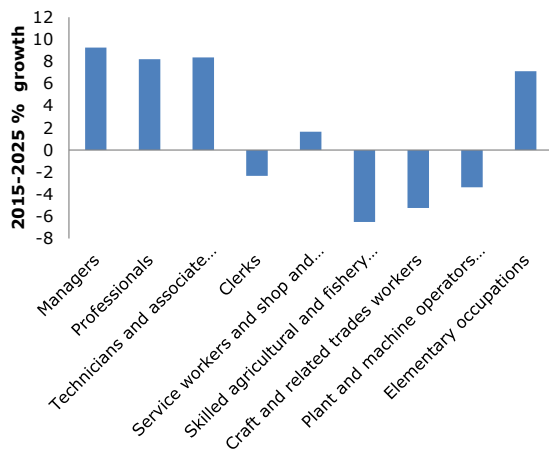
⁽¹⁵⁷⁾ No estimates of full-time equivalent number of jobs employed on the on-demand platforms in the euro area are available. Surveys suggest that it is less than 1% of labour force. See, for instance, Centre for Economic policy Studies (CEPS) and European Economic and Social Committee (EESC) (2017), 'Impact of digitalisation and the on-demand economy on labour markets and the consequences for employment and industrial relations'. Abadie, F. et al. (2016), 'The labour market implications of ICT development and digitalisation', Chapter 4, the European Employment and Social Developments Report state that platform service providers tend to be younger and more highly educated than the general population, work long hours on several platforms, earn below or just above minimum wages, and use the collaborative economy earnings as an income top-up.

⁽¹⁵⁸⁾ Digitalisation is expected to raise productivity via several channels including productivity improvements in the ICT sector, capital deepening in combination with an upgrade of workers' skills as well as network effects. See, for instance, Van Ark, B. (2014), 'Total factor productivity: Lessons from the past and directions for the future', *National Bank of Belgium Working Paper Research*, No. 271.

⁽¹⁵⁹⁾ Either because prices decrease or nominal wages and profits increase. Assuming no changes in bargaining power between labour and capital. Nevertheless, digitalisation may also raise concerns regarding the erosion of labour standards. See, for instance, McKinsey Global Institute (2017), 'Technology, jobs, and the future of work'.

⁽¹⁶⁰⁾ See, for instance, Autor, D. (2015), 'Why Are There Still So Many Jobs? The History and Future of Workplace Automation', *Journal of Economic Perspectives*, Vol. 29, No 3, pp. 3–30.

Graph III.5: **Employment growth by occupational groups**
Cedefop skills demand forecast



Source: European Centre for the Development of Vocational Training (Cedefop)

The uncertainty effect. However, in the absence of adequate labour market institutions and policies to accommodate a swift and smooth labour reallocation⁽¹⁶¹⁾, job uncertainty may increase, which in turn may lead to a rise in precautionary savings that would decrease overall demand and the demand for labour.

The labour income distribution effect. While productivity growth may support aggregate demand via its impact on domestic total income, its net impact also depends on its distribution. Indeed, as digital technologies are expected to complement high-skilled workers and replace the less-educated ones, income gains will flow primarily to the high-skilled. If the marginal propensity to consume of the higher income deciles is lower than that of the lower income deciles, aggregate demand may decrease.

The factor income distribution effect. In addition, downward pressure on the total amount of wages paid could strengthen if labour's bargaining power (compared to capital's bargaining power) would decrease as work organisation becomes more decentralised and less unionised by the use of digital platforms. Moreover, to the extent that

⁽¹⁶¹⁾ Such as the European Commission's New Skills Agenda for Europe. This strategy aims to help people thrive in fast-evolving workplaces; help companies access the talent they need to invest and innovate; ensure that everyone has a solid foundation of basic skills; look ahead to the skills needs of tomorrow; and ensure that skills and qualifications are more transparent and therefore better recognised across borders.

capital becomes more mobile a significant part of the productivity gains may accrue to non-residents who have a lower propensity to spend their income in the country where it was generated.

The international competitiveness effect. In a currency union without internal nominal exchange rates, cost competitiveness may also be affected if differences in productivity growth across Member States are not offset by corresponding differences in nominal wage growth. This could trigger changes in competitiveness between Member States, which in turn could lead to changes in external aggregate demand and subsequently the demand for labour.

The above effects do not all point in the same direction. Based on experience with previous general purpose technologies, it can be expected that in the short run the displacement effect would dominate, whereas in the long run the productivity effect would dominate. This is likely to impact on labour tax bases and revenues, which are a significant source of tax revenue in the euro area. However, the quality of framework conditions - including labour market institutions - is likely to affect the strength of the impact and the speed of adjustment.

III.6. Financial markets: FinTech's impact

Digital technological innovations including artificial intelligence, network computers, big data and distributed ledger technologies (blockchain) may give rise to the development of new financial products and services as well as new business models - provided barriers get removed or at least lowered.⁽¹⁶²⁾

FinTech innovations that could support economic resilience and potential growth include digital payment systems facilitating trade across borders, as well as a more diversified supply of credit at a lower cost. Nevertheless, in this respect, it remains crucial to make the financial sector more cyber resilient by ensuring that financial services are delivered effectively and smoothly across the EU, and that consumer and market trust and confidence are preserved - as is one of the

⁽¹⁶²⁾ See, for instance, European Commission (2018), 'FinTech Action plan: For a more competitive and innovative European financial sector', COM(2018) 109/2, which identifies as an important barrier a lack of common approaches between national regulators and supervisors.

objectives of the European Commission's FinTech Action Plan.

Finally, FinTech innovations may also carry important risks in terms of overall financial stability; while the added value of virtual currency schemes to the well-functioning of financial markets can be regarded as non-existent.

III.6.1. Lowering barriers

With the aim of lowering barriers and help the financial industry make use of the rapid advances in technology such as blockchain and other IT applications and strengthen cyber resilience, the European Commission launched the FinTech Action Plan in March 2018. The Action Plan has three main objectives: i) to support innovative business models to scale up across the single market; ii) to encourage the uptake of new technologies in the financial sector; and to iii) increase cybersecurity and the integrity of the financial system. ⁽¹⁶³⁾

Clear and consistent licensing requirements are a foundational requirement for supporting the scaling up of innovative business models across the single market. This applies to both new business models such as crowdfunding platforms for which the European Commission presented a new legal framework, or the emergence of crypto-assets and Initial Coin Offerings, as well as the use of flexibility and proportionality in existing regulatory frameworks governing activities such as banking, investment firms, payment services, e-money services, etc. Technology based solutions are also highly dependent on standards, interoperability and open application programming interfaces. Scaling up digital financial services across the EU requires a determined effort in this respect. Also the use of innovative and alternative methods of supervision through innovation facilitators, hubs and sandboxes has an important role to play in scaling up activity, both from the perspective of market participants and for regulators and supervisors as a means to acquaint themselves with new technologies and business models.

Digitalisation of finance across the EU also requires new technologies to be implemented in

the financial sector across all Member States. Regulatory and supervisory hesitations and lack of familiarity with new technologies may hinder the take-up of innovations, especially where financial institutions require approval, endorsement or at least non-opposition from their supervisors for implementing innovations in their operations or product and service offerings.

Finally, further digitalisation also requires a reviewing for existing rules and requirements for unjustified obstacles to financial innovation as a result of regulation acting as an enforced standard that reflects or requires dominant designs and business models or product features that have emerged in previous innovation cycles. This applies for example to the use of cloud computing service providers by financial institutions or the promotion and application of distribution ledger technology and blockchain based solutions in the financial sector. Financial regulators and supervisors therefore also need to build the required skills and expertise that go beyond familiarity with traditional economic or financial risks such as credit, market or liquidity risk, and that also cover technology governance and the risks and opportunities inherent in the advanced use of technology and data.

Digitalisation of finance raises increased concerns and interest in cybersecurity as an essential pre-condition for technology and data based financial services provision to develop across the EU. Building on horizontal and cross-sector cybersecurity policies, attention should also be given to the special role of the financial sector as both among the most mature but also the most attacked sectors. Advanced threat intelligence sharing, a detailed review of ICT security and governance requirements and associated supervisory practices and the development of a coherent cyber resilience testing framework for financial institutions and infrastructures all play an important role here.

III.6.2. Digital payment systems

Traditional cross-border payments, especially those crossing euro area borders, involve high transaction costs and inefficiencies. ⁽¹⁶⁴⁾ These high costs

⁽¹⁶³⁾ For more details on the Action Plan, see https://ec.europa.eu/info/publications/180308-action-plan-fintech_en

⁽¹⁶⁴⁾ Cross-border payments involve mainly large correspondent banks facing significant variable and fixed costs (IMF Staff Team (2017)). These costs include building the capacity to take on credit risks, maintain liquidity in foreign accounts as well as carry fixed

reduce competitiveness in retail markets, especially for SME's. Furthermore, inefficiencies create, among other problems, uncertainty over settlement timing and associated foreign exchange risks, which are major barriers especially for large enterprises. ⁽¹⁶⁵⁾

Well-functioning digital payment systems, which link the payer and the online merchant via the payer's online banking module (like PayPal), may contribute to a more integrated and efficient European payments market. ⁽¹⁶⁶⁾ In turn, better functioning payment schemes increase consumer choice not only with respect to the type of goods and services, but also with respect to the location of the provider. Hence, as FinTech payment systems are expected to lower these transaction costs, small and large businesses will gain the opportunity to further diversify their sales markets, and, in that way also strengthen the economy's capacity to withstand idiosyncratic shocks.

Nevertheless, digital payment platforms may also be subject to systematic risks such as an external shock that triggers a crisis of confidence or failure of a major participant. ⁽¹⁶⁷⁾ Addressing such challenges calls for a number of measures including enhanced cooperation and information exchange between national authorities in the context of authorisation and supervision of payment institutions, ⁽¹⁶⁸⁾ and a better understanding of the vulnerabilities of emerging payment systems. ⁽¹⁶⁹⁾

III.6.3. FinTech Credit

While in 2018 the size of FinTech credit is still small compared to traditional banking credit ⁽¹⁷⁰⁾, FinTech is expected to give rise to faster, cheaper and more efficient business processes ⁽¹⁷¹⁾ that in turn may strengthen economic resilience.

For example, FinTech technologies make it easier to enter the market which increases competition and lowers monopoly rents. At the same time, the application of FinTech technologies, by using of big data algorithms, might help provide small-scale loans at a lower fixed-cost than traditional banks, ⁽¹⁷²⁾ thereby not only potentially lowering the cost of finance but also broadening credit supply and promoting social inclusiveness. ⁽¹⁷³⁾

By using big data analytics to assess creditworthiness, FinTech firms can provide credit at a lower cost. However, no firm evidence that such tools are more effective is yet available.

Crowd-funding has the potential to act as a catalyst in a recovery phase by facilitating, for instance, the entry of new firms that need start-up capital or complementing firms' other forms of traditional financing, bringing in new sources of funding that might otherwise remain outside the usual financial market channels. ⁽¹⁷⁴⁾

Nevertheless, while digital financial services rely on volume, economies of scale and network effects, possible differences in national regulation across euro area Member States remain an important barrier to fully realise this potential. ⁽¹⁷⁵⁾

Moreover, FinTech credit may also pose risks in terms of the stability of the financial system ⁽¹⁷⁶⁾ – notwithstanding that such risks could also be associated with traditional credit provision. For example, a pro-cyclical credit provision could arise if lending standards would weaken during an economic boom. This risk is especially strong if FinTech credit provision were to occur outside of

costs in back-office operations. See, for instance, IMF Staff Team (2017), op cit.

⁽¹⁶⁵⁾ See, Committee on Payments and Market Infrastructures (CPMI) (2018), Cross-border retail payments.

⁽¹⁶⁶⁾ As, for example, foreseen in Directive (EU) 2015/2366 of the European Parliament and of the Council of 25 November 2015, on payment services in the internal market.

⁽¹⁶⁷⁾ See, for instance, Pauget, G. (2016), 'Systemic risk in payment', in Banque de France, *Financial Stability Review*, No. 20.

⁽¹⁶⁸⁾ See, for instance, Payment services Directive 2015/2366.

⁽¹⁶⁹⁾ See, for instance, Pauget, G. (2016), op cit.

⁽¹⁷⁰⁾ As surveyed in, for example, FSB and BIS (2017), op cit.

⁽¹⁷¹⁾ Draghi, M. (2017), 'Into the future: Europe's digital integrated market', Opening remarks by Mario Draghi, President of the ECB, at the Joint ECB and European Commission Conference.

⁽¹⁷²⁾ See, for instance, FSB and BIS (2017), op cit.

⁽¹⁷³⁾ Because of lower transaction and information costs FinTech makes financial services more accessible for people with low-income. See, for instance, FSB (2017). The lack of access to financial services reinforces the risk of social exclusion as it prevents people from getting a job, creating a business and accessing to other services. See European Commission (2010), 'The European Platform against Poverty and Social Exclusion: A European framework for social and territorial cohesion'.

⁽¹⁷⁴⁾ Nevertheless, still in its initial phase several issues still need to be addressed to get crowd-funding reach its full potential, including protection of intellectual property, combatting fraud, addressing consumer protection concerns and issues of legal uncertainty. European Commission (2014), 'Unleashing the potential of Crowdfunding in the European Union', COM(2014) 172 final.

⁽¹⁷⁵⁾ See, for instance, European Commission (2018), op cit.

⁽¹⁷⁶⁾ See, for instance, Financial Stability Board (FSB) and Bank for International Settlements (BIS) (2017), 'FinTech credit. Market structure, business models and financial stability implications'; and IMF Staff Team (2017), 'Fintech and Financial Services: Initial Considerations', IMF Staff Discussion Note, SDN/17/05.

the purview of financial regulation and supervision that is not tailored to the specific characteristics of FinTech firms. ⁽¹⁷⁷⁾

These risks may be reinforced by the digitalisation process itself, if overly optimistic expectations about future productivity gains brought by the new technologies were to lead to an excessive accumulation of debt - partly fuelled by less regulated and supervised FinTech firms.

III.6.4. Virtual currency schemes

Distributed ledger technologies have also given rise to virtual currency schemes. ⁽¹⁷⁸⁾ However, so far such schemes have proven to be volatile, risky and energy intensive which makes them unsuitable as investment, savings or retirement planning products. ⁽¹⁷⁹⁾

This is mainly because virtual currency schemes lack an authority (or private issuer) that guarantees their stability. ⁽¹⁸⁰⁾ The legal status of virtual currency schemes remains unsettled. The applicability or not of existing EU legislation and regulation requires a careful and case-by-case assessment of the precise facts and circumstances surrounding each virtual currency scheme and the legal and natural persons providing the virtual currency related services. In addition to legal uncertainty on rights and obligations associated with specific virtual currencies, service providers in this field still face severe operational problems affecting the transparency and integrity of the price formation process, the security of the system or its availability to users who due to operational and cyber incidents and limitations have found themselves unable to access their assets and buy or sell virtual currencies. Information made available to consumers is in most cases incomplete, difficult to understand, or does not properly disclose the risks. ⁽¹⁸¹⁾

Furthermore, as its supply is fixed (or growing at a constant rate) no lender of last resort support is available in times of a liquidity crisis - which undermines its long-term credibility. ⁽¹⁸²⁾

Virtual currencies saw a dramatic price increase in the course of 2017, reaching a peak of global market capitalisation estimated to be in the 800 bn US\$ range, before deflating and settling in the 300 bn US \$ range in the year 2018 to date. At this size, and given the relative isolation between traditional financial markets and virtual currency markets with an absence so far of significant transmission channels, virtual currency markets at this stage do not present a financial stability risk, as confirmed by the Financial Stability Board. ⁽¹⁸³⁾ This situation may, however, change, especially as financial institutions and institutional investors start engaging in the market for example through the development of synthetic crypto-assets and crypto-asset derivatives. For example, crypto-assets may be used as collateral or strongly leveraged so that when their volatile price drops significantly it could trigger instability as margin calls intensify and wealth losses adversely affect agents' solvability. ⁽¹⁸⁴⁾ It was the risks to investors that motivated the European Commission to request the European Supervisory Authorities to issue warnings about the speculative market environment and other risks associated with crypto-assets. ⁽¹⁸⁵⁾

⁽¹⁷⁷⁾ See, for instance, FSB and BIS (2017), op cit.

⁽¹⁷⁸⁾ I.e. "a digital representation of value, not issued by a central bank, credit institution or e-money institution" as defined in ECB (2015), 'Virtual currency schemes – a further analysis'.

⁽¹⁷⁹⁾ See the European Supervisory Authorities for securities (ESMA), banking (EBA), and insurance and pensions (EIOPA) pan-EU warning about the great risks of virtual currencies at <https://www.eba.europa.eu/documents/10180/2139750/Joint+ESAs+Warning+on+Virtual+Currencies.pdf>

⁽¹⁸⁰⁾ Mersch, Y. (2018), 'Virtual or virtueless? The evolution of money in the digital age', lecture delivered at the Official Monetary and Financial Institutions Forum, London.

⁽¹⁸¹⁾ See, ESMA, EBA and EIOPA op cit.

⁽¹⁸²⁾ De Grauwe, P. (2018), 'Bitcoin is not The Currency Of The Future', *Social Europa* (January 2018)

⁽¹⁸³⁾ For more details, see <http://www.fsb.org/2018/06/fsb-assesses-financial-vulnerabilities-and-takes-stock-of-actions-under-its-2018-workplan/>

⁽¹⁸⁴⁾ See, for instance, Merch (2018), op cit.

⁽¹⁸⁵⁾ Warning to consumers on Virtual Currencies. EBA/WRG/2013/01

<https://eba.europa.eu/documents/10180/598344/EBA+Warning+on+Virtual+Currencies.pdf>; EBA Opinion on Virtual Currencies – EBA/Op/2014/08

<https://www.eba.europa.eu/documents/10180/657547/EBA-Op-2014-08+Opinion+on+Virtual+Currencies.pdf>; ESMA alerts investors to the high risks of Initial Coin Offerings – ESMA50-157-829

https://www.esma.europa.eu/sites/default/files/library/esma50-157-829_ico_statement_investors.pdf; ESMA alerts firms involved in Initial Coin Offerings (ICOs) to the need to meet relevant regulatory requirements – ESMA50-157-828

https://www.esma.europa.eu/sites/default/files/library/esma50-157-828_ico_statement_firms.pdf; ESMA, EBA and EIOPA warn consumers on the risks of Virtual Currencies – 12 February 2018

<https://www.eba.europa.eu/documents/10180/2120596/Joint+ESAs+Warning+on+Virtual+Currencies.pdf>

III.7. Conclusion

A general finding of this section is that the macro-economic effects of the ongoing digital revolution go in different directions and that digital structural reforms can affect macro-economic outcomes, including on Member States' economic resilience, growth potential and relative convergence.

The impact of the revolution will manifest itself through cyclical and permanent effects that may well be different across Member States, potentially leading to divergent outcomes. To avoid this, and rather build on the opportunities provided by the digital revolution, it seems crucial to continue efforts to reinforce convergence towards resilient economic structures across the euro area.

First, it is important to quickly overcome the uneven distribution of the legacy of the crisis across the euro area, as this could hinder the smooth transition towards the digital economy. Several factors, such as high indebtedness and a sustained lack of investments, may limit Member States' capacity to adjust and innovate and fully benefit from the opportunities of the digital revolution.

In addition, as the ability to absorb shocks during the crisis differed significantly among countries, the temporary effects linked to digital transformation could crystallise into larger structural differences across Member States.

An important risk in this regard could emerge if the speed at which the diffusion of digital technologies leads to great differences in the speed at which economies transit to the digital economy.

Hence, improving the regulatory framework and completing the Digital Single Market remain pressing policy challenges to foster access to online activities under conditions of fair competition.

Furthermore, the digitalisation process also has the potential to transform existing comparative advantages worldwide and to affect potential growth and convergence. As such, not only lagging euro area Member States will have to catch-up with the leading ones, but the leaders will have to transform with a view to maximising the opportunities created by knowledge-intensive activities. This calls for policies aimed at promoting wide-reaching innovation and investment and tackling remaining structural rigidities.

The ongoing digitalisation process calls also for a strengthening of labour markets to support smoother transitions into the new job opportunities, as well as building up skills and expertise on the part of financial regulators and supervisors that will see the nature of the firms and activities they supervise undergo substantial change, with the role of technology and data in the financial value chain and risk and opportunities mix becoming substantially more outspoken. Importantly, Member States, businesses and individuals will need to invest more in training in digital skills across the whole spectrum of education and training so that machine-learning complements the tasks of skilled workers rather than displace them, while mitigating at the same time the risk of further labour market segmentation.

Finally, the available evidence suggests that FinTech has the potential to both strengthen the economic resilience of euro area economies, and to trigger new macro-economic risks. A key challenge is therefore to create a regulatory framework that enables the euro area's financial sector to take full advantage of these digital technologies while keeping a hold on these risks.