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Can R&I save the day? A fair, green and digital recovery from COVID-19

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Can R&I save the day? A fair, green and digital recovery from COVID-19

Lukas Borunsky, Ana Correia, Roberto Martino, Ruzica Rakic and Julien Ravet (DG R&I)

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POLICY MESSAGES

- Policy support to stimulate R&I on COVID-19 is essential. There is a need to coordinate with various R&I actors to address the COVID-19 pandemic and steer proper R&I response.

- The impact of this crisis on R&I investment can be smoothened by supportive policy packages to businesses.

- It is essential to kick-start the economy, help private investment and capitalise on innovative responses to the pandemic, e.g. through targeted investments in innovative SMEs, startups and midcaps.

- The adaptation of economies and societies to the pandemic, with wide-ranging changes to how work is organised and businesses operate, call for measures securing broad uptake of these solutions.

- Policy actions should support measures that aim at building system-wide resilience to limit the impact of all long-term threats and develop adaptation and investment strategies to fight the challenges we face, including most notably climate change.

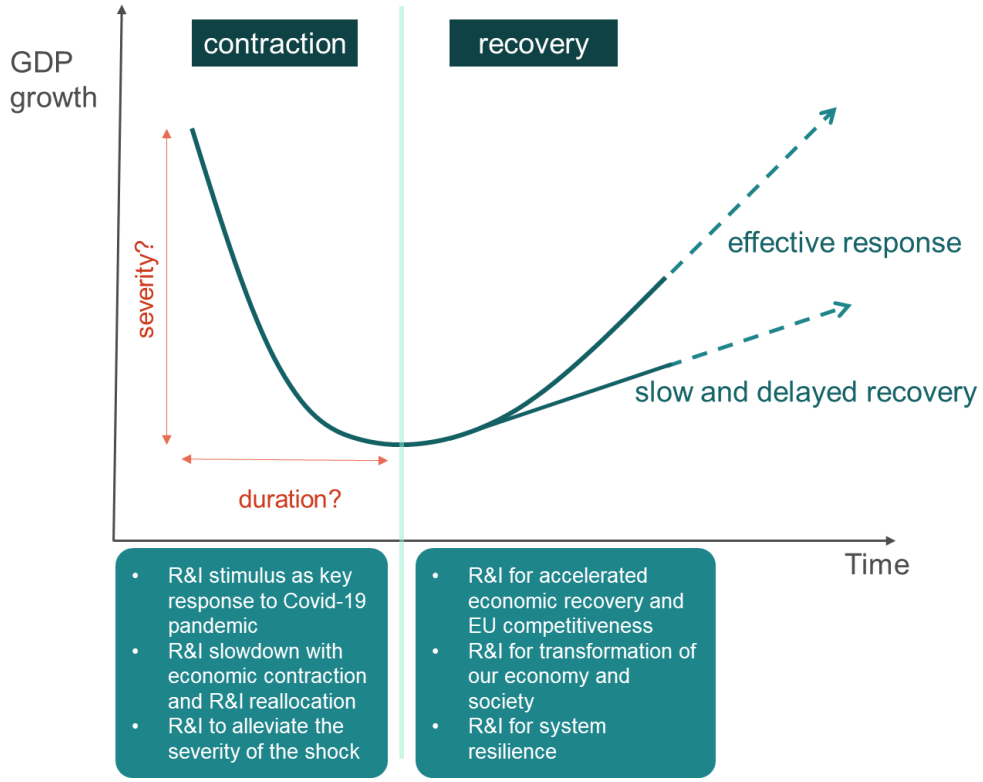
1 Introduction

The COVID-19 crisis is unprecedented. It has disrupted our lives, economy and society and the world has been struggling to contain the pandemic. While **research and innovation (R&I) are at the core of the response to the pandemic itself** in the areas of virology, vaccines development, treatments and diagnostics, it will be **crucial also in the economic recovery from the crisis**, not only to spur economic activity, but also to accelerate the transitions that our planet and society need - a new economy for health, wellbeing and equality in a broad sense (physical, mental, skills, gender, social, environmental and economic aspects). R&I can also help build system-wide resilience. Technologies already help alleviate, at least partially, the severity of the economic shock, with digital technologies being at the core of business continuity in several sectors. Overall, **the role of R&I can be considered in the short-term context of the sanitary crisis and economic contraction, but also in the longer term and aftermath of the crisis, as a key driver of the recovery** (Figure 1). It is of paramount importance to invest in making our society and economy stronger, more resilient, sustainable and capable of a rapid and integrated response drawing on the latest scientific discoveries, ensuring equal access to healthcare, education and ICT across the EU, and social and economic support to its most vulnerable populations.

The **unique nature of the COVID-19 crisis** has led to war analogies, due to similarities in having the population dealing simultaneously with death tolls, lockdown and economic recession, but these are to be considered cautiously (see Box 1). Compared to previous sanitary crises such as SARS or Ebola, it has also generated

higher levels of economic uncertainty[1]. It is also tempting to make an analogy between the current crisis and the global financial crisis from a decade ago, also due to similarities in terms of uncertainties, economic collapse and massive support from monetary and fiscal policies to limit the shock[2].

Figure 1. R&I and the economic recovery from the COVID-19 crisis



Source: Authors' elaboration.

While the assumption of a significant **economic contraction** in 2020 caused by COVID-19 is indeed supported by the latest economic forecasts, there are still uncertainties about the severity of the impact as it will also depend on policy actions, the evolution of the pandemics and the development of vaccines in the next months. IMF[3] estimates suggest that we are living the worst recession since the Great Depression (*global* economic growth is estimated at -4.9% in 2020 and the cumulative loss over 2020 and 2021 may amount up to 9 trillion dollars[4]). According to the

[1] https://blogs.imf.org/2020/04/04/global-uncertainty-related-to-coronavirus-at-record-high/
[2]https://www.atlanticcouncil.org/blogs/new-atlanticist/can-we-compare-the-covid-19-and-2008-crises/
[3]https://blogs.imf.org/2020/04/14/the-great-lockdown-worst-economic-downturn-since-the-great-depression/

Summer 2020 Economic Forecast of the European Commission[5], the EU economy is forecast to contract by 8.3% in 2020, with a rebound growth by 5.8% in 2021. Applied to R&D, assuming constant R&D intensity, that would translate into a drop of EUR 25 billion. The shock to the EU economy is symmetric in that the pandemic has hit all Member States, but both the drop in output in 2020 and the strength of the rebound in 2021 are set to differ markedly across sectors, regions and countries. Regarding jobs, the impact is also expected to differ according to regional and sectoral variations[6], with *teleworkability* being a key factor in alleviating the negative impact of the crisis.

Box 1. COVID-19: the War analogy

While a comparison between the World War II (WWII) and the current crisis may be an interesting exercise that has been used recently in public debates, it may be also strongly misleading. The current pandemic differs from a war in many ways, including the impact on infrastructures, people, mobility and production. In particular, differences[1] include the fact that WWII maximised mobilisation of resources to sustain the war efforts while the COVID-19 shutdown minimised mobilisation. The COVID-19 shutdown is also a temporary one that does not damage equipment, infrastructure, or human capital. Among policy interventions, governments are trying to support businesses to restart when the situation will go back to a (new) normal.

In terms of GDP, WWII brought a significant GDP drop to Europe. Per capita GDP of western European countries in 1946 was 23% lower than in 1939 and countries reached the pre-war levels only in 1950 (source: Maddison data). Nevertheless, the following years brought a quick recovery and the GDP increased by 26% until 1955. As today, the war period affected European countries differently, but not in comparable ways.

The World War II required a shift of production from consumer production (e.g. cars) to war tools (e.g. tanks, guns, etc.) to support the war effort, converting factories of peacetime industries into manufacturing plants for weapons and military equipment. This may echo the current COVID-19 emergency and the urgent problem of shortage of critical supplies such as masks, ventilators and test kits for

[4] Estimates are from the IMF's June World Economic Outlook, 2020. https://www.imf.org/en/Publications/WEO/Issues/2020/06/24/WEOUpdateJune2020

[5]https://ec.europa.eu/info/business-economy-euro/economic-performance-and-forecasts/economic-forecasts/summer-2020-economic-forecast-deeper-recession-wider-divergences_en

[6] According to OECD estimates, the share of jobs at risk will range from 15% to 35% across OECD countries, with regional and sectoral variation, in particular: tourist destinations and big cities have more jobs at risk, as also do activities in manufacturing, wholesale and retail, personal activities (e.g. hairdressers) and air transports. Cities and capital regions have higher shares of jobs potentially suited for teleworking. Regional differences in teleworkability are up to 20% across OECD countries, with lowest shares in rural areas. Overall high skills intense jobs are more suited for teleworking and will be more resilient. According to the Spring 2020 Economic Forecast, in the EU the

both the healthcare sector and the wider population. Policymakers are calling for firms across manufacturing sectors to temporarily repurpose their production in order to increase global production capacity. In terms of R&I, the sanitary challenge of the COVID-19 outbreak calls for a mobilisation of science that could also reflect the unprecedented research effort triggered by WWII. Gross and Sampat (2020) show how the significant R&I efforts of the US government during WWII, through large, mission-driven government R&D programmes, had large effects on the direction and location of US inventions.

However, the economic impact and the scale remarkably differ from what happened during WWII. The reconversion of production is different in scale. The economic impact of the growing coronavirus outbreak has been shifting from service-driven industries - like hotels and restaurants - to the manufacturing sector on both sides of the Atlantic, with a synchronized shutdown of heavy industry that historians and industry experts say is unlikely to have been the case during WWII.

The war also impacted employment in a substantially different (and "positive") way than the current crisis, consistently with the need to mobilise resources. This differs remarkably from the limitations imposed by the shutdowns to prevent the spread of the covid-19 pandemic.

This paper analyses R&I dynamics in the context of the COVID-19 crisis and its aftermath, along different angles that are presented in Figure 1: while R&I is key as a response to the pandemic (section 2) and its consequences in the shorter term (including business continuity, section 4), it is also expected to be directly affected by the economic contraction caused by the lockdown (section 3); in the aftermath of the sanitary crisis (or at least its peak), R&I will be key in a successful recovery, from the economic perspective (section 5), but also social and environmental (section 6), while building resilience in view of future crises (section 7).

2 R&I stimulus as key response to the COVID-19 pandemic

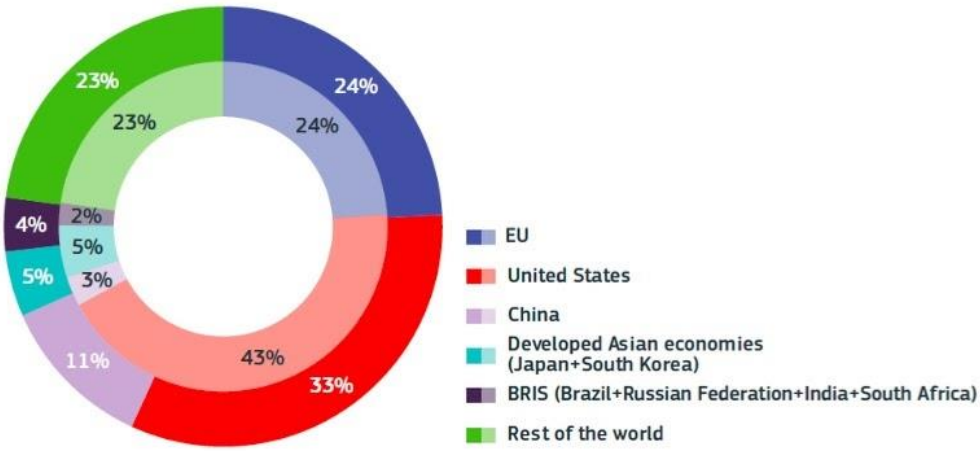
R&I is at the core of the response to the COVID-19 pandemic. The crisis highlights, among others roles, the importance of R&I as part of a fast and innovative **healthcare response**, and for monitoring and containing the spread of the infection. R&I activities are needed to improve our scientific understanding of the virus, including its characteristics, such as the symptoms, the demographics of those most-at risk, the pre-existing medical conditions that magnify the negative health impacts from those infected. The outbreak also stresses the need for R&I solutions to be quickly produced

unemployment rate is forecast to rise from 6.7% in 2019 to 9% in 2020 and then fall to around 8% in 2021.

to tackle the virus: R&I is needed to develop vaccines, treatments and diagnostics, and to provide safe and fast tracking (European Commission, 2020c).

Health is a major field in terms of R&I production. In the EU, publications related to health and well-being (together with demographic change) account for about 60% of all publications (European Commission, 2020a). On the world stage, the EU represents almost one fourth of health publications (Figure 2) and this share has been stable since 2006. This is less than the United States, which accounts for one third of these publications. However, the US weight in health publications shows a significant decline over time, while China represents today more than 10% of health publication (against 3% in 2006). In terms of patents, the EU accounts for one fifth of worldwide PCT patent applications in Health (European Commission, 2020a), and the same pattern can be observed for the US, which has experienced a decrease in its share since 2006 (from 48% of worldwide patents in 2006 to 27% in 2016) and China, which shows a rapid increase (from 2% in 2006 to 9% in 2016).

Figure 2. Shares (%) of top 10 % of scientific publications in Health, demographic change and well-being in 2006 (interior) and 2016 (exterior)



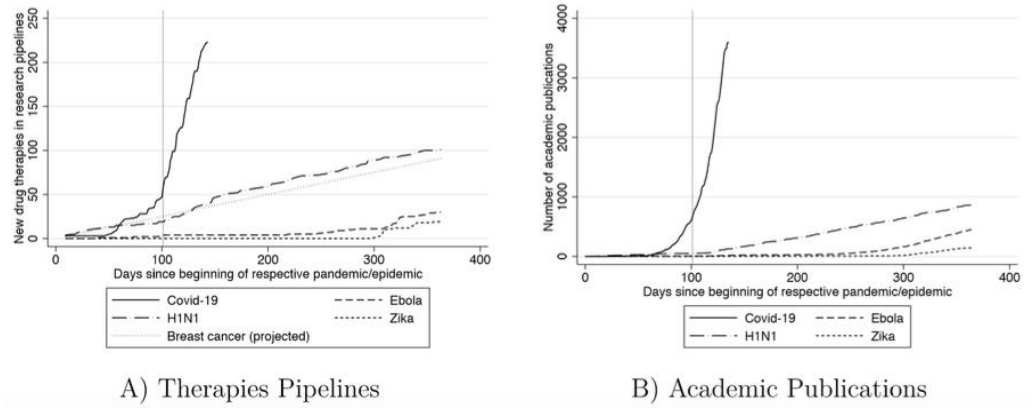
Source: European Commission (2020a), Science, Research and Innovation Performance of the EU 2020

The COVID-19 creates a clear stimulus in terms of R&I efforts in the health sector. R&I actors all over the world have turned their attention to the COVID-19 health challenge. As of July 2020, the European Medical Agency has been in discussion with the developers of 35 potential vaccines and 144 potential treatments, including immunomodulators, antivirals and hyperimmune serums[7]. Brian et al. (2020) show a break in the rate at which therapies entered pharmaceutical pipelines worldwide about

[7]https://www.ema.europa.eu/en/human-regulatory/overview/public-health-threats/coronavirus-disease-covid-19/treatments-vaccines-covid-19#potential-treatments-under-investigation-section

100 days after the beginning of the COVID-19 outbreak (Figure 3). Compared to previous recent viral epidemics (Zika, Ebola and H1N1), they observe a rate of production of academic medical publications related to COVID-19 that is much higher. They also show that the rate of production of new drug therapies is much faster in the COVID-19 context compared to previous epidemics. This explosive growth seems to be primarily driven by non-vaccine and repurposed[8] drug therapies. These results suggest that R&I has involved more research on short-term solutions than previous epidemics. This may be explained by the behaviour of firms entering the R&I market, attracted by potential high pay-off in the context of the crisis, but focusing on quick solutions rather than long-run projects such as vaccines.

Figure 3. Drug therapies in pharmaceutical research pipelines and disease-related academic medical publications by pandemic/epidemic



Source: Bryan, Lemus and Marshall (2020).

At the same time, **the COVID-19 crisis highlights the idea that R&I activities, including in health, typically face underinvestment by the private sector**, which calls for governments to support R&I efforts. This is particularly true in the context of the pandemic. Regarding R&I efforts, the pharmaceutical and biotechnology sector accounts for 16% of EU R&D, and the EU represents 19% of R&D worldwide in this sector[9]. According to Foray et al. (2020), there is a clear underinvestment in this industry when it comes to research in the field of vaccines. Several companies have been starting to work on the development of COVID-19 vaccines with the pandemic progressing more clearly, but there is evidence that coronavirus research was not so attractive before the outbreak. According to Foray et al. (2020), the significant underinvestment in vaccines research by the pharmaceutical and biotechnology industry, compared to other products in the same industry, can be explained by two factors:

[8] Drugs which existed before the beginning of the outbreak and that have multiple indications.

[9] Source: 2019 EU Industrial R&D Scoreboard.

- *First*, there is not enough demand for vaccines outside of outbreak periods. In normal times, individuals are more likely to exhibit free-riding behaviours, benefitting from herd immunity. They can also have limited belief in the benefits from vaccination and seem in general to show stronger willingness to pay for treatment than prevention, which incentivise companies to favour investments in drugs.

- *Second*, R&I investments are traditionally subject to market failures, with innovators not being able to capture all the economic benefits from their inventions and R&I activities being riskier by nature. Because of positive externalities, there is a gap between the private and social returns from R&I solutions, which results in systematic underinvestment compared to a socially optimal level[10].

In this context, policy support to stimulate R&I on COVID-19 is needed. As highlighted by OECD (forthcoming), a diversity of foundations and institutions have been actively engaged with **national governments** to address the COVID-19 crisis. **International institutions** are involved in steering R&I response, including the World Health Organisation (WHO), the Global Research Collaboration for Infectious Disease Preparedness (GLOPID-R) and the Coalition for Epidemic Preparedness and Innovation (CEPI). Overall, the crisis has brought back science into the lead of policymaking, although with national biases in science-based policy advice and policy implementation (Soete, 2020). At the **EU level**, R&I actions are an essential part of the coordinated EU response to the public health threat. These actions focus on: funding and financing R&I in virology, vaccines development, treatments and diagnostics and wider social and economic impacts; speeding up research by optimising framework conditions; translating research findings into public health policy to mitigate the impacts and improve crisis preparedness; internal and external coordination; and citizen outreach and communication (European Commission, 2020a). Most notably, the EU Framework Programme for research and innovation plays a central role in mobilising funds on COVID-19-related R&I projects. The ERAvsCorona[11] Action Plan also sets out key measures that the Commission services and the Member States are activating to coordinate, share and jointly increase support for research & innovation, in line with the objectives and tools of the European Research Area.

It is also important to highlight the role of research infrastructures (RI) in supporting the fight against COVID-19. RI include major scientific equipment, knowledge-based resources (e.g. collections, archives and scientific data), and e-infrastructures. For example, Horizon 2020 has stepped-up efforts to support the European Virus Archive and TRANSVAC for vaccine research. Other pan-European RIs

10 Conditions that prevent investors from fully appropriating economic returns from their R&I investments are often associated with market power, imperfect information, externalities, and public goods (Arrow, 1962).

11 https://ec.europa.eu/info/sites/info/files/covid-firsteravscorona_actions.pdf

include e.g. SoBigData-Plus (big data), ELIXIR (coordinating the storage of and access to biological data) and ECRIN (clinical trials), among others.

The COVID-19 pandemic demonstrates the importance of data and digital technologies as part of the current R&I response. Free flow of data, researchers and ideas are critical to ensure accurate, quick R&I-based response. Openly accessible, machine-readable, interoperable data is needed to track, monitor and forecast the spread of COVID-19. Key datasets include clinical, epidemiological and laboratory data. At the EU level, the Action Plan - Research data-sharing platform for the SARS-CoV-2 and COVID-19 disease, launched by the EMBL's European Bioinformatics Institute (EMBL-EBI) and the European COVID-19 research data platform intend to speed up and improve the sharing, storage, processing of and access to research data and metadata on the SARSCoV- 2 and COVID-19 diseases.

In particular, artificial intelligence (AI) and big data are essential in the fight against the virus (European Commission, 2020a). In just one week, scientists in China were able to recreate the genome sequence of the virus by using AI[12]. AI-related applications have enabled population screening, tracking the spread of the infection, and the detection and diagnosis of COVID-19. AI has been used to detect visual signs of COVID-19 on images from lung CT scans, monitoring changes in body temperature in real time, providing an open-source data platform to track and monitor the spread of the disease, and is increasingly being used to help identify potential treatments and cures. At the same, the use of AI tracking and surveillance tools in the context of this pandemic has clearly shown the **need for a global ethical governance of AI**. AI is also used to further speed up the drug development process by modelling the efficacy of these drugs prior to clinical trials. In this context, AI could also optimise the process of clinical trials to discover new and effective drugs and vaccines. There is also a greater speed in which scientific research results have been released. Many journals have accelerated their peer-review process to ensure rapid dissemination (OECD, forthcoming).

3D printing has also proven its relevance in the current pandemic as an **Industry 4.0 technology** that was efficiently mobilised to manufacture personal protection equipment and ventilators in view of disruptions in their supply chains and increased demand. Due to restricted movements and the rise of infections, the supply of face masks and shields, and ventilators was limited during the pandemic. In this context, 3D printing has been used to produce some of these essential items.

With knowledge flows being key in the current context, collaboration in R&I activities has become even more important. Early evidence shows that collaborative research on COVID-19 has been significant (OECD, forthcoming). According to Bryan et al. (2020), collaboration between firms increases as crises intensify. In the current crisis, they observe that 40% of COVID-19 drug therapies are

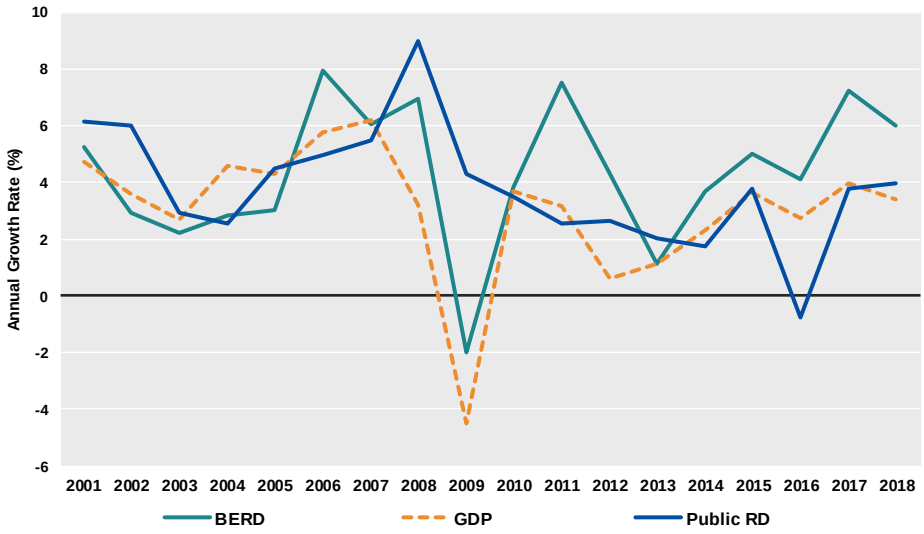
[12]https://www.cnbc.com/2020/03/03/bluedot-used-artificial-intelligence-to-predict-coronavirus-spread.html

being developed by teams of firms, against 21% for H1N1, 9% for Ebola and 11% for Zika. China and the United States also seem to have intensified their collaboration in absolute terms, as well as the collaborations with each other in the context of the COVID-19 crisis (Fry et al., 2020). However, they seem to partner with fewer nations.

3 R&I slowdown with economic contraction and R&I reallocation

The theoretical and empirical literature suggests that R&D investments are highly procyclical, therefore they tend to decline during economic downturns and increase with economic output. During recessions, different factors may cause R&D investors to face reduced incentives to invest in innovation creation and adoption. For instance, in sectors with faster obsolescence of knowledge or higher difficulties in protecting intellectual property (e.g. higher positive externalities), expected declines in demand may lead to postponement of innovative activities (Fabrizio and Tsolmon, 2014). Similarly, R&D spillovers and the quasi-public nature of knowledge may lead investors to weigh more short term than long term profits (Barlevy, 2007; Sedgley et al., 2019). Alternatively, the aggregate pattern may be explained by micro dynamics, most notably when firms face credit constraints that have severe implications for investments decisions, especially in risky innovative projects (Aghion et al., 2012) or for start-ups heavily relying on external sources of capital (Howell et al., 2020). Empirical evidence supports the cyclicality between R&D and output, and further develops on the link between the slow-down of R&D spending and its implications for innovation diffusion, its adoption and long-run growth (Anzoategui et al., 2019).

Figure 4. Business and public investment in R&D vs GDP, 2001-2018



Source: DG Research and Innovation, Chief Economist- R&I Strategy and Foresight Unit, based on Eurostat (online data code: rd_e_gerdtot and nama_10_gdp)

The COVID-19 crisis is not fully comparable to previous economic downturns, both because of the conditions triggering it and the economic and social implications. While current estimations foresee a great impact on economic output compared to previous crises, with consequences in terms of employment, social and innovation dynamics as in previous recessions (European Commission, 2020d), the nature of the current crisis is different. First of all, while the epidemic spreads differently across countries and regions, depending also on the variety of government responses (Hale et al., 2020), its impact did not depend on previous macroeconomic conditions, because of the peculiar nature of the crisis. Furthermore, its impact will depend on several factors, including the length of mobility restrictions, the development of vaccines and behaviour of the pandemics in the upcoming months (OECD, forthcoming). All these factors increase uncertainty both in terms of the magnitude and length of the recession and concerning implications for innovation output (Dachs et al., 2020).

The pandemic has direct implications for R&D activities, whose net effect is still uncertain. On the one hand, the cyclicality of R&D investments may imply a reduction in R&D following the contraction in GDP. For instance, the estimates from ECFIN (European Commission, 2020d) predict a contraction of 8.3 % GDP in 2020 in the EU which could translate into a decline in R&D investments of about €25 billion[13] (European Commission, 2020c). On the other hand, in order to face the spread of the virus, policy packages worldwide have introduced R&D stimuli to face the effects of the pandemics in the short term, as well as to finance the development of vaccine(s) in the medium-long term, as outlined above. The OECD Science Flash Survey 2020[14] indicates that nearly half the researchers interviewed have experienced or expect to experience a decrease in funding for scientific research.

Furthermore, the lack of time and resources available to respond to the crisis, as well as the need for rapid scaling in every context, has led to an explosion of innovative responses in the business sector. For example, Chanel, Ikea, Inditex and Prada started manufacturing surgical masks and medical gowns, while L'Oreal, Givenchy, Christian Dior, Absolut Vodka and Brewdog shifted their operations towards hand sanitizers[15]. Car manufacturers, such as SEAT[16], Mercedes-Benz and Tesla[17] are applying their manufacturing capability to produce ventilators or ventilator parts. These responses bear the hallmarks of 'frugal innovation' — that is, doing more, with less by repurposing, reuse and rapid deployment (Harris et al., 2020). Such economisation of resource use and cost of frugal innovations can reduce negative environmental impacts and lead to more sustainable products (European Commission, 2017).

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[13] If the overall R&D intensity remains constant and based on the recent Spring Economic Forecasts for GDP growth.

[14] https://oecdsciencesurveys.github.io/2020flashsciencecovid/

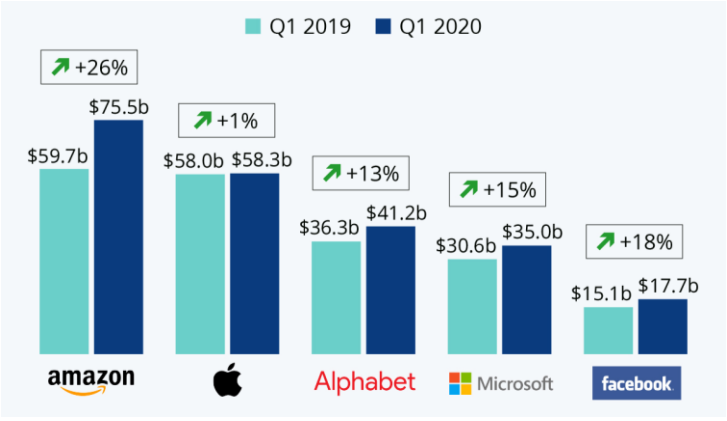
[15] https://www.retailmenot.com/blog/brands-shifting-production-to-fight-covid-19.html

[16] https://www.volkswagenag.com/en/news/2020/03/cars_to_ventilators.html#

[17] Harris et al. (2020)

The crisis has affected sectors differently. R&D spending in the **health sector** has increased as government packages worldwide have introduced R&D stimuli to finance the development of vaccine(s) and improve diagnosis. Companies operating in the **digital sector** have shown to be less affected (Figure 5)[18], as digital technologies (e.g. cloud), products and services (e.g. video conferencing, e-learning solutions, gaming) proved to be essential during the crisis, enabling business continuity through teleworking and changing business models (e.g. e-commerce). Manufacturing sectors relying on extensive international supply chains, such as **automobile industry,** have suffered tremendously (OECD, forthcoming) as most of the manufacturing companies have some portion of their supply chain based in China. Also, significant share of work has to be done in factories, where components and vehicles are assembled, hence it cannot be performed remotely[19].

Figure 5. Revenue of selected tech companies in the first quarter of 2020 Vs 2019



Source: Statista, based on company filings.https://www.statista.com/chart/21584/gafam-revenue-growth/

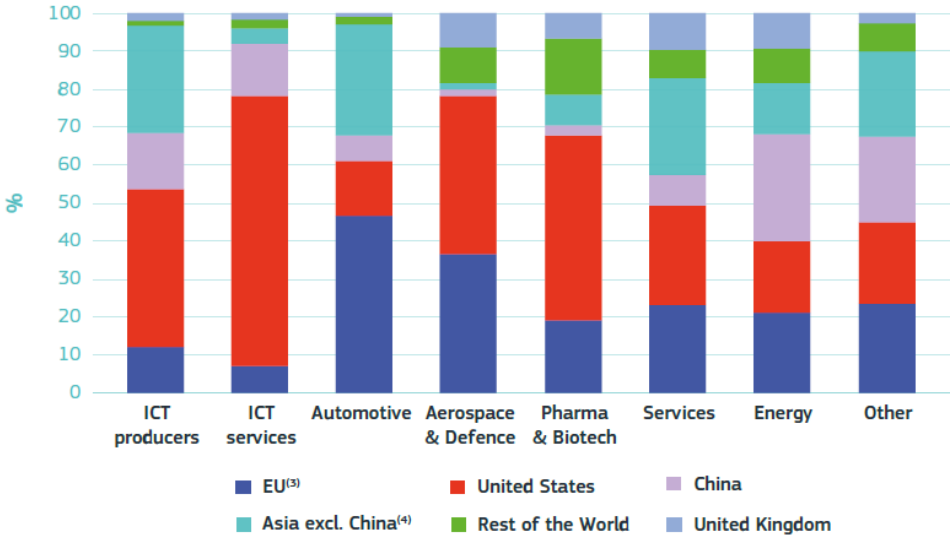
The above trends suggest that the medium-long term effects of the crisis on private R&D investments may vary globally according to the sectoral specialisation of economies. Based on the 2019 EU Industrial R&D Investment Scoreboard[20] (Hernández et al., 2019), the EU largely dominates R&D investments in the automotive sector that was hardly hit by the crisis, while US companies account for 71% of the global R&D share of ICT services and 48% in pharmaceuticals & biotechnology (Figure 6) – both sectors being less affected by the crisis.

[18] However, in Europe, "the most valuable European tech & internet companies lost a combined €383 billion in value, down 33% from €1.1 trillion to €0.8 trillion (February-March 2020) according to https://blog.dealroom.co/wp-content/uploads/2020/03/Corona-vFINAL.pdf

[19] https://www.pwc.com/us/en/library/covid-19/coronavirus-impacts-automotive.html

[20] Which covers more than 90 % of business spending on R&D (BERD) worldwide.

Figure 6. Geographical distribution of business R&D spending by economic sector, 2018

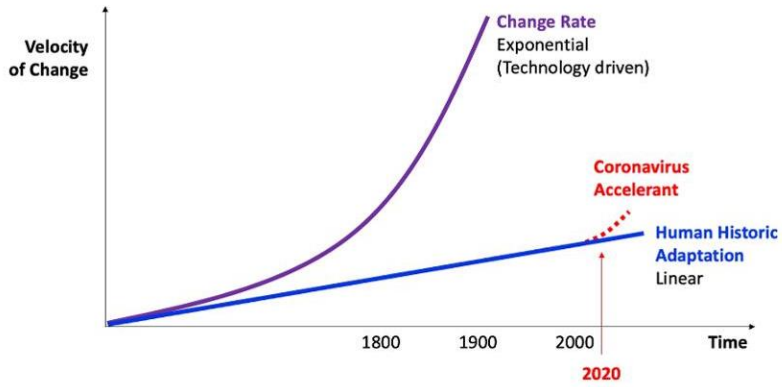


Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on the 2019 EU Industrial R&D Investment Scoreboard.
Notes: (1) R&D spending corresponding to the top global 2500 companies. (2) ICT producers: electronic and electrical equipment, technology hardware and equipment. ICT services: software and computer services. Automotive: automobiles and parts. Services: leisure goods, personal goods, banks, life insurance, non-life insurance, financial services, real estate investment and services, media, general retailers, food and drugs retailers, healthcare equipment and services, support services, travel and leisure. Energy: alternative energy, oil and gas producers, oil equipment, services and distribution, electricity. Other: chemicals, general industrials, industrial engineering, household goods and home construction, construction and materials, industrial transportation, mining, industrial metals and mining, food producers, tobacco, forestry and paper, beverages, fixed line telecommunications, gas, water and multi utilities, mobile telecommunications. (3) EU corresponds to the EU Member States shown in the dataset.

4 R&I to alleviate the severity of the shock

To some extent, the adaptation of economies and societies to the COVID-19 "new normal" has accelerated the digital transformation. An external shock such as the current public health crisis and the consequent need for social distancing has pushed for new and remote ways of working and collaborating that required new skills, as well as new company strategies to sell online and deliver their products and services, or even new ways for governments to deliver public services and interact with citizens remotely. This "jump" is illustrated in Figure 7.

Figure 7. Coronavirus accelerant: speeding up digital (human) transformation



Source:https://www.forbes.com/sites/heathermcgowan/2020/03/23/the-coronavirus-pandemic-accelerates-the-future-of-work-and-provides-opportunity/

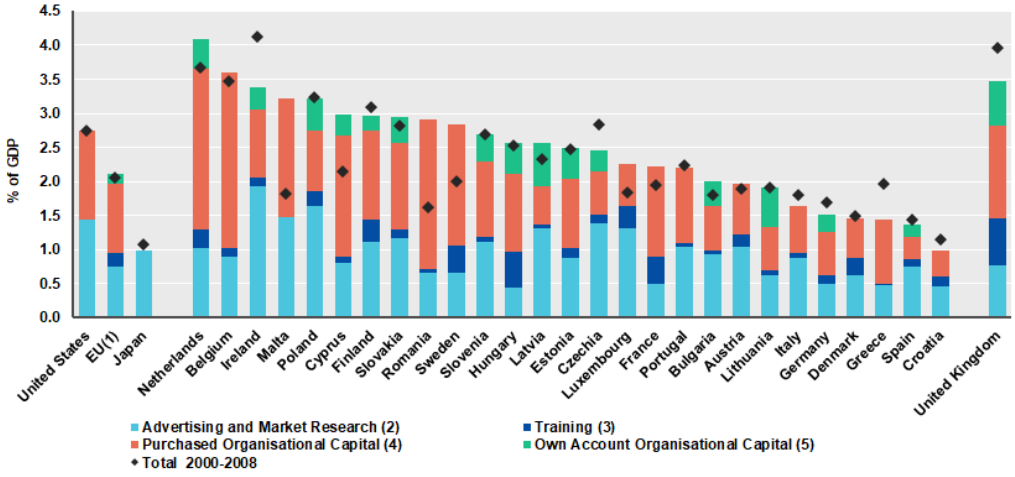
While many of the workplace adaptations related to the global spread of coronavirus are viewed as short-term measures to enable large-scale social distancing, the rapid implementation of innovation and technologies could lead to longer-term lifestyle and productivity changes. The rise of automation and digital technologies, even if slowly, already manifests itself through increasing number of jobs requiring high skills and the declining demand for simple routine tasks (both cognitive and physical) (European Commission, 2020a). These trends may be accelerated with the on-going outbreak. Since its onset, it has forced businesses as well as education and training institutions to transfer many of their activities online. Depending on the duration of the epidemic, it may further facilitate the deployment of digital technologies to mediate physical interactions. Broadening these interactions through AI may boost the possibilities of further replacement and automation.

The COVID-19 pandemic has shown the importance of investing in complementary intangible assets that can help in better coping with "forced" adjustments related to external shocks. These include economic competencies such as branding (advertising and market research), knowledge embedded in firm-specific human capital (e.g. training) and organisational capital following the framework in Corrado et al. (2005). Organisations need to adapt and create structures that are flexible enough to react to new market and technology trends. This requires a company culture that promotes 'resilience in discomfort', allowing for experimentation, collaboration, creativity and critical thinking. Bloom et al. (2016) found that higher management quality leads to increase firms´ productivity[21]. At the EU level, the contribution of economic competencies to both economic and productivity growth has increased between 2009 and 2017 (European Commission, 2020a). Also, these competencies may be essential for firm

[21] Comparable cross-country evidence on management quality remains scarce. Bloom et al. (2016) showed cross-country differences in average management scores in manufacturing.

survival in this crisis and, depending on the severity of the shock by sector, may even allow for turning the crisis into new opportunities, i.e. "reinvention" to create value (e.g. new goods and services, distribution channels, business models). However, Figure 8 shows the intra-EU disparities which may affect the capacity of EU firms as a whole to respond to demand shocks, supply chain disruptions, etc.

Figure 8. Investment in economic competencies as a percentage of GDP, 2009-2017 with breakdown, and total for 2000-2008

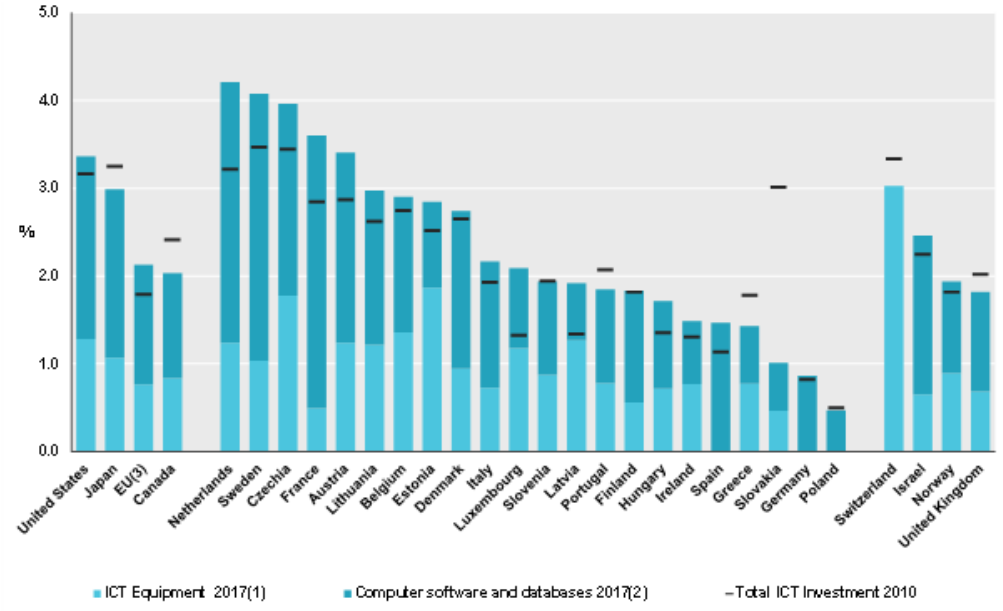


Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on EU KLEMS
Notes: (1) EU was estimated by DG Research and Innovation. (2) JP: 2009-2015. HR: 2009-2016. (3) Data not available for US, JP and MT. HR, UK: 2009-2016. (4) Data not available for JP. HR: 2009-2016. (5) Data not available for US, JP, BE, DK, EL, FR, HR, IT, LU, MT, AT, PT, RO and SE. UK: 2009-2016.

Moreover, **investments in other intangibles such as software and databases are needed** to enable the tracking and monitoring of the spread of the virus, and also can be used as research tools towards new diagnostics, treatments and vaccines. This holds also for businesses that especially in lockdown and social distancing times need software capabilities to e.g. manage online sales and new distribution channels[22]. Figure 9 shows that countries vary substantially in the share of ICT investments in GDP, in both ICT equipment and software and databases.

[22] https://medium.com/@stianstian/quarantine-in-an-intangible-economy-4303c6b84004

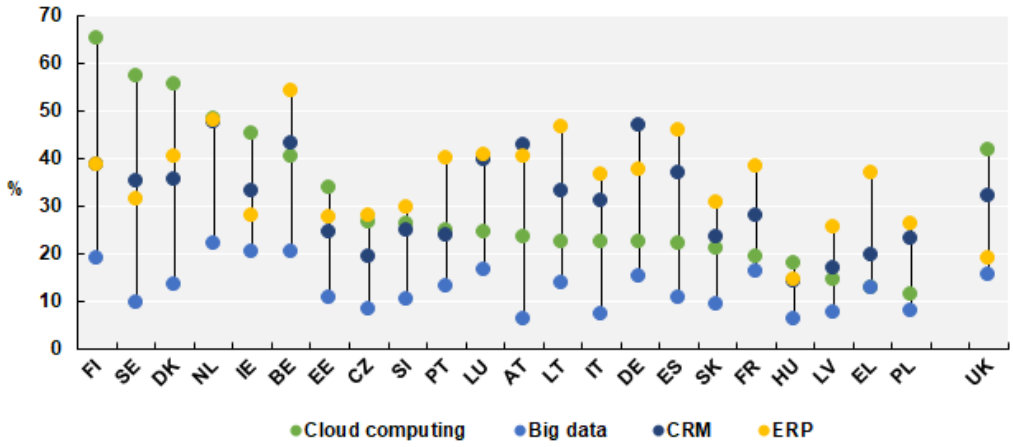
Figure 9. Investment in ICT as a % of GDP by country, 2010 and 2017



Source: OECD (Capital formation by activity ISIC Rev4) and Eurostat (online data code: nama_10_gdp).
Notes: (1) DK: 2015. LV, NO: 2016. (2) DK, EE, EL, PL: 2015. IE, ES, LV, PT, SE, NO: 2016. (3) EU value estimated with the available countries. The number of countries is not the same in both categories.

Digital technologies such as cloud computing and big data analytics have seen their importance rise in the current crisis in order to efficiently manage servers, store and process large amounts of user and machine-generated information. However, Figure 10 shows that their uptake varies considerably by country across all technologies represented in the figure- cloud computing, big data analytics, customer relationship management software and enterprise resource planning systems. For example, the adoption of cloud computing ranges from 65% in Finland to only 11.5% in Poland. The adoption of digital technologies has been a driver of productivity already before the pandemic. EIB (2019) found that firms that have adopted digital technologies have both higher labour productivity and engagement on innovation than non-digital firms.

Figure 10. Diffusion of selected ICT tools and activities in enterprises, by technology (% of enterprises with 10 or more employees), 2018

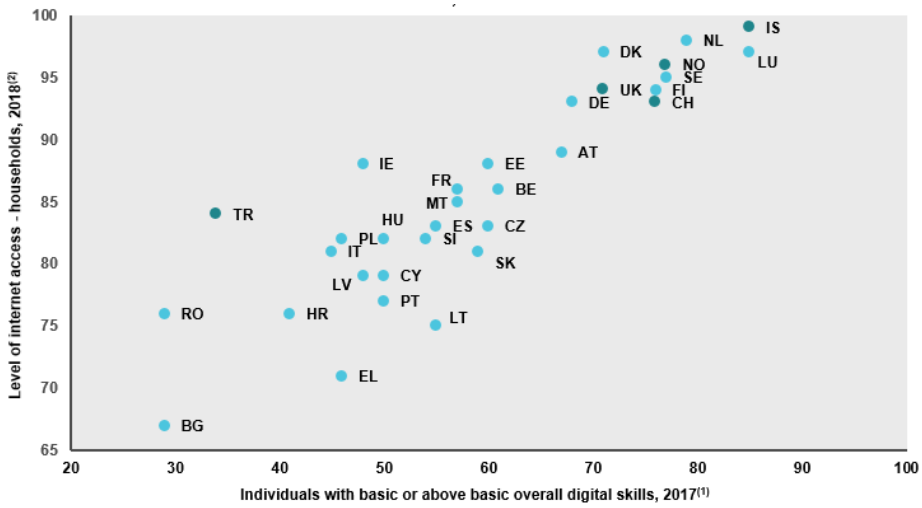


Source: Adapted from OECD, ICT Access and Usage by Businesses Database, http://oe.cd/bus.
Notes: (1) CRM- customer relationship management software; (2) ERP- Enterprise resource planning system.

Broader deployment of digital technologies may be hampered by a low level of digital skills of workers or insufficient resources at the company level. Looking at the EU labour force, more than 40% of the EU population has only low basic digital skills or no digital skills at all (European Commission, 2020b). This digital skills gap is also most pronounced among individuals with generally low levels of education and skills. Although the basic level of ICT skills in the EU seems to be slowly improving, the progress is not sufficient given the rapidly evolving technological context, labour market needs and in particular the current crisis. Furthermore, the shortage of IT specialists with advanced digital skills has often been flagged by industry. The lack of skills reinforced through the exogenous pandemic shock could have a disproportionate effect on small and informal enterprises due to their limited financial, managerial and information resources (e.g. Fort et al. 2013). These firms are also less likely to be able to respond to the crisis with technological solutions such as teleworking, (Panizza, 2020).

While such negative developments could lead to disruption in supply chains, increasing gaps in productivity and, in general, reduce innovation activities, policymakers can compensate with schemes for helping enterprises to respect social distancing, protection needs for people at risk, accelerating digitisation and developing required skills. To bring these solutions to a larger scale, policymakers should consider how to effectively support the development of digital capacities and how to implement e-learning solutions. Importantly, the spread of platforms, and digital goods and services has exposed the need for workers with the skills to manage digital security risks (OECD, 2019).

Figure 11. Individuals with basic or above basic digital skills and level of internet access in households, 2017 and 2018



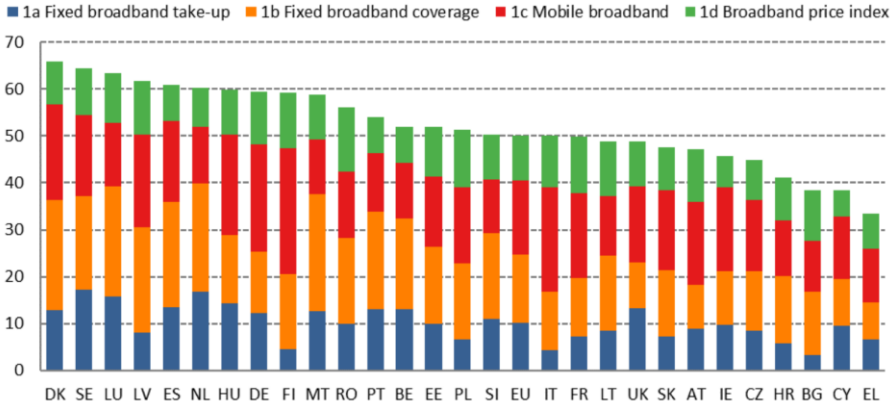
Source: Eurostat (online data code: TEPSR_SP410 and isoc_ci_in_h)

During the pandemic, most researchers have reported an increase in the use of digital tools for scientific research according to preliminary survey findings[23]. The OECD Science Flash Survey 2020 also shows that the use of research materials and facilities has declined in most cases (as it would be expected in a situation of restricted mobility). Based on the 2018 International Survey of Scientific Authors, Bello and Galindo-Rueda (2020) found that "the challenges faced by authors in the digital era concern principally access to data and infrastructure, including basic Internet connectivity". This has regained even greater importance for scientific research in the current pandemic.

Both the move towards an accelerated digital economy and society and the intensification of R&I activities to support the public health crisis require quality research and digital infrastructures. European Commission (2020b) points to progress in EU Member States in terms of connectivity. However, Figure 12 shows the current disparities in performance across the EU for example regarding fixed very high capacity networks or mobile broadband. Accordingly, "4G networks cover almost the entire European population", but not much progress has taken place in 5G readiness. This matters not only due to the increased reliance upon digital infrastructure, but also because 5G can lead to new markets and business opportunities. For example, Spotify (music streaming service) benefitted from high-speed broadband in Sweden early on which also drove its success. Research Infrastructures will also increasingly have a key role in the recovery and the European Research Area by making resources and services for research communities available.

[23] https://oecdsciencesurveys.github.io/2020flashsciencecovid/

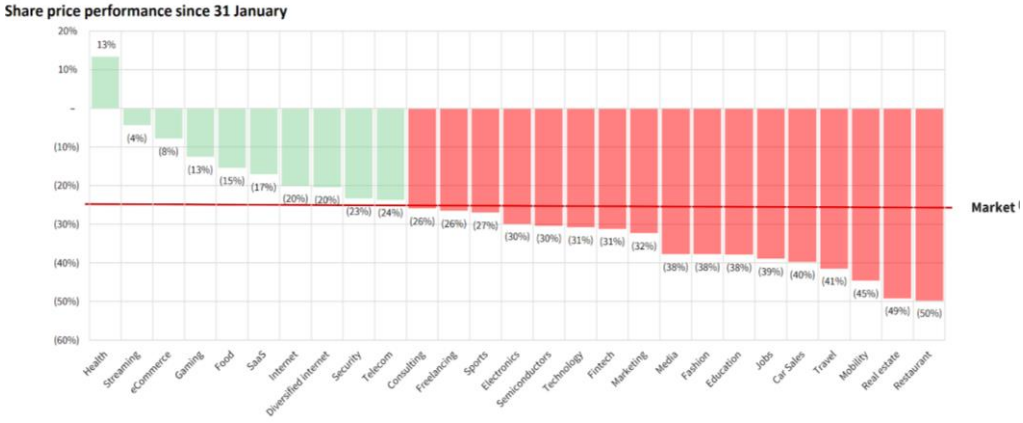
Figure 12. Digital Economy and Society Index 2020- Connectivity



Source: European Commission (2020b), Digital Scoreboard 2020

Some sectors have been "hit harder" than others, most notably those whose activities are less suited to remote work or are less "digital". A particular negative trend has been registered by travel industries, most notably air transport, together with retail and mobility. Differently, other industries are outperforming the market, for instance the health sector, food delivery, software-as-a-service and entertainment (Figure 13). Hellotomorrow (2020) survey reveals as well that companies with a digital strategy have been the ones with the most successful outcomes in the current pandemic.

Figure 13. Health, streaming, gaming, e-commerce, food delivery and most software-as-a-service companies outperform the market

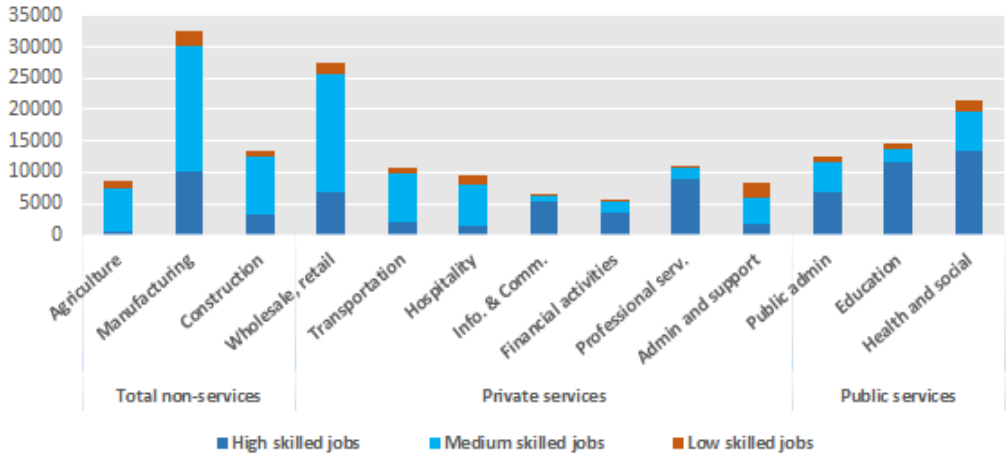


Source: Dealroom.com, Google Finance (March 23rd), "Impact of the Corona Crisis on startups & tech"
Note: NASDAQ and S&P500 dropped roughly 25% in the same period.

The employment impact of social distancing measures taken to limit the spread of COVID-19 varies across sectors and Member States. More generic assessments on the potential to telework suggest higher flexibility across more skilled occupations, demonstrating that digitalisation seems to favour more the higher skilled workers (Veneri,

2020). Nevertheless, this trend alone could not assess jobs suitable for teleworking as there are many highly skilled jobs in education, health or other public services with high barriers to technological mediation or replacement (Figure 14). Other assessments at the industry level looking at different occupational groups suggest shares of about 30-40 % of jobs in advanced economies (Dingel and Neiman, 2020). More detailed studies assessing restrictions in specific sectors combined with teleworking or partly active jobs suggest that between 50 and 60 % of EU28 employment would be active in strict confinement (Fana et al., 2020). The generally high potential of technology for a large-scale transition to teleworking regimes is limited by low capabilities and experience with telework in the EU. With sectoral and national variations, only 5% of the labour force in the EU usually worked from home and an additional 8% sometimes. Therefore, this forced transition to a much more generalised telework regime is likely to be more challenging for some countries than others.

Figure 14. Sectoral composition of jobs (in thousands) by level of skills required in the EU, 2019



Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat [lfsa_egised]

5 R&I for accelerated economic recovery and EU competitiveness

The role R&I plays as a key engine of productivity has been widely acknowledged in the economic theoretical and empirical literature, since Romer (1990). Research and innovation investments are crucial as they create new ideas and technologies, or recombine and find new applications for existing ones, fundamentally changing the way production systems and business models work. This has positive implications on overall productivity and competitiveness of firms, regions and economies. For instance, using country data from the EU KLEMS (2019), it is found that **R&I broadly defined contributes to around two thirds of labour productivity growth in EU member states** (European Commission, 2020a). Similar evidence is reported at the industry (Niebel et al., 2017) and firm level (Cincera et al., 2020).

While the above holds in general, it is particularly relevant in the context of the COVID-19 crisis. The reported cyclicality of innovation, both in terms of creation and its diffusion (Anzoategui et al., 2019), implies that, while this crisis is intrinsically different from any other financial or economic recession, **innovation benefits will slow down because of the current downturn.** On the demand side, companies may decide to postpone innovative investments as they do expect a persisting decline in demand and because returns are perceived as higher during periods of growth (Dachs and Peters, 2020). This view is consistent with the evidence in Anzoategui et al. (2019), and can be magnified by the effects on absorptive capacity, employment displacement and reduced innovation diffusion.

Though the consequences of restrictions to mobility will materialise also in the medium term, there is already evidence that the current crisis has impacted negatively on revenues and has constrained innovation efforts. Startup Europe[24] identifies as the most critical challenges brought by the current pandemic to the survival of deep-tech startups the immediate funding needed to address the decline in revenues, the current and any potential contraction of demand again in the future, R&D projects that have been cancelled or are on hold, insufficient IT expertise, and disruptions in international transportation of goods. In addition, the results of StartupGenome´s survey[25] to startups on the impact of the COVID-19 crisis indicate that 74% of startups saw their revenues decline (most of them modestly) since the beginning of the crisis[26]. Moreover, Business-to-Consumer (B2C) startups appear to be "three times more likely to be in industries experiencing growth in the face of the COVID-19 crisis when compared to Business-to-Business (B2B) startups".

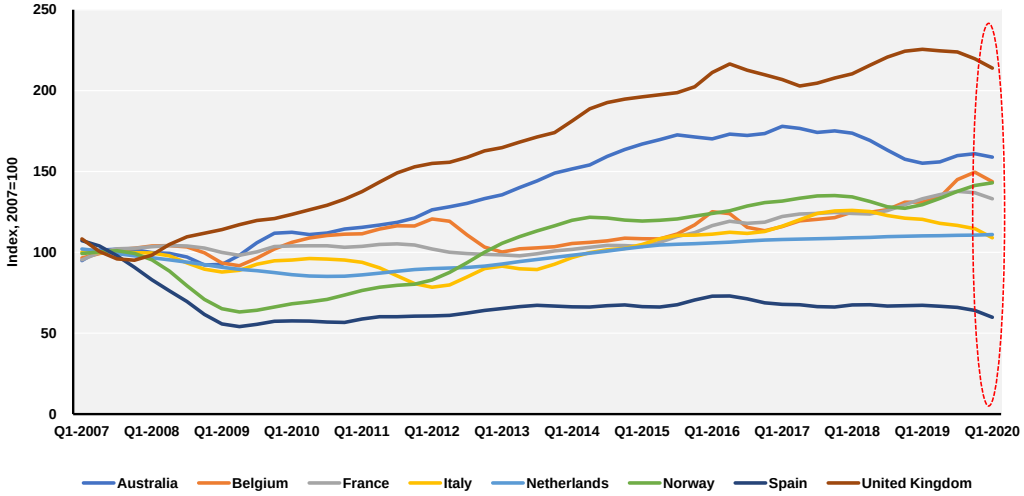
Overall, business dynamism has been negatively affected by the crisis, while long-term prospects will depend on the evolution of the pandemics and policy actions in the next months. The creation of new companies has already contracted, with a decline in entry rates in the first quarter of 2020 in countries such as the United Kingdom, Australia, Belgium, France, Spain or Italy (Figure 15). The US Census Bureau also reports a deficit in new business applications for employer enterprises since week 11 of 2020 (but as of June 20 that downward trend appears to have been interrupted). Similarly to their relevance for innovative activities and knowledge diffusion in the economy, young companies contribute disproportionately to net job creation (Criscuolo et al., 2014) therefore a "missing generation" may have notable employment effects (OECD, 2020a). A decline in entry rates may undermine the role of business dynamism in 'creative destruction' and hence productivity growth prospects (Bauer, 2020).

[24] http://startupregions.eu/blog/2020/06/04/scale-up-champions-survey/

[25] https://startupgenome.com/blog/covid19-insights-global-startup-survey, April 16 2020

[26] This is also because the big majority of the startups in the sample work in industries highly affected work in industries severely affected by the crisis.

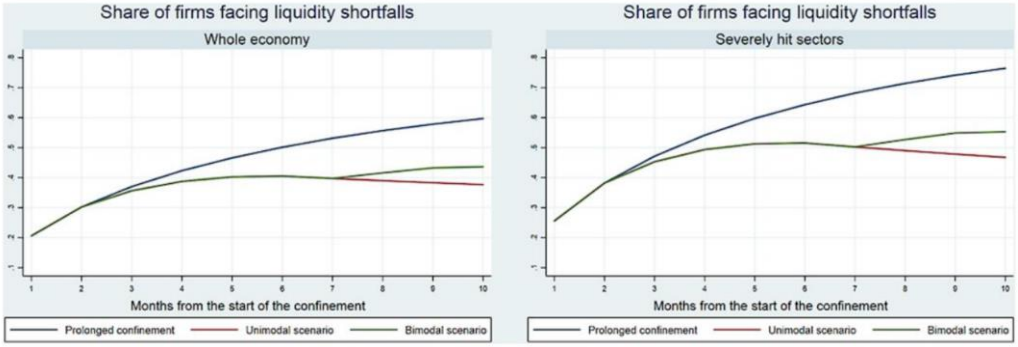
Figure 15. Number of enterprise entries by quarter relative to 2007



Source: DG Research and Innovation- Unit A1- Chief Economist R&I Strategy and Foresight, based on OECD Timely Indicators of Entrepreneurship (ISIC4)
Notes: Corporations only.

These developments call for swift policy actions to support innovative companies to minimize the impact of medium-long term developments on innovation and productivity. While it is true that on average innovative firms and startups tend to be more resilient than less innovative companies (Dachs et al., 2017), the main issue of the COVID-19 crisis is the prolonged lockdowns and their impacts on business activities (Dachs and Peters, 2020). This is crucial for both supply and demand expectations, as it is still uncertain whether a second wave of contagion will take place in the coming months, and when a vaccine is going to be available. The OECD (2020b) estimates suggest increasing shares of companies facing liquidity shortfalls (if no government intervention), with the scenario being worse in case a second wave of the epidemics materialises, and with stronger impacts for 'manufacturing of transport equipment', 'real estate', 'arts, entertainment and recreation', 'wholesale and retail trade', 'air transport', 'accommodation & food services', 'construction' and 'professional service activities' (Figure 16).

Figure 16. Estimated share of firms facing liquidity shortfalls without government intervention, OECD countries, in the whole economy and severely hit sectors

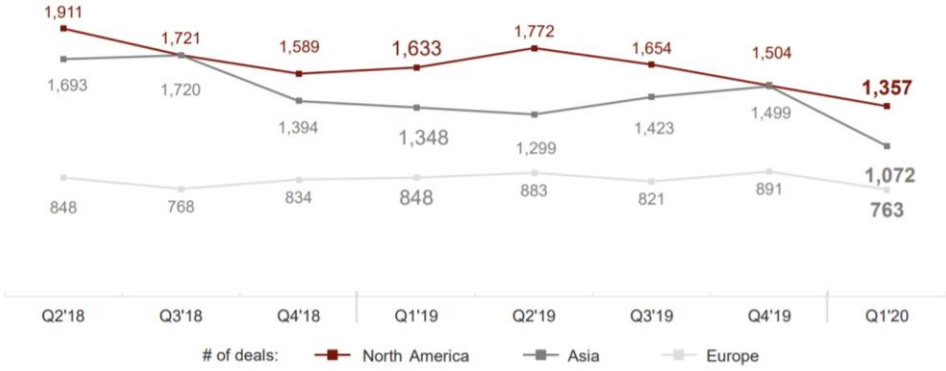


Source: OECD (2020b) based on ORBIS data.
Notes: The unimodal scenario foresees a sharp drop in activity lasting two months, followed by a four-month progressive transition towards normality, and a return to pre-crisis activity levels from the seventh month after the start of the epidemic. The bimodal scenario overlaps with the unimodal scenario for the first seven months, but then models a second outbreak from the eight month onwards. The decline in output is assumed to be: between 50 and 100% in the most severely hit sectors-manufacturing of transport equipment, real estate services, arts, entertainment & recreation, other service activities, wholesale & retail trade, air transport, accommodation & food services, construction, professional services; 15%: others

Besides the need for liquidity, deep-tech startups tend to be also reliant upon risk capital to scale-up their activity. There is evidence that the supply of venture capital may have overall contracted during the current crisis. Howell et al. (2020) find that innovative startups relying on venture capital (especially at the early-stage) have been seriously affected by the economic downturn. Figure 17 shows that the number of deals in Q1 2020 has declined relative to the last quarter of 2019, and this appears to be the case not only in Europe, but also in North America and Asia. Moreover, preliminary findings for the United States hint at investor interest having shifted (relative to 2019) to industries perceived as more resilient/"essential" during the crisis and for the recovery, such as Pharma and Life, Software and Services, and Energy and sustainability[27].

[27] https://medium.com/swlh/covid-19s-impact-on-early-stage-venture-capital-2851230c0c64?

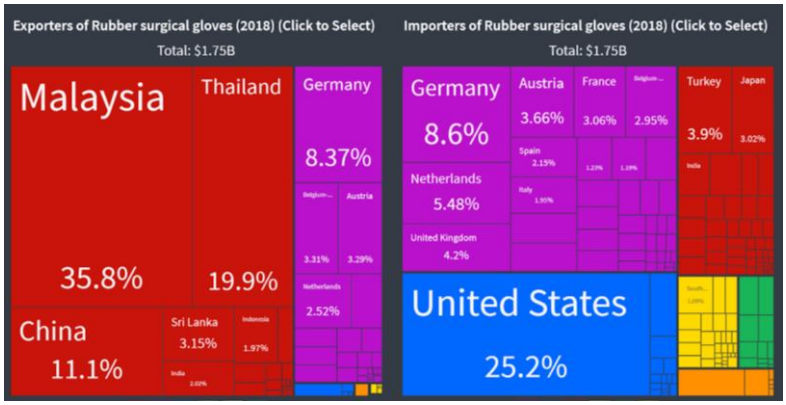
Figure 17. Global deal activity: number of deals in North America, Asia, and Europe



Source: PwC CB Insights MoneyTree™ Report Q1 2020

The COVID-19 pandemic has also triggered global tensions due to intensified pressure to make personal protection equipment quickly and widely available to healthcare and essential workers at a global scale, as the virus spread. This has led to reflections on **whether there is a need to diversify supply chains to minimize risk from external shocks especially in relation to critical assets.** For example, the province of Wuhan in China is a leading supplier of masks but was also the first area to be severely hit by the pandemic[28]. Figure 18 gives another example- of rubber gloves- where Asia emerges as the top exporter continent, while Europe was the top importer of this good in 2018. Had the virus impacted Asian economies more widely, and likely the supply of these protective gloves for hospitals would have been more limited.

Figure 18. Top exporters and importers of Rubber surgical gloves, 2018



Source: Observatory of Economic Complexity: https://oec.world/en/profile/hs92/rubber-surgical-gloves

[28]https://mitsloan.mit.edu/ideas-made-to-matter/5-bold-ideas-economic-restart?utm_source=mitsloantwitter&utm_medium=social&utm_campaign=restartideas

Though the majority of companies will be negatively impacted by the COVID-19 pandemic and the economic downturn, some have better weathered the crisis and turned it into new opportunities. For example, Startup Genome (2020) notes that 12% of startups registered a 10% increase in their revenues since the onset of the crisis, and "one out of every 10 startups are in industries actually experiencing growth"[29]. Figure 19 gives some examples of companies that became successful despite being founded at the time of the Global Financial Crisis (social media, retail, software, fintech). As a result, there may be **new post-crisis "champions"** after this pandemic too. In this context, the Financial Times[30] reports that in terms of equity added value, there are companies (referred to as "the fortunate few") in health, entertainment, cloud computing, pharmaceuticals and e-commerce that have prospered during the crisis. This list includes not only companies such as Zoom, Netflix, Spotify, Tesla and Slack, but also less "well-known" companies with lower valuations but that saw big percentage gains in market cap working on e.g. producing a vaccine for COVID-19), producing PPE for medical workers, developing new drugs, proving cloud computing services, online stores for home-made produced goods, etc. As part of these "alternative corporate winners" are 5 EU companies- Northern data (DE), NetEnt (SE), Sinch AB (SE), HelloFresh (DE), Shop Apotheke Europe (NL).

Figure 19. 10 examples of successful companies founded during the global financial crisis (2007-2010)

Source: Larry Kim, MobileMonkey.com; https://fi.co/insight/successful-companies-started-in-recession

6 R&I for transformation of our economy and society

The climate dimension is also closely connected to the current sanitary crisis. Without an effective action against global climate change, there could be more significant

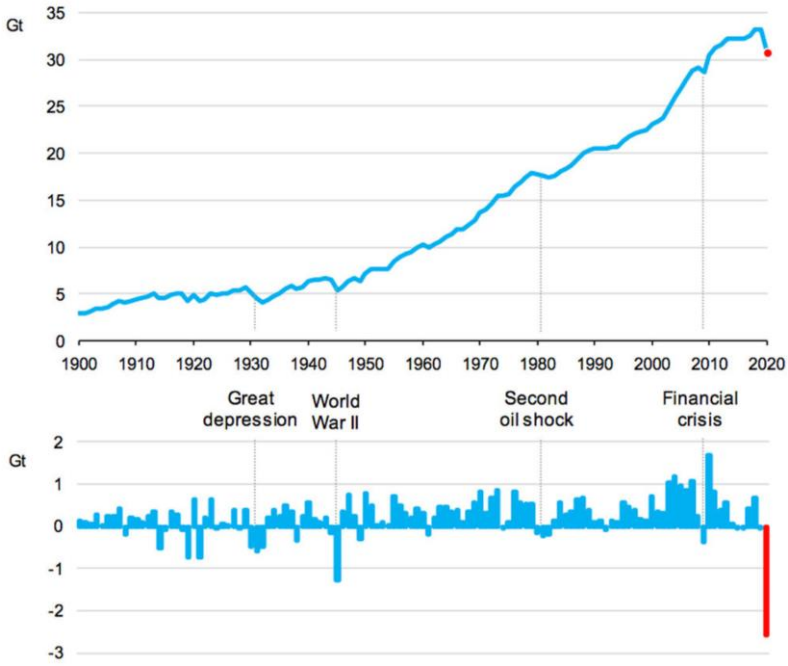
[29] For example, Pitchbook reports that the pandemic led to an increase in capital to supply chain tech in Q1 2020:https://pitchbook.com/news/articles/coronavirus-updates-latest-news-and-analysis?utm_source=DY&utm_medium=newsnav&utm_campaign=covid19#reports

[30] https://www.ft.com/content/496bc09a-4646-407a-a0d4-a22dac55c1e6

spread of microbes that are typically associated with tropical diseases. Not only trends like population expansion or increase in global travel and trade can accelerate the spread of infectious diseases, but the changes brought by climate warming can have further impacts on the occurrence of microbes in territories further from the equatorial region (Osterholm and Olshaker, 2017). Therefore, it is important to be aware of certain interdependence among these risks and combat both together.

This pandemic has also brought some rather short lasting environmental improvements, such as reductions in levels of air pollution and greenhouse gas emissions, which allowed citizens, particularly in urban areas, to experience different living environments. Before the COVID-19 pandemic, emissions of carbon dioxide were rising by about 1% per year over the previous decade (Peters et al., 2020). With the crisis, we can already observe decreased CO2 emissions. Daily global CO2 emissions decreased by 17% by early April 2020 compared to the mean 2019 levels, with almost half of the decrease due to changes in surface transport. At their peak, emissions in individual countries decreased by 26% on average (Le Quéré et al, 2020). Figure 20 shows global energy-related emissions (top) and annual change (bottom) in GtCO2, with projected 2020 levels.

Figure 20. Global energy-related emissions (top) and annual change (bottom) in GtCO2, with projected 2020 levels highlighted in red



Source: International Energy Agency (2020), Global Energy Review
Note: Other major events are indicated in the graph to give a sense of scale.

However, these trends are likely to be reversed and the magnitude of this will depend on the nature of the economic recovery and the type of recovery policies

that will be implemented. Hepburn, C. et al (2020) identify five policy actions that can make COVID-19 fiscal recovery packages climate-positive: clean infrastructure investment, building efficiency, investment in education and training, natural capital investment and clean R&D investment. The identified policies are perceived as both highly desirable for climate targets and characterised by high multipliers in the long term, because of strong returns on public investment.

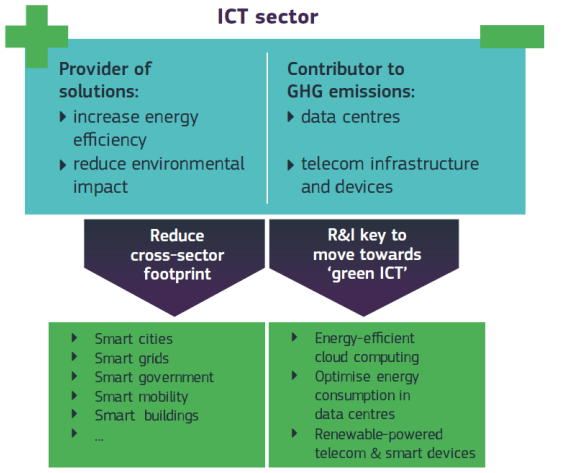
The sudden and global disruption of normality in everyday lives stopped many social practices, which were altered or substituted. As learning and adaptation to these practices and a new organisation of everyday lives required efforts from everyone, there is an opportunity to capitalise on these investments in the context of a broader transformation. The emergence of social changes under specific conditions may lead to system-wide change in the long term and position the society better or worse towards a sustainable future. Any changes to social practices are of great relevance as they are a major factor in shaping the environmental and social impact of the technologies, products and services. Existing research indicates widespread disruption and change of practices in key areas such as hygiene, food provision, mobility, shopping, water use and gardening, household work and care (Boons, et al., 2020).

R&I is the main driver behind the digital and ecological transformation of our societies, enabling decarbonisation and more circular economy. Any systemic transformations bear important consequences for public policy, which is becoming increasingly aware of the need for forward-looking solutions, rather than quick fixes to outstanding emergencies. Conditions can be attached to business recovery investment programmes to enable transformation of sectors, shifting the focus on a strategy of lowering carbon emissions. The same holds for more specific recovery investment to transform products, processes or supply chains towards more sustainable solutions. At the same, such investment should encompass workers so that they can adapt to new technologies (Mazzucato and McPherson, 2018). Mission-oriented finance or mission-oriented innovation could decrease material consumption for products and encourage innovation around areas such as eco-design, durability and waste reduction. Clear orientation for public-private partnerships towards the important longer-term goals of the Green Deal should follow the short-term rescue measures and guide the path out of the coronavirus crisis (Göpel, 2020).

Digital technologies have been shown to be essential during the crisis, enabling business continuity through teleworking and changing business models. However, with the exponential growth of data, more storage and computing capacity is needed. Moreover, the use of sophisticated telecoms equipment, infrastructure and mobile devices is also consuming increasing amounts of energy[31] (European Commission, 2020a). **R&I can be fundamental in the move towards 'green ICT'** – i.e. by exploring and creating new ways of making cloud computing and data centres energy efficient, telecom operations powered by renewables, and by generating smart devices (Figure 21).

[31] The new EU Digital Strategy explains that today the ICT sector accounts for 5-9% of electricity use and more than 2% of global greenhouse gas emissions (as much as all air traffic). If unchecked, the footprint could increase to 14% of global emissions by 2040 (European Commission, 2020a).

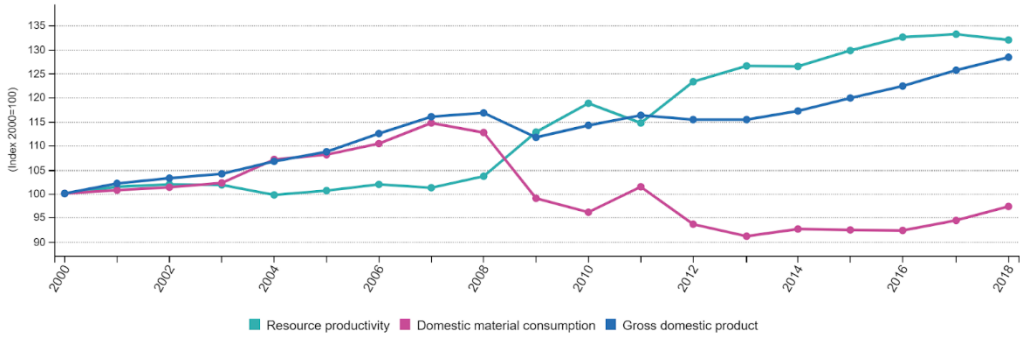
Figure 21. Visual representation of the impact of ICT on the environment



Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Global e-Sustainability Initiative (2015) and presentation by Richard Labelle (2014)

The ongoing debate on the role of future economic growth in achieving the SDGs has a strong focus on material consumption and carbon footprint of the growth. The evidence suggests that the problem is not necessarily the growth of GDP per person, but humanity's footprint growth in terms of resource use and pollution outputs (Stockholm Resilience Centre, 2018). Figure 22 shows that between 2000 and 2018 resource productivity has improved in the EU, i.e. GDP has increased, but domestic material consumption has in fact decreased (on average) since 2007. McAfee (2019) notes that the United States and other advanced economies have undergone a process of "dematerialisation": while economic output has grown, it has also used less timber, metals, fertilizer, and other resources over time. He points to technological advancement as one key explanation for this positive development. A genuine green growth model for the economy could spur the economic growth essential to achieve the broad set SDGs while respecting planetary boundaries.

Figure 22. Resource productivity in the EU, 2000-2018



Source: Eurostat (online data code: nama_10_gdp, env_ac_mfa; env_ac_rp)
Notes: Resource productivity will increase if the economy, measured by GDP, is growing at a faster rate than the consumption of raw materials, measured by domestic material consumption (DMC). DMC indicates the total amount of material actually consumed domestically by resident units calculated as the direct material input (DMI) minus

physical exports. DMI includes all materials available for use in production and consumption and it is the sum of domestic extraction plus physical imports.

While the EU economy is accumulating large stocks of metals and plastics, it could **meet a large share of its need for these materials by 2050 by recirculating what has already been produced.** Unfortunately, there are not practices in place to facilitate these high recycling rates (Material Economics, 2018). Therefore, an influx of new materials is required both to replace materials that are lost and to compensate for downgrading of quality in recycled ones. It suggests an important role for R&I in tackling both, supply and demand side. On the supply side, it could help to reduce emissions from the production of steel, cement, chemicals, and other materials, and on the demand side it can support more circular approaches for reductions of emissions through better use and reuse of materials that already exist in the economy. These efforts to achieve a low-carbon energy system and a more circular economy of materials can help Europe to cut its CO2 emissions and reduce the footprint of European societies.

7 R&I for system resilience

The current pandemic situation testified that major societal and environmental disruptive events can develop to humanitarian crises, affecting developed as well as developing countries. The imminent policy question arising is how much resources should governments devote to achieve **more resilient and agile societal and economic systems** able to withstand such rare but potentially catastrophic events. The answer to this question is not straightforward as the probability, scale, and in some cases even the full nature of such events cannot be predicted.

Addressing these risks relies on robust evidence-based decision-making, which is why research and innovation must intersect with policy in order to be fully effective. **In the context of the current pandemic**, any scientific advances in disease treatment or prevention must be given consideration by the policymakers to reach a proper leverage effect. For a potential coronavirus vaccine, these range from early-stage research to large-scale production and distribution, e.g. through joint procurement at the EU level. **For the transition to sustainable development**, bio-economy, circular economy, sufficient level of biodiversity and land management are vital elements, but are also extremely challenging to implement. Contributions from R&I in the design, manufacturing and organisation are needed to build on the potential restorative powers of natural systems, combined with strategies to reduce overall demand for resources (Weber et al., 2018).

A key challenge for policy-makers dealing with risk management across policies and sectors is to capitalise on the wealth of available scientific knowledge from local to the global level. Science, defined as a body of knowledge accumulated through systematic and logical rules of research, remains the best-suited source of evidence to inform policy making, while politics may also need to factor in other sources as personal experience or popular opinion (European Commission, 2018). European institutions and national governments play an important role in designing strategic approaches to resilience, which should also involve local initiatives, including providing them with advice as well as technical and financial resources (Ricci, et al., 2017).

While many natural or human-induced disasters present major risks to the economy, the security and well-being of our society, most of these events are limited locally or in time. **There are only few such events that have the power to negatively affect the entire planet**, such as a global pandemic or a thermonuclear war (Osterholm and Olshaker, 2017). We currently face two such events with truly global impact that emerged on a different timescale, but both are calling for urgent actions. Compared to the sudden outbreak of an infectious disease as COVID-19 reaching global pandemic within a few months, the impact of climate change unfolds over the long-term. Nevertheless, scientific knowledge points to the urgency of both events.

The COVID-19 crisis struck at a time when Europe was preparing its investment strategy to fight climate change. As this crisis arose abruptly, it demonstrates that high probability events with the risk of serious impact must be tackled in a timely manner since any delays in the response would increase the required amount of investment. As such, policymakers should integrate the solutions to both crises into a coherent response so that health, safety and social protection measures are followed immediately by inclusive recovery programmes, paving the way for the global economy towards sustainable growth and increased resilience (Figueres and Zycher, 2020).

Therefore, this pandemic must be perceived as a part of potential series of shocks and long-term risks to human health, economic prosperity and planetary stability. If we cope with each new crisis on its own as it arises, they could soon exceed the capacity of governments, public institutions, corporate crisis managers and society as a whole. Consequently, in their seeking for recovery from this crisis, leaders can decide to stimulate the economy in a way that either amplifies global threats or mitigates them. So they need to choose wisely (Club of Rome, 2020).

8 Conclusions

As R&I is at the core of the response to the recent spread of COVID-19, the pandemic is expected to provide a stimulus to R&I efforts in the health sector. R&I actors turned their attention and resources to halt the spread of the virus, and a surge in R&I production in the health area (drug therapies, medical publications) can be observed since the beginning of the crisis. On the other hand, the outbreak magnifies the underinvestment of the private sector in R&I activities, traditionally justified by market failures, and the importance of also supporting digital and data-driven solutions to fight the virus. This calls for more involvement and coordination from policymakers.

The impact of this crisis on overall R&I investment will depend on the type of economic downturn caused by the pandemic and the policy response to it. Experience from the last economic crisis shows that business R&D can slow down significantly with economic contraction, and the willingness of R&I investors may dampen in the case of a long and serious economic recession. But there can be positive expectations due to supportive policy packages worldwide and the expansion of innovative responses in the business sector.

Investments in innovative SMEs, startups and midcaps are hence critical for the recovery to capitalise on these innovative ideas and preempt lack of their funding (European Commission, 2020c). It is essential to kick-start the economy and help private investment. At the EU level, the InvestEU Programme will contribute to building stronger value chains within the EU, support critical infrastructure, developing nascent technologies, as well as supporting new ecosystems of new entrepreneurs, and cross-border strategic sectors. The European Innovation Council will also support the scale up of start-ups and SMEs, focusing on breakthrough innovations and emerging technologies.

With the adaptation of economies and societies to the pandemic, there have been wide ranging changes to the organisation of workplaces or work in general and to ways businesses operate. In broad terms, these adaptations have accelerated digital transformation but also have the potential to increase inequalities in the future. This concerns workers in particular occupations, companies in across several industries as well as states that did not cope well with the ongoing digital transformations before the pandemic struck. At the same time, the World needs long-term adaptation strategies and investment to fight climate change and to deal with other challenges such as loss of biodiversity, an ageing population, and growing inequalities.

Policy action should support measures that aim at building system-wide resilience to limit the impact of all such long-term threats. First, in a response to a pandemic, it is of paramount importance to invest in national health systems, making them more resilient and capable of a rapid response reflecting the latest scientific discoveries, and ensuring broad access to healthcare. The recent crisis testified how the health system's capacities make a difference in terms of response to outbreaks. Second, recovery programmes need to include incentives for firms that maintain their economic activity and investment in people together with research and innovation during the crisis. Support schemes should allow return of employees from sectors or tasks shut down during the crisis, or for broader digitisation of enterprises and skills to foster quick responses to the crisis situation.

For a better future, creating greater resilience by design, not by disaster should be at the core of a coordinated recovery response to the COVID-19 outbreak. In the midst of a global health emergency and imminent economic recession, a widely oriented recovery model and a concerted investment in research and innovation-led transformation could improve the resilience of societies after this pandemic (European Commission, 2020e). More ambitious and forward looking economic recovery plans support transformative changes by investing in people, nature and low carbon development and thus to secure a path to net zero emissions, improve global health and rethink how we use land and transform our food systems (Club of Rome, 2020). Nevertheless, in order to be truly transformative, these recovery packages should be designed to include some strong economic incentives and conditions for industries to shift to a low carbon circular business model, and invest in nature and people.

9 References

Aghion, P., Askenazy, P., Berman, N., Cette, G., & Eymard, L. (2012). Credit constraints and the cyclicality of R&D investment: Evidence from France. Journal of the European Economic Association, 10(5), 1001-1024.

Anzoategui, D., Comin, D., Gertler, M., & Martinez, J. (2019). Endogenous technology adoption and R&D as sources of business cycle persistence. American Economic Journal: Macroeconomics, 11(3), 67-110.

Arrow, K. (1962). 'Economic Welfare and the Allocation of Resources to Invention' In The Rate and Direction of Inventive Activity: Economic and Social Factors, edited by the Universities - National Bureau Committee for Economic Research and the Committee on Economic Growth of the Social Science Research Councils, 609– 26. Princeton, NJ: Princeton University Press.

Barlevy G (2007) On the cyclicality of research and development. American Economic Review 97(4):1131–1164

Bauer, P., Fedotenkov, I., Genty, A., Hallak, I., Harasztosi, P., Martinez Turegano D., Nguyen D., Preziosi, N., Rincon-Aznar, A. and Sanchez Martinez, M. (2020), Productivity in Europe – Trends and drivers in a service-based economy. JRC Technical Report, European Commission, Brussels.

Bello, M. and Galindo-Rueda, F. (2020), "Charting the digital transformation of science: Findings from the 2018 OECD International Survey of Scientific Authors (ISSA2)", https://doi.org/10.1787/18151965

Bloom, N., Sadun, R. and Van Reenen, J. (2016), Management as a Technology?, (No. w22327), National Bureau of Economic Research.

Boons, F., Browne, A., Burgess, M., Ehgartner, U., Hirth, S., Hodson, M., Holmes, H., Hoolohan, C., MacGregor, S., McMeekin, A., Mylan, J. Oncini, F., Paterson, M., Rödl, M., Sharmina, M., Warde, A., Welch, D., Wieser, H., Yates, L., Ye, C. (2020). Covid-19, changing social practices and the transition to sustainable production and consumption. Version 1.0 (May 2020). Manchester: Sustainable Consumption Institute.

Bryan, K., J. Lemus and G. Marshall (2020), Innovation During a Crisis: Evidence from Covid19, SSRN Electronic Journal

Cincera, M., Delanote, J., Mohnen, P., Santos, A., Weiss, C. (2020). Intangible investments and productivity performance (No. 0145). Gabinete de Estratégia e Estudos, Ministério da Economia.

Corrado, C., Hulten, C. and Sichel, D. (2005), Measuring capital and technology: an expanded framework. In Measuring capital in the new economy (pp. 11-46), University of Chicago Press.

Criscuolo, C., Gal, P.N. and Menon, C. (2014), "The dynamics of employment growth: new evidence from 18 countries", OECD Science, Technology and Industry Policy Papers, forthcoming.

The Club of Rome (2020). Open Letter to Global Leaders – A Healthy Planet for Healthy People. March 26, 2020. Available at: https://clubofrome.org/impact-hubs/climate-emergency/open-letter-to-global-leaders-a-healthy-planet-for-healthy-people/

Dachs, B., and Peters, B. (2020). Covid-19 and its impact on business R&D. Austrian Institute of Technology Policy Brief.

Dingel, J. and Neiman, B. (2020). How many jobs can be done at home? NBER Working Paper No. 26948.

EIB (2019), Investment report 2019/2020: Speeding up Europe's transformation. Luxembourg: European Investment Bank.

European Commission (2020a). Science, Research and Innovation Performance of the EU 2020.

European Commission (2020b), Digital Economy and Society Index 2020.

European Commission (2020c). The role of research and innovation in support of Europe's recovery from the Covid-19 crisis. R&I Paper Series, Policy Brief.

European Commission (2020d). European Economic Forecast: Summer 2020. European Economy. Institutional Paper 132.

European Commission (2020e). Protect, prepare and transform Europe: Recovery and resilience post COVID-19. ESIR Policy Brief No. 1.

European Commission (2018). Making sense of science under conditions of complexity and uncertainty. Scoping paper of Scientific Advice Mechanism.

European Commission (2017). Study on frugal innovation and reengineering of traditional techniques.

Fabrizio K, Tsolmon U (2014). An empirical examination of the procyclicality of R&D investment and innovation. Rev Econ Stat 96(4):662–675

Fana, M., Tolan, S., Torrejón, S., Urzi Brancati, C., Fernández-Macías, E. (2020). COVID confinement measures and EU labour markets. JRC technical report, JRC120578.

Figueres, C. and Zycher, B., (2020). Can we tackle both climate change and Covid-19 recovery? Financial Times series Coronavirus: The world after the pandemic, May 7 2020.

Foray, D., de Rassenfosse, G., Younes, G. A., Ayoubi, C., Ballester, O., Cristelli, G., Gaule, P., Pellegrino, G. & van den Heuvel, M. and Webster, B, (2020). COVID-19 Insights from Innovation Economists.

Fry, C. et al. (2020). Consolidation in a Crisis: Patterns of International Collaboration in COVID-19 Research. SSRN Electronic Journal

Global e-Sustainability Initiative (2015), Smart 2020: Enabling the low carbon economy in the information age.

Göpel, M. (2020), A Social-Green Deal, with just transition—the European answer to the coronavirus crisis, Social Europe, 31 March 2020: https://www.socialeurope.eu/a-social-green-deal-with-just-transition-the-european-answer-to-the-coronavirus-crisis

Gross, D.P. and Sampat, B.N. (2020), Inventing the Endless Frontier: The Effects of the World War II Research Effort on Post-war Innovation. NBER Working Paper No. 27375.

Hale, T., Petherick, A., Phillips, T., & Webster, S. (2020). Variation in government responses to COVID-19. Blavatnik school of government working paper, 31.

Harris, M., Bhatti, Y., Buckley, J. and Sharma, D. (2020). Fast and frugal innovations in response to the COVID-19 pandemic. Nature Medicine 26, 814–817.

Hellotomorrow (2020), Four challenges that innovations teams need to tackle to thrive right now, https://hello-tomorrow.org/wp-content/uploads/2020/06/Innovation-Survey-V4.pdf.

Hepburn, C., O'Callaghan, B., Stern, N., Stiglitz, J. and Zenghelis, D. (2020). Will COVID-19 fiscal recovery packages accelerate or retard progress on climate change? Forthcoming in the Oxford Review of Economic Policy.

Howell, S., Lerner, J., Nanda, R. and Townsend, R. (2020) Financial Distancing: How Venture Capital Follows the Economy Down and Curtails Innovation.

IEA (2020), Global Energy Review 2020, IEA, Paris

Le Quéré, C., Jackson, R.B., Jones, M.W., Smith, A. J. P., Abernethy, S., Andrew, R. M., De-Gol, A.G., Willis, D. R., Shan, Y., Canadell, J. G., Friedlingstein, P., Creutzig, F. and Peters, G. P. (2020). Temporary reduction in daily global CO2 emissions during the COVID-19 forced confinement. Nature Climate Change.

McAfee, A (2020), More from Less: The Surprising Story of How We Learned to Prosper Using Fewer Resources—and What Happens Next, Publisher: Scribner

Niebel, T., O'Mahony, M., Saam, M. (2017). The contribution of intangible assets to sectoral productivity growth in the EU. Review of Income and Wealth, 63, S49-S67.

OECD (forthcoming), Science, technology and innovation in times of Covid-19 and policy responses. Forthcoming.

OECD (2020a). Start-ups in the time of COVID-19: facing the challenges, seizing the opportunities, tackling coronavirus (COVID-19) Contributing to a global effort.

OECD (2020b). Evaluating the initial impact of COVID-19 containment measures on economic activity. https://read.oecd-ilibrary.org/view/?ref=126_126496-evgsi2gmqj&title=Evaluating_the_initial_impact_of_COVID-19_containment_measures_on_economic_activity

OECD (2019). Measuring the Digital Transformation: A Roadmap for the Future, OECD Publishing, Paris, https://doi.org/10.1787/9789264311992-en.

Osterholm, M. T. and Olshaker M. (2017). Deadliest Enemy: Our War against Killer Germs. New York: Little, Brown and Company.

Peters, G. P. et al. Carbon dioxide emissions continue to grow amidst slowly emerging climate policies. Nat. Clim. Change 10, 3–6 (2020).

Rockefeller Foundation (2015). 100 resilient cities - 100RC. Website. http://www.100resilientcities.org/author/100rc#/-_/ Sedgley, N. H., Burger, J. D., & Tan, K. M. (2019). The symmetry and cyclicality of R&D spending in advanced economies. Empirical Economics, 57(5), 1811-1828.

Soete, L. (2020). Hammer or nudge? Science-based policy advice in the COVID-19 pandemic. United Nations University, Policy Brief Number 4, 2020.

Veneri, P. (2020). Short-term economic effects of the Covid-19 outbreak. First insights on OECD regions. 8th meeting of the Spatial productivity for regional and local development, 7 May 2020.

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While research and innovation (R&I) are at the core of the response to the pandemic itself in the areas of virology, vaccines development, treatments and diagnostics, it will be crucial also in the economic recovery from the crisis, not only to spur economic activity, but also to accelerate the transitions that our planet and society need. Hence this working paper discusses the role of R&I in the short-term context of the sanitary crisis and economic contraction, as well as in the longer term and aftermath of the crisis, as a key driver of the recovery. It concludes that policy should promote the coordination of the R&I response to COVID-19, support businesses to cope with the crisis and create innovative solutions to tackle the direct and indirect consequences of the pandemic, help workers and businesses adjust to new ways of working and operating, and build system-wide resilience to address long-term threats such as climate change.

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