European Commission

Quarterly R&I literature review 2020/Q1

R&I for new EU priorities

R&I PAPER SERIES
LITERATURE REVIEW

Research and Innovation

Quarterly Literature Review of R&I Economics and Policy

European Commission
Directorate-General for Research and Innovation
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Unit A.1 — Chief Economist – R&I Strategy and Foresight

Contact **Ruzica Rakic**, Coordinator of the Literature Review, Unit A1
Román Arjona, Chief Economist and Head of Unit A1
Email Ruzica.RAKIC@ec.europa.eu
Roman.ARJONA-GRACIA@ec.europa.eu
RTD-ECONOMIC-ANALYSIS@ec.europa.eu
European Commission
B-1049 Brussels

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Literature Review

2020 Directorate-General for Research and Innovation

QUARTERLY R&I LITERATURE REVIEW 2020/Q1
R&I FOR NEW EU PRIORITIES

This review is developed by the 'Economics of R&I' team of the Chief Economist unit of DG Research and Innovation. Contributors: Lukas Borunsky, Ana Correia, Roberto Martino, Oliver Podmanicky, Ruzica Rakic (coordinator for the review), Julien Ravet (team leader). It provides a brief summary of a selection of recent publications on R&I economics and policy.

For this edition, the review provides several insights on **sustainability**, including a historical perspective of the sustainability framework and principles to minimise trade-offs between policy objectives. We had a particular interest in how **R&I** can play a role in the **transformations** that are required to achieve a safe and just space for humanity. Technological and economic developments, especially in the context of **digitalisation** (inc. artificial intelligence), are also examined through the perspective of sustainable development, with a focus on **inequalities**, **future of work** and **regional aspects**. All these have important policy implications, in particular for R&I policy. Given the current context, we open this edition with an editorial from Nature on how science should react to the **Coronavirus pandemic**.

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1. COVID-19: WHAT SCIENCE ADVISERS MUST DO NOW

Nature Editorial (2020). Coronavirus: three things all governments and their science advisers must do now. Nature, 579, 319-320.

Messages	**1.** The authors invite political leaders to follow World Health Organization advice for their expertise in handling global pandemics. **2.** Authors advocate ending secrecy in government decision-making allowing others to challenge potential mistakes. **3**. Global cooperation will help save lives during the COVID-19 pandemic.

Follow the World Health Organization's advice

The coronavirus pandemic has led many governments to close their borders and quarantine their citizens as measures to prevent or delay the virus from spreading, in line with the global effort of containing the pandemic. The authors emphasise the importance of breaking the chain of viral transmission based on the WHO recommendations which states to aggressively test, track and isolate as many COVID-19 cases as possible. The authors invite policy makers to be more transparent with the underlying methodology supporting their decisions and to take advantage of the robust expertise of the WHO.

Publish the evidence and embrace open research

From the start of the outbreak, researchers around the world have led the way in sharing research data ranging from viral gene sequences to epidemiology studies. The authors of the editorial recommend that key research leaders who advise governments during the pandemic do so in a shared and collaborative environment which would allow others to challenge potential mistakes or assumptions. Consequences of not publishing evidence can be seen in the UK's controversial decision to delay school and workplace closures based on the initial reasoning that developing herd immunity would also reduce the peak of infection whilst minimising its economic impact. The evidence behind this approach was not revealed. This approach is no longer part of UK policy due to subsequent criticism from infectious-disease specialists.

International cooperation will save lives

The authors question the decision of governments which overlook the value of international cooperation and instead rely on unilateral decisions. When deciding to close borders to block spread of virus, evidence was not published, other states were not consulted. Furthermore, the decision to impose flight bans is questionable if high levels of community based transmission already existed. Advisers are asked to persevere and persuade their leaders that coordinated collective action is in everyone's interest. For example, if they disagree with WHO's analysis, they are invited to share their evidence so that the virus can be defeated together.

2. SUSTAINABILITY AND ITS THREE PILLARS: A HISTORICAL PERSPECTIVE

Purvis, B., Mao, Y., & Robinson, D. (2019). Three pillars of sustainability: in search of conceptual origins. Sustainability science, 14(3), 681-695.

Messages	**1.** The three sustainability pillars have been developed as a progressive critique to the main economic mainstream theory, and they have been reconciled in a unique framework only recently. **2.** The "twin" environmental and the social critique spurred the original debate, challenging the "pure" economic growth model. **3.** The concept of sustainable development integrated the economic dimension and eventually came to the core of the policy debate across international institutions.

The characterisation of **sustainability in three intertwined dimensions** encompassing the environmental, social and economic aspects is nowadays acknowledged in both the academic and policy discourse. The concept of three pillars jointly contributing to the achievement of sustainable development, while being interconnected and interdependent among them, provides guidance to policy at all levels.

The authors explore the relevant academic and institutional literature in the search of the theoretical roots of the sustainability concept. Their findings suggest that the sustainability framework has developed as a cumulative process that started with the **"twin" critique to the mainstream approach to economic growth that started to spur in the 1970s, giving birth to the so-called "eco-development" movements.** It is only starting from the 1980s that the sustainability discourse fully introduced the **economic pillar** within the new framework of sustainable development that has since institutionalised in the international policy debate, most notably following the Bruntland report in 1987.

Therefore, while the multidimensionality of sustainability is acknowledged in both the academic and policy discourse, the authors come to two main conclusions. First, the development of the concept did not have a robust theoretical roots, but it was the result of different critiques of the main economic growth theory cumulating overtime. Second, they find that there is still a concern with regard to the introduction of the economic pillar and its mainstreaming, as there is the risk that it may contribute to preserve the main paradigm status quo.

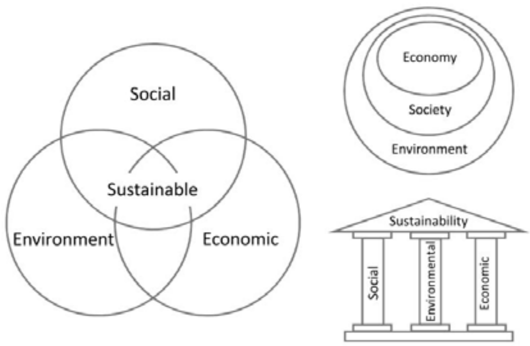


Figure 1: representation of sustainability as intersecting circles, concentric circles and pillars.

3. THE 6 TRANSFORMATIONS NEEDED TO ACHIEVE SDGS

Sachs, J. D., Schmidt-Traub, G., Mazzucato, M., Messner, D., Nakicenovic, N., and Rockström, J. (2019). Six Transformations to achieve the Sustainable Development Goals. Nature Sustainability 2, 805–814.

Messages	1. Key interventions are identified to make implementations of the Sustainable Development Goals (SDGs) operational. **Science** is called to produce knowledge necessary for **designing, implementing and monitoring the 'SDG Transformations**'.

To reach Sustainable Development Goals, there is a necessity for profound structural changes across all sectors of society. The trade-offs and synergies between SDGs and their targets are creating difficulties for their implementation. This paper proposes an action agenda for achieving the SDG outcomes in a manageable way. This integrated approach provides **six key transformations**, based on the main drivers of societal change, such as the digital revolution, consumption and production, human capacity, and decarbonisation. Each transformation illustrates necessary changes in 'the organization of societal, political and economic activities that transform resource use, institutions, technologies and social relations to achieve SDG outcomes'. The proposed transformations are presented in the figure below.

For example, within Transformation 1, one way to reduce inequalities (SDGs 5 and 10) is through supporting economic growth. To achieve this, some of the necessary interventions are **boosting innovation and ensuring knowledge diffusion.**

The trade-offs between the SDGs are addressed through the design of the interventions. **Each transformation should be guided by principles such as 'leave-no-one-behind' and the 'principle of circularity and decoupling'.** The first principle can be applied by taking into account the needs of the most vulnerable when designing the policies. By reusing and recycling materials, well-being can be decoupled from the resource depletions.

Science will play a crucial role in making this transition operational. From the need for new and improved tools, through breaking down the complex processes into workable units, to policy tracking and monitoring the progress, the authors create a clear action agenda for science to support each Transformation.

Fig. 1 | Six SDG Transformations. Each Transformation describes a major change in the organization of societal, political and economic activities that transforms resource use, institutions, technologies and social relations to achieve key SDG outcomes (represented by the SDG wheel in the centre). Figure adapted from ref. [1], TWI2050; SDG colour wheel courtesy of UN/SDG.

4. Tracking economic development – beyond GDP – across European regions

Ayouba, K., Le Gallo, J., & Vallone, A. (2020). Beyond GDP: an analysis of the socio-economic diversity of European regions. Applied Economics, 52(9), 1010-1029.

Messages	**1.** Regions tend to locate according to the level of economic development, creating agglomerations with high and low performance in the EU. **2**. Such agglomerations have persisted despite the 2008 economic crisis, with an estimated 96% (87%) of regions in high-high (low-low) clusters in 2000 remaining in the same cluster in 2015. **3**. Convergence in economic development has been moderate, with low distributional mobility for regions, being less pronounced than when considering GDP only.

Reducing disparities across Member States and their regions has always been one of the main objectives of European policies. More than one third of the EU budget has been devoted to the Cohesion Policy in the period 2014-2020, aiming at supporting and incentivising competitiveness, economic growth and job creation across European regions.

GDP per capita is usually used as an indicator for measuring economic performance and the level of standard of livings. However, scholars and policymakers have been **increasingly challenging the view that GDP is a suitable indicator of individual wellbeing and social welfare**, being unable to account for the different dimensions of economic development and social progress, let alone the degree of sustainable development of economies.

In this context, this paper analyses the evolution of economic development across NUTS-2 region for the EU28 from 2000 to 2015, by **measuring economic development beyond the simple GDP indicator**. Applying a Multi Factor Analysis approach, the authors develop an indicator of (socio)economic development that put together information on GDP and several measures of employment rates across industries and gender and the degree of education and training across the youth. The indicator is then used to analyse the spatial and temporal dynamics of European regions.

Results reveal **significant and persistent agglomerations patterns**: regions with high (low) economic development tend to be spatially close to regions with a similar level of economic development and mobility is limited overtime. This implies that convergence within the EU has been limited, regions being unable to significantly improve their performance. The weak convergence process is more pronounced than when considering GDP, suggesting that the social (employment) dimension is characterised by higher rigidity than the economic component. The paper concludes by analysing trends for additional indicators encompassing the health, education and demographic trends, revealing more disperse patterns.

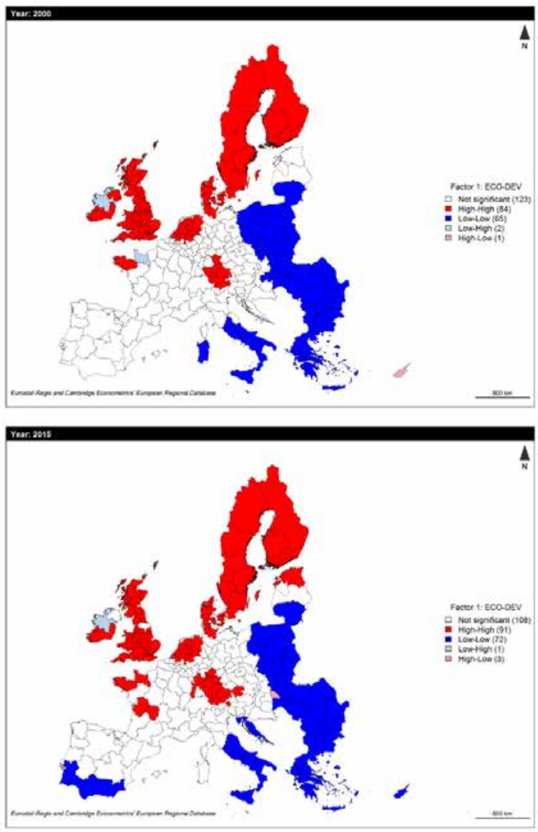


Figure 3: spatial clusters across EU regions, by economic development (Moran Index)

5. THE IMPACT OF ARTIFICIAL INTELLIGENCE ON SDGS

Vinuesa, R., Azizpour, H., Leite, I. et al. (2020). The role of artificial intelligence in achieving the Sustainable Development Goals. Nat Commun 11, 233.

Messages	**1. Trade-offs** may occur. While AI can act as an enabler on 79% of all targets, the progress of 35% of them may be inhibited by AI, at least to some extent. **2.** This requires policies that help direct the vast potential of AI towards the highest benefit for individuals and the environment, as well as towards the achievement of the SDGs.

The study follows a consensus-based expert elicitation process, where the experts involved are academics in the fields of engineering, natural and social sciences. The authors conducted an **assessment of the different connections between AI and the 17 SDGs and the 169 respective targets**. Hence the paper attempts to map and discuss some significant trade-offs of the use of AI and the ability to move towards sustainable development, according to three main categories: AI and Society, AI and the Economy, as well as AI and the Environment.

In terms of the impact on the 'Society' pillar of sustainable development, the authors conclude that 67 targets (or 82%) could in principle benefit from AI applications. These include SDG1 (no poverty), SDG4 (quality education), SDG 6 (clean water and sanitation), SDG 7 (affordable and clean energy) and SDG 11 (sustainable cities). For example, AI can be an enabler of smart cities, it can optimise power grids and water management systems. On the other hand, deep learning and other forms of AI require high computational capacity which increases the demand for energy in data and computing centres. Its carbon footprint may thus inhibit the progress of SDG 13 (Climate Action). This calls for *green growth of ICT technology*. Decision making based on algorithms due to e.g. inherent existing biases in the data may also compromise SDG 5 (gender equality) discriminatory decisions penalising women and minorities. Regarding the 'Economic' pillar, the study identifies potential benefit across 42 targets (70%) and negative impacts are reported for 20 targets (33%). The latter may be linked for instance to rising inequalities. Within the 'Environment' pillar, 25 targets (93%) are also expected to benefit from AI technologies. The benefits include understanding of climate change and modelling its impacts and analysis of large-scale datasets linked to environmental protection. Finally, the authors believe that there is a strong need to establish adequate policy and legislation frameworks, to help direct the vast potential of AI towards the highest benefit for individuals and the environment, as well as towards the achievement of the SDGs. This should include ethics-driven legislation and certification mechanisms for AI systems.

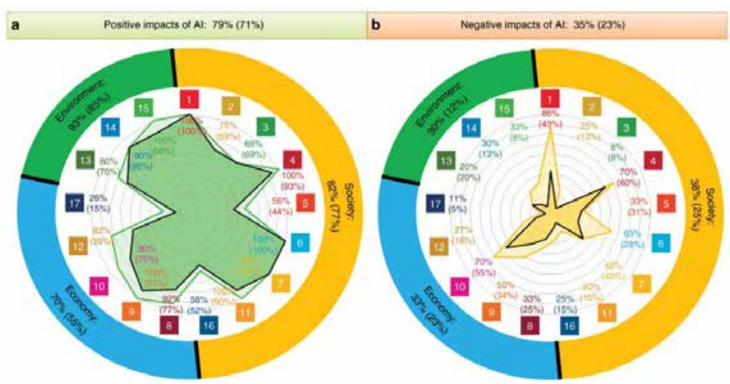


Figure 4 Documented evidence of the potential of AI acting as (a) an enabler or (b) an inhibitor on each of the SDGs. The numbers inside the colored squares represent each of the SDGs. The percentages on the top indicate the proportion of all targets potentially affected by AI and the ones in the inner circle of the figure correspond to proportions within each SDG. The results corresponding to the three main groups, namely Society, Economy, and Environment, are also shown in the outer circle of the figure. The results obtained when the type of evidence is taken into account are shown by the inner shaded area and the values in brackets.

6. Seven policy principles to achieve a safe operating space for humanity

Sterner, T., Barbier, E. B., Bateman, I., van den Bijgaart, I., Crépin, A.-S., Edenhofer, O., Fischer, C., Habla, W., Hassler, J., Johansson-Stenman, O., Lange, A. Polasky, S., Rockström, J., Smith, H. G., Steffen, W., Wagner, G., Wilen, G. F., Alpízar, F., Azar, C., Carless, D., Chávez, C., Coria, J., Engström, G., Jagers, S. C., Köhlin, G., Löfgren, Å., Pleijel, H., and Robinson, A. (2019). Policy design for the Anthropocene. Nature Sustainability 2, 14–21.

Messages	**1**. Even though the policy instruments for mitigating environmental change are already available, the difficulty is to select the appropriate policy mix given the global and complex nature of the environmental change. **2.** Seven guiding principles, such as calculation of the distance to the boundaries, or interdisciplinary collaboration, have been identified to help policy makers design necessary interventions by minimizing potential conflicts between planetary boundaries and by reaping benefits of the potential synergies.

The **Anthropocene** is defined as the current geological epoch in which human activities have become the main driver of the global environmental change. The authors use a framework based on 'planetary boundaries' to analyse policies that can prevent human actions from pushing the Earth system outside sustainable environmental levels. Given that the four out of nine[1] planetary boundaries may have already been overstepped, there is an indisputable urgency to act at all levels from local to global.

The paper discusses a vast number of **policy instruments for mitigating environmental change**. It provides examples where the price-based instruments, such as taxes and subsidies, and the rights-based interventions, such as tradable permits and quotas, are the most effective tools. Also, the effectiveness of 'direct' regulatory instruments, such as bans, and 'indirect' interventions, as financial regulation or public participation, are explored. However, when designing an appropriate policy mix consisting of interacting policies, the less efficient instruments can be preferable, as suggested in the 'theory of second best'.

The authors suggest **seven guiding principles** for the policy design to achieve safe operating space for humanity. 1. Interdisciplinary collaboration. 2. Identification of the distance to the boundaries. 3. Necessity to consider two or more boundaries together at the same time. 4. Policy instruments already exist, it is important to select the appropriate ones. 5. Identification of the socioeconomic causes of the problem, and the most effective leverage. 6. Policy choice should be based on efficiency, cost and political aspect. 7. Policies should be functional on international and local level at the same time. Finally, the paper stresses the importance of research, development and deployment (RD&D) in creating solutions that match the urgency of the environmental and social challenges of our time.

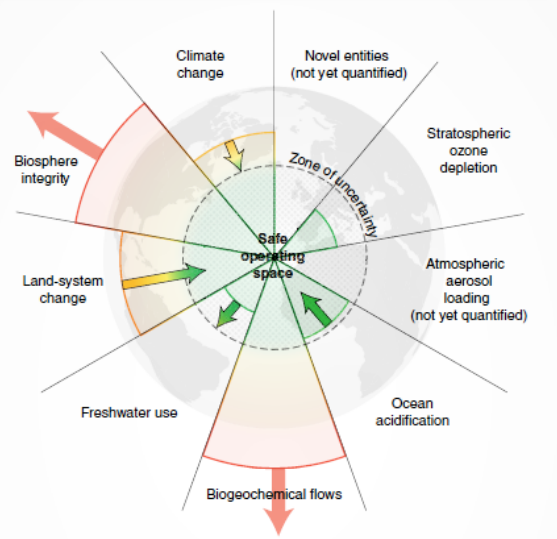


Fig. 2 | Planetary boundaries and policy trade-offs. The arrows illustrate the principle of trade-offs involving a policy aiming to reduce stress on one planetary boundary (as an example, we take increased forestry to reduce climate change) that may have side effects (positive or negative) on other boundaries (for example, biosphere integrity, land-system change, freshwater use and biochemical flows). The arrows give an approximate illustration of a possible effect with respect to current conditions[4], where green is safe, yellow increasing risk and red high risk.

[1] Nine planetary boundaries have been identifies: climate change; rate of biodiversity loss (terrestrial and marine); interference with the nitrogen and phosphorus cycles; stratospheric ozone depletion; ocean acidification; global freshwater use; change in land use; chemical pollution; and atmospheric aerosol loading.

7. What should researchers do to contribute to sustainable development?

Schneider, F., Kläy, A., Zimmermann, A. B., Buser, T., Ingalls, M., and Messerli, P. (2019). How can science support the 2030 Agenda for Sustainable Development? Four tasks to tackle the normative dimension of sustainability. Sustainability Science, 14, 1593–1604.

Messages	**1.** The traditional role of the science is to produce facts to inform policy makers. Under 2030 Agenda, the researchers are urged to add 'value' to their research, thus it created a notion of 'good' science. **2.** The paper discusses the importance of the researchers' reflection on this values, given the ethical and moral implications of their research.

The authors point out two conflicts related to the science for SDGs. First, there are many **trade-offs between SDGs**, hence addressing one goal may have positive or negative side effects on the others. Also, the importance of a particular SDG varies greatly across society. Second, traditionally, 'science should separate facts from values', however **the 2030 Agenda introduced values to the research**. Creating knowledge that is relevant for the sustainable development is thus considered as **'good' science**.

In order to mitigate aforementioned conflicts and to stay accountable, the authors introduce **four tasks for researchers that want to contribute to the sustainable development.** The researches should: 1. be clear about the *ethical values* in sustainability. 2. identify *sustainability values* of their research. 3. define what the *sustainability in a specific situation* is, by connecting with other societal actors. 4. clarify *own ethical values*. Given that the research results can have policy implications, the authors urge more reflections among researchers on the normative dimension of the sustainability.

8. THE NEED TO PROMOTE THE ADOPTION OF PRODUCTIVITY-ENHANCING TECHNOLOGIES

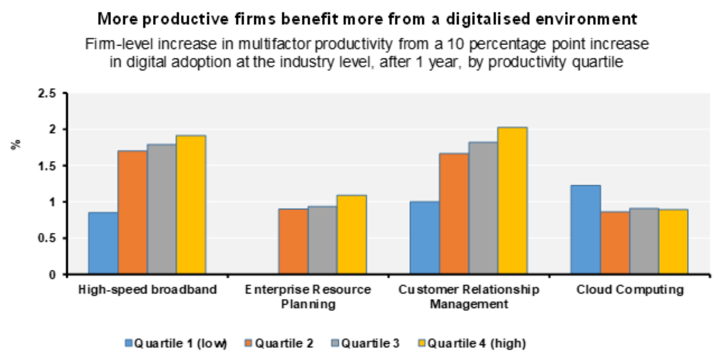
Sorbe, S., Gal, P., Nicoletti, G., & Timiliotis, C. (2019). Digital dividend: Policies to harness the productivity potential of digital technologies. OECD Economic Policy Paper, No.26.

Messages	**1. More productive firms tend to reap larger benefits from the adoption of digital technologies** since they also invest more in complementary intangibles such as training, good management, and organizational capital. **2. Differences in the take-up of digital technologies persist across countries, industries and firms**. This hints at the need for policies to promote the generalised adoption of these productivity-enhancing technologies to counteract the widening productivity gap.

The authors assess both the **drivers and the productivity implications of the adoption of digital technologies**, namely access to high-speed broadband internet, simple and complex cloud computing (i.e. e-mail services vs. online renting of data or computing capacities), back and front office integration systems such as customer relationship management (CRM) and enterprise resource planning (ERP) software, for European countries between 2010 and 2016.

The analysis is based on two previous OECD analytical papers that find that i) *both capabilities (e.g. managerial and technical skills) and incentives (e.g. a competitive business environment) support digital adoption, with strong complementarities between the two,* and ii) *digital adoption at the industry level supports firm productivity, especially among firms that already had high productivity*. The latter is because the most productive firms tend to also invest in other complementary intangibles, such as strategic management, flexible work and process structures. This allows them to more promptly benefit from the adoption and the spilovers of digital technologies. Another key factor is the access to top digital infrastructure such as high-speed internet that is underpinning the development and uptake of digital technologies.

Overall the authors find that **the manufacturing sector reaps larger benefits from digital adoption than services, and the impact is higher in industries that are more *intensive in routine tasks***. At the policy level, measures that **improve the business environment** to allow for an efficient reallocation of resources from less- to more-productive firms, would be beneficial. **Upskilling** can also contribute to improvement of capabilities and incentives for the take-up of digital technologies. Finally, the authors raise attention for the fact that, while it is true that *a certain degree of market power can reflect a legitimate rent for past innovation and even be the sign of healthy competition, market power can – if too entrenched – allow these firms to use strategic patenting or buy smaller innovative firms to stifle competition.*



Source: Gal et al. (2019)[3]
Note: This figure presents the estimated increase in multifactor productivity growth (after one year) associated to an increase in the industry-level diffusion of digital technologies by ten percentage points across different productivity quartiles. Quartile 1 refers to the bottom of the distribution (i.e. low productive firms), quartile 4 to the top of the distribution (i.e. high productive firms), in each industry-country-year cell.

9. Technological change and the Future of Work

Goos, M., Arntz, M., Zierahn, U., Gregory, T., Carretero Gómez, S., González Vázquez, I., Jonkers, K. (2019). The Impact of Technological Innovation on the Future of Work, European Commission, JRC Working Papers Series on Labour, Education and Technology 2019/03.

Messages	**1.** Recent technological developments have had little effect on the aggregate number of jobs but lead to significant restructuring of jobs. **2.** European labour markets will face shifts in skills requirements, processes of organisational change in companies and rising shares of alternative work arrangements.

Labour markets are constantly evolving as improved organisation, new machinery and production processes alter the labour division among workers or between humans and machines. In particular, **technological change affects both the demand for and supply of labour**, which has important consequences for people as regards employment and wages, as well as for businesses. Moreover, technological change has been corroborated by the 'digital revolution', which accelerated the application of digital technologies in production and organisational processes and led to the creation of new products, services, or business models.

After reviewing the theoretical approaches to the impact of technological development on jobs, the authors conclude that the impact on employment levels ultimately depends on the **relative sizes of the displacement effect and other compensating effects such as productivity or capital accumulation**. Furthermore, they argue that the nature and magnitude of each of these effects will be central for workers, businesses and policy makers.

Beyond the discussion on numbers of displaced and newly created jobs, technological change will bring along **organisational changes and corresponding shifts in skills demand**. The reduction of communication or monitoring costs, increased work standardisation and fragmentation of work have enabled **outsourcing of tasks**. Following these developments, new non-standard forms of employment, in particular platform work, are evolving amid technological innovations and changing workers' preferences. Reinforced by the emergence of new business models with new organisational forms, these trends contributed to a large increase of alternative work arrangements, which are not imposed necessarily on the employees, but may reflect their **changing preferences such as demands for more freedom, flexibility and better work-life balance**.

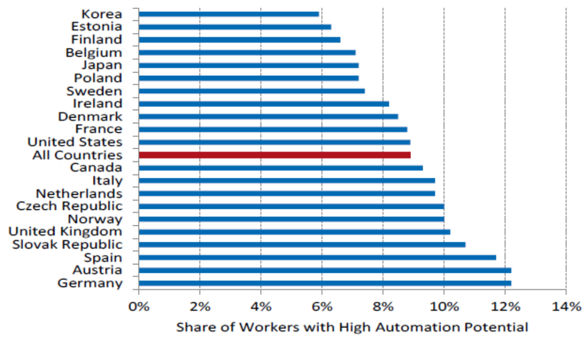


Figure 7 Automation Potentials in OECD Countries. Source: Arntz et al. (2016).

10. RIGHT SKILLS SUPPLY AND REGIONAL PRODUCTIVITY

Barzotto, M. and De Propris, L. (2019). Skill up: smart work, occupational mix and regional productivity. Journal of Economic Geography 19.

Messages	**1**. Loss of certain type of jobs could threaten innovation capabilities in a wide range of production industries and decrease competitiveness of regions. **2**. Policy-makers should reinforce skills linked to regionally active industries, digital skills and to pay attention to the occupational mix as a part of a broader industrial strategy.

European regions face globalisation and technological developments that may have a profound impact on their competitiveness and productivity. Firstly, the process of **industrial development favours high value-added activities**, while low value-added operations have been facing offshoring pressures to lower labour cost economies. This led to higher participation in global production and expansion of services sector in many regions. **Technological change** is the second major trend that altered the job skills demands and led to substantial changes in the labour force composition. This trend has been characterised by a high rate of job polarisation, suggesting a rise of employment in both the highest-skilled and lowest-skilled employment.

Both trends have influenced the EU labour market on the demand side and thus changed the local and regional stock of competences. Such changes affect the local labour market composition and could increase the **skills mismatch**. As these changes raise concerns over the sustainability of EU competitiveness in the longer term, the research aims to identify **which job profiles are needed to sustain economic growth and support productivity increase** across the EU regions. In particular, this work aims at extrapolating which occupational mix offers the competitive edge under the current industrial dynamics and emerging production models by comparing contribution of certain occupations to regional productivity against the contribution of other occupations.

The results confirm the importance of certain occupations linked to emerging production models and thus a certain portfolio of skills that contribute to higher labour productivity. This implies that sustaining particular job types is crucial for regional innovation capabilities. Manufacturing seem to profit from a combination of new technologies with a know-how heritage of craft workers. Following these conclusions, the immediate recommendation would call manufacturing-dominated regions to **skill-up their labour pools to leverage on new production models introduced by the technological change.** Although the papers provides a set of policy conclusions, the authors admit that it is challenging to increase supply of competencies reflected in the regional industrial endowment and connect these with the new and emerging technologies.

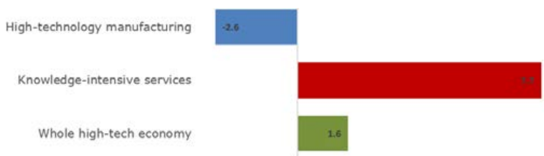


Figure 8 Employment growth in high-tech economy sectors in EU in 2018-2030. Source: Skills Panorama - Cedefop's Skill Projections

11. EUROPEAN WELFARE STATES AND DIGITALISATION OF WORK

Petropoulos, G., Scott Marcus, J., Moës, N., Bergamini, E. (2019). Digitalisation and European welfare states. Bruegel Blueprint Series, volume 30.

Messages	1. The risk digitalisation poses to jobs should not be overstated as changes in the nature of work and reallocations of tasks or workers from existing to new ones will take place. 2. Artificial intelligence and emerging digital technologies will potentially have a far broader impact than robotisation because there is a high potential impact on the service sector. 3. In light of these developments, the funding of welfare systems needs to be rethought and EU countries will have to make critical choices about their welfare systems in the coming years.

While the principles of big data analytics are not brand new, the great development of machine learning and AI systems within the last decade have been advancing due to significantly higher volumes of data available, increase in computing power and improved connectivity together with the drop in capital costs of digital technologies. However, all these technological advancements require a broad adoption of new efficient technologies by companies.

The paper uses indicators such as number of industrial robots and level of investment in information and communication technologies (ICT) to assess the uptake of automated technologies. It further examines regional impacts by analysing the relationship between the change in regional employment rate and real wages compared to the change in regional exposure to the advanced technologies. The **regional exposure to industrial robots and ICT capital are both positively correlated with higher employment rates**. There is also a **positive correlation between real wages with exposure to ICT**, but there is a **negative correlation between development of real wages and uptake of robots**. Given that robots can reduce labour demand for specific physical tasks, it can thus potentially reduce wages. The study looks into other channels of technological change on employment, e.g. how application of AI systems could have an impact on young people entering the work force.

After the mapping of technologically driven developments, the study looks at new forms of work across EU labour markets. Moreover, it provides an overview of social protection policies in the EU, points out the main challenges and discusses a broader approach to social protection in light of the analysed developments. An extensive recommendations list touches upon the position and protection of workers (e.g. transferability of entitlements across different types of employment), funding of the welfare state (shift towards universal social protection funded out of general revenues) and anticipatory measures accompanied by management of changes through education and training (e.g. focus on lifelong learning).

Exposure to industrial robots relative to employment rate in EU regions for the total economy

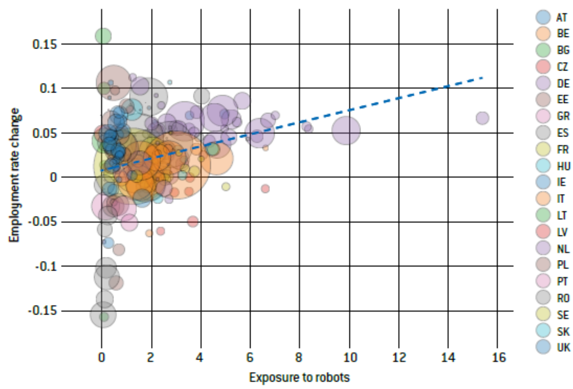


Figure 9 Source: Bruegel. Note: Each circle depicts a distinct region (NUTS-2 level). The diameter of each circle indicates the size of working population within the region.

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