3 Challenges and new demands on the academic research workforce

Academic career structures and the allocation processes for research funding largely reflect merit-based competition among individuals, which has proven its effectiveness over time in promoting excellence in fundamental research. However, concern is growing about how these structures and processes affect the precarity and attractiveness of research careers and generate a lack of diversity in the scientific workforce. There is an expectation that science will not only produce highly-cited publications, but also rapidly translate into societal benefits and solutions to global challenges – such as the COVID-19 pandemic. The emphasis on individual disciplinary excellence and short-term outputs fits uneasily alongside the need for more transdisciplinary research, more novelty and risk-taking in research, and more data-intensive research. This chapter reviews recent OECD analysis of the challenges within science systems, many of which are accentuated by COVID-19, and what these imply for policy measures to build a diverse, appropriately skilled and motivated science workforce.

Key findings

- **The academic research workforce is leading the fight against COVID-19**, generating the new knowledge that is required to understand the pandemic and develop effective mitigation strategies. This extends far beyond medical research and the development of new diagnostics, treatments and vaccines but encompasses all research domains from mathematics to social sciences and humanities.
- **Countries need to continue to support a breadth of research**, whilst implementing measures to ensure that a new generation of researchers with inter- and trans-disciplinary skills is encouraged. The crisis has highlighted the importance of data-intensive science, in particular, propelling it forward as a critical tool. Investment in research data infrastructures needs to be matched by long-term investment in human resources, including data stewards, software engineers and data analysts.
- **The COVID-19 pandemic has severely affected researchers and shed light on the existing weaknesses in academic structures**. There has been a 25% increase in the number of people with PhDs in OECD countries over the past decade with no corresponding increase in academic posts. The current hyper-competitive system – with its focus on narrow measures of individual performance and evaluation by peers – discriminates against women and a number of social groups leading to a lack of diversity in the research workforce. Important scientific outputs, such as databases or software, policy reports or citizen engagement activities, which are critical for crisis response, are undervalued. New incentives and measures for evaluating and rewarding both individual and collective contributions to science are urgently required.
- **There is need for systemic changes in the way academic research is structured and supported** if it is to attract and retain the diversity of talent that is necessary to address current and future societal challenges. New and more attractive career paths that provide greater security and alternative options for mobility in and out of academia and other research sectors are required. National governments have a critical role to play in engaging all actors in the research ecosystem to develop co-ordinated research workforce strategies, incentives to implement these strategies and indicators and measures to monitor what is happening.

Introduction

The COVID-19 pandemic is putting enormous pressure on public science systems and those who work within them, with research being mobilised in unprecedented ways across many different disciplines. Researchers across the world are being encouraged and incentivised to quickly redirect their efforts to focus on COVID-19. There is intense pressure to release data and results rapidly, short-cutting or circumventing normal peer-review publication processes (see Chapter 2) and highlighting pre-existing concerns about quality assurance and accreditation of research findings. At the same time, scientists are being called upon as experts to provide input on public health and other policy responses to the pandemic (see Chapter 8) and they are being asked to communicate incomplete and changing evidence in a way that promotes public confidence and trust. These are activities that most scientists were not trained for and which would normally go largely unrecognised within academic structures, with their predominant focus on scientific merit and excellence.

Even in the absence of COVID-19, many researchers, particularly in the early stage of their careers, were in precarious positions and employed on short-term contracts with no clear perspective of a permanent academic position. For women in particular, the hyper-competitive environment and lack of security are an active disincentive to continuing in research (Pollitzer, Smith and Vinkenburg, 2018[1]). The COVID-19 pandemic has added to the sense of insecurity. While it has led to increased funding in some research areas, it is also threatening the future of many universities that depend on overseas students. Although some countries or institutions have taken mitigation measures, such as extending PhD grants and postdoctoral research contracts, this is not universally the case. The majority of young researchers now expect to have even more limited academic career opportunities (Woolston, 2020[2]), a sentiment compounded by the fact that COVID-19 has radically disrupted the movement of researchers between countries.

Many of the technological innovations introduced in response to COVID-19 have been driven by research and development in the private sector, particularly in the digital domain. For example, artificial intelligence (AI), which is playing a variety of roles in pandemic response and recovery (OECD, 2020[3]), is a field that is dominated by private firms, which attract many of the best science, technology, engineering and mathematics (STEM) graduates with employment packages and prospects that academia cannot match (The Royal Society, 2019[4]). At the same time, efforts to develop and test effective treatments and vaccines have been characterised by different public and private sector research actors working in tandem (see Chapter 5). The potential benefits of inter-sectoral co-operation and exchange of skills and knowledge for promoting innovation were obvious well before the current crisis and have long been a focus for STI policy. Nevertheless, the reality remains that there are substantial barriers for those who enter the academic research path and subsequently decide to make the transition from academia to other sectors and vice-versa (Vitae, 2016[5]).

Not only have digital tools and open-data infrastructures allowed many scientists to continue to function effectively outside their usual laboratory or field environments during lockdowns, they have also massively accelerated data-driven discovery and knowledge dissemination. At the same time, these developments have emphasised the digital divide between countries, institutions, disciplines and research teams, highlighting the need for more digitally skilled scientists and research professionals to conduct data-intensive research and support open science in academic settings (OECD, 2020[6]).

As the pandemic progresses, and governments move from the public health response to addressing the broader socio-economic challenges, there is a growing need not only for public-private partnerships but also for more inter- and trans-disciplinary research to produce the integrated knowledge necessary to address these issues (see Chapter 5). Many countries are seeing the “COVID moment” as an opportunity to transition to more sustainable and resilient societies, and interest is growing in co-design and co-production processes that can enable such transitions. This places greater emphasis on team working,

people skills and public engagement, which are not always fully valued in an academic research setting (OECD, 2020[7]).

COVID-19 has helped reveal both the strengths and the weaknesses of existing science systems with major implications for the research workforce of the future. This chapter reviews recent OECD work on several topics related to the research workforce. It explores the policy implications for different actors in the research ecosystem, including governments, research agencies, universities and public research institutes.

The quest for research excellence

Scientific research is largely organised around disciplines. Individual career progression depends on assessment by peers, which itself is highly dependent on a researcher's publication record. The structures and processes of universities, public research institutes and funding agencies heighten this focus on disciplinary expertise and publication outputs, driven by the quest for research excellence. This arrangement has arguably been very successful, with a growing number of scientific publications being produced annually. This increase is particularly striking in the university sector (see Figure 3.1).

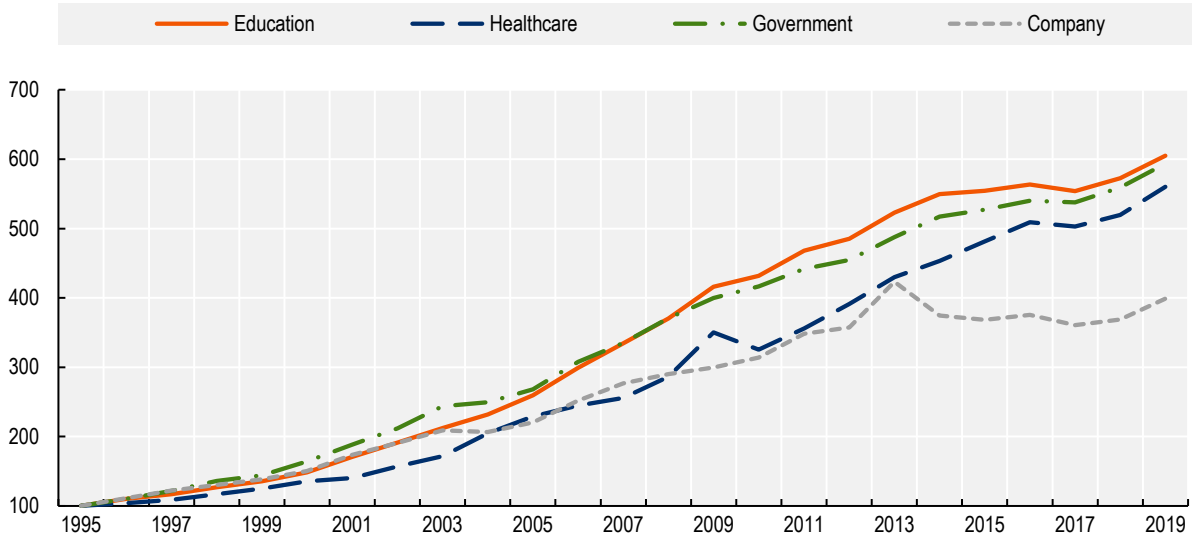
If publication numbers are an indicator of scientific performance then the system is performing well and also responding well to the COVID-19 pandemic (see Chapter 2). But numbers rarely tell the whole story. Excellence is an elusive concept, which can only be defined by peers. Hence, quantitative indicators of peer-esteem such as citation indices, journal impact factors and h-indexes have become the currency of scientific excellence or quality. Despite strong criticism (e.g. see the San Francisco Declaration on Research Assessment (DORA, 2013[8]), these proxy measures have become a major determinant of scientific behaviour. Being the lead author of a well-cited paper in a high-impact journal has become the "holy grail" for an early-career researcher, and brings with it the prospect of a secure long-term future in academia.

Hyper-competition and the "publish or perish" culture may have its merits but it is also exerting a high toll on researchers, particularly at the doctorate and postdoctoral level, where the next position depends on what the researcher publishes. It also has perverse effects on the composition of the research workforce and discriminates against certain population groups, including women (Pollitzer, Smith and Vinkenburg, 2018[1]). Even if it works in terms of triaging the truly excellent from the merely good, it discourages risk-taking and inter- or trans-disciplinary research, for which short-term outputs are less certain but which are increasingly required for science to meet societal needs. For example, bibliometric scores are of limited use for assessing public engagement activities or evaluating and rewarding the new cohorts of highly skilled research software engineers, data stewards or data analysts that are urgently required to support data-intensive research (OECD, 2020[6]).

Focusing on individual merit and disciplinary excellence has taken science a long way and should not be abandoned altogether. However, the way these qualities are assessed and measured no longer meets the broader societal expectations of science. Nor does it reflect the growing emphasis on open science (OECD, 2015[9]) and the increased tendency in many research areas to work in large, often distributed and diverse, teams (see footnote to Figure 3.1). Maintaining scientific rigour and research excellence are critical for ensuring trust in science in the current pandemic situation. However, there is a need to redefine what is meant by excellence in relation to all of the different expectations of science.

Figure 3.1. Trends in scientific publication output by type of institution, 1995-2019

Whole counts, index 100 = 1995



Note: The numbers by institutional type are not additive, as a single paper can have multiple authors with multiple affiliations with any of the types. Over the same period of time the average number of authors per paper has risen from 3.18 to 4.82 (based on separate OECD analysis using SCOPUS database) indicating an increase in the size of research teams.
Source: OECD calculations based on the Lens Database, https://www.lens.org (accessed October 1, 2020).

StatLink https://doi.org/10.1787/888934223308

Precarity of research careers

One of the issues that the COVID-19 pandemic has highlighted is the precarious employment situation of many researchers in academia. Whilst precarity is not unique to academic research, it is more prevalent than in many other sectors that depend on highly skilled professionals and it stands in striking contrast to expectations that research will attract the 'best minds' to promote long-term socio-economic development and resilience in the face of crises. The working conditions of academic researchers have been deteriorating in recent years. This is especially true for the growing number of postdoctoral researchers on fixed-term contracts and with limited continuous employment prospects. Country responses to the OECD Global Science Forum policy survey on reducing the precarity of research careers showed, for example, that in Germany, 92% of junior scholars in higher education institutions, and 83% in non-university research facilities have a fixed-term contract; in Finland, 70% of academics are on fixed-term contracts; and in Belgium, 58% of those working in universities are on fixed-term contracts.[1]

While the majority of early-career researchers display a strong intrinsic motivation and ambition for long-term academic careers, precarity can have significant negative consequences on their motivation, behaviour and well-being, affecting the nature and quality of scientific outputs (Vitae, 2016[5]; Wellcome, 2020[10]). At the same time, there is widespread concern about the capacity of countries to retain their best national talent and attract good foreign researchers. In some countries and research fields, the problem is evident even upstream of the research pipeline, as evidenced by difficulties in attracting the best candidates to doctoral training.

The precarity and insecurity of research careers is also a major obstacle to advancing gender equality and social diversity in the research workforce (Forrester, 2020[11]). On top of this, COVID-19 is making matters

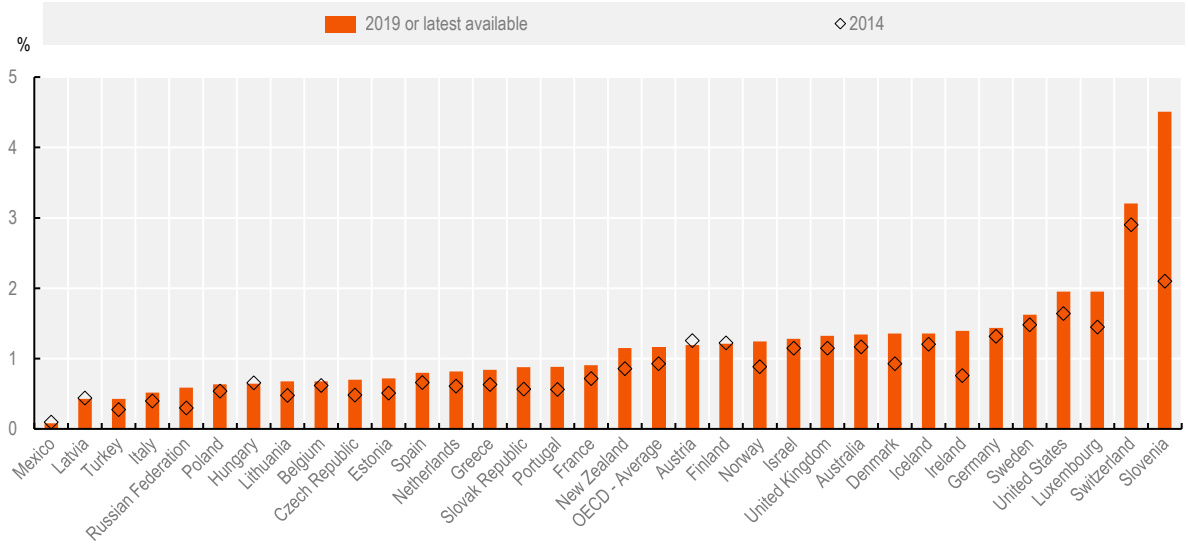
worse for many in the research precariat. Responses to the OECD Science Flash Survey 2020[2] suggest that the pandemic is having detrimental effects on job security and career opportunities in science, as well as on research funding and the time available for performing research. Younger researchers and women appear to be more vulnerable to these effects, as also shown by a recent survey by *Nature* (Nature, 2020[12]).

The shift from core institutional funding to short-term, project-based funding, together with the increasingly competitive nature of core-funding, is making research (and higher education) systems increasingly dependent on a contingent of junior staff employed on casual contracts. In Australia, 56% of researchers in higher education are postgraduate students. In Switzerland, 64% of researchers are doctoral and postdoctoral researchers. In Germany the proportion of junior scholars in the scientific staff at higher education institutions has been approximately 75% since 2010. In Finland, the number of postdoctoral researchers has increased by 144% in the last decade.[3]

The inability of traditional academic career paths to absorb the growing number of doctorate holders wishing to remain in academia is heightening the competitive pressure to extreme levels. The average share of doctorate holders aged 25-64 year-olds in the OECD, which currently stands at around 1%, has been steadily increasing (OECD, 2019[13]). Figure 3.2 presents the share of doctorate level attainment in the population aged 25-64 year olds in OECD countries. It shows a 25% average increase in doctorate holders across the OECD during the five-year period from 2014 to 2019.

Figure 3.2. Share of doctorate-level attainment in the population

25-64 years, 2014 and 2019 or latest year available



Note: The data for most countries are derived from national labour force surveys. It includes Short-cycle tertiary education (L5) for Switzerland 2014-2019. 2019 data for Russian Federation correspond to 2018 value.
Source: OECD (2020[14]), "Education at a glance: Educational attainment and labour-force status", OECD Education Statistics (database), https://doi.org/10.1787/889e8641-en (accessed on 22 September 2020).

StatLink https://doi.org/10.1787/888934223327

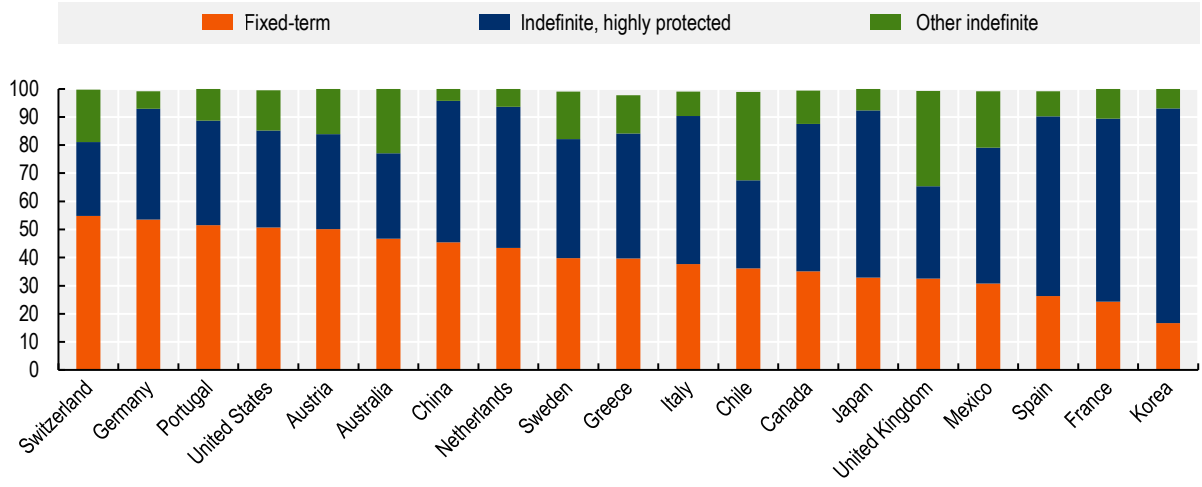
Higher education has been the traditional sector of employment for doctorate holders in most countries. However, many younger PhDs will no longer find a stable career position in academic research. Around one third of the total OECD labour force work in temporary or part-time jobs, or are self-employed (OECD, 2019[15]). The scale of precarity is even higher in the academic research sector. Results from the 2018

OECD International Survey of Scientific Authors (Bello and Galindo-Rueda, 2020[16]),[4] presented in Figure 3.3 show that, while a majority of corresponding authors in Korea, France, Spain and Japan hold an indefinite, highly protected contract (e.g. civil servant, tenure) this is not the case in most countries. In the United Kingdom and Chile, less protected (e.g. open-ended) contracts are more common. In Switzerland and Germany, the majority of corresponding authors are on fixed-term contracts. While these differences may partially reflect different conventions for authorship, it is clear that in many countries researchers who are leading scientific production do not have secure positions.

The median age of new entrants to doctoral studies across the OECD is 29 years; 60% of entrants are between 26 and 37 years old (OECD, 2019[13]). This means that the majority obtain their doctorate in their thirties. Most of those who transition to the postdoctoral stage stay there well into their late thirties and even early forties, often lingering as "postdocs", "research assistants and associates", or even "hidden researchers". They normally spend long periods pursuing research, although they may be employed in non-research roles (such as full-time teaching) while waiting for a more secure academic research position to become available. Despite a lack of preparation and training for alternative careers, many eventually "drop out" of academia in a move that is frequently stigmatised as failure. In fact, across the OECD, the majority of researchers (62.5%) eventually end up working in the business enterprise sector (OECD, 2020[17]).

Figure 3.3. Job security of corresponding authors, by country of residence

Percentage of corresponding authors, 2018, selected economies



Note: Indefinite highly protected contracts mean the respondent can only be dismissed by the employer for gross misconduct. This level of protection is typically afforded by civil servant status or tenure. Other indefinite contracts are open-ended, as opposed to fixed-term positions, which have a set duration.
Source: OECD calculations based on OECD (2018[18]) International Survey of Scientific Authors, 2018. http://oe.cd/issa.

StatLink https://doi.org/10.1787/888934223346

The precarity of research careers is particularly problematic for women. Many struggle with the pressures of a postdoctoral position and embarking on an academic career while caring for young children or elderly relatives. Gender stereotyping and systemic biases exist across society. They are also embedded in science education and research systems meaning that even when women do obtain secure positions, they

are less likely than their male counterparts to advance to leadership positions (Bello and Sarrico, 2020[19]) (OECD, 2020[20]).

COVID-19 is also having a disproportionately negative effect on women researchers, particularly those at the early-career stage (Viglione, 2020[21]). Since the start of the pandemic, scientific publications have been rising more quickly for men than women. Women are more likely to lose their jobs, as they are more likely to be on fixed-term contracts. The pandemic is threatening the gender-equity gains of recent years (Gewin, 2020[22]), making it even more pressing to have a co-ordinated policy effort on gender that provides both targeted support to female researchers and addresses systemic biases, with careful monitoring of progress (Pollitzer, Smith and Vinkenburg, 2018[1]).

International mobility in the global labour market for researchers can expand opportunities – but it can also increase precarity – for early career researchers. Although mobility at the early career stage is a choice, it is also often considered a necessary step for those with longer-term ambitions in academia. Results from the OECD International Survey of Scientific Authors show that corresponding authors on fixed-term contracts are more likely to be working in a country different from the one where they earned their doctorate and are much more likely to be planning to move to another country (OECD, 2018[18]). Working conditions for foreign researchers are often worse than those for native researchers with respect to issues such as access to employment contracts, right to stay and welfare benefits. Mobility, when accompanied by short-term contracts, can entail significant personal sacrifices, especially when early career researchers are considering starting a family and/or entering the housing market, and working abroad can lead to loss of social capital in one's country of origin. It is not surprising, then, that women doctorate holders are less internationally mobile than their male counterparts.

Whether or not the short-term negative effect of COVID-19 on international mobility is destined to last, the pandemic has most likely inhibited at least a cohort of researchers from moving abroad for either doctoral education or postdoctoral work (Woolston, 2020[2]). Some countries are also likely to lose foreign research talent owing to visa expirations and new regulations for visiting workers. Immediate policy intervention is required to support the many researchers, whose already insecure positions have been made more precarious because of the pandemic. Potential actions, which are already been put in place in many countries, range from the extension of PhD studentships and research grants to ensuring visas for researchers.

However, precarity in research careers existed well before COVID-19 and will certainly not automatically disappear when the current pandemic comes to an end. Over the longer-term there are a number of areas for policy action that governments, together with funders and research organisations, will need to address if they wish to reduce this precarity, make academic research careers more attractive and promote workforce diversity.[5]

- Doctoral training: moving the emphasis from increasing the number of doctorate holders to broadening the training at doctoral level to encourage professional development, including transferable skills that can be used in a variety of economic sectors.
- Employment status: making changes to the employment status of postdoctoral researchers by including them in formal career structures (e.g. as staff scientists), and collective bargaining agreements. In this regard, Portugal has moved away from providing stipends to granting employee status for postdoctoral researchers, making open recruitment the norm. Spain is allowing researchers who have occupied fixed-term positions for some time to apply for a permanent contract in a competitive process. In Germany, the maximum duration of fixed-term contracts for the purpose of qualification is capped at six years prior to being awarded the doctoral degree and six years (medicine: nine years) after. France is introducing tenure-track positions.
- Tracking the careers of doctorate holders: collecting, analysing and publishing data on the careers of doctorate holders to provide evidence to underpin the development, implementation and effectiveness of human resource policies. For instance, Belgium has created the Observatory of

Research and Scientific Careers, Portugal has launched a Scientific Employment Observatory, and Korea is building a comprehensive database on postdoctoral researchers.

- Human resource management: improving human resource management in institutions. The European Commission has adopted the European Charter for Researchers and a Code of Conduct for the Recruitment of Researchers. The United Kingdom has developed a concordat between funders, institutions and researchers to support the career development of researchers and improve institutional human resource policies and practices. Belgium, the United Kingdom and the European Union grant human resource excellence awards to institutions demonstrating good practice.
- Funding: making funds available to enhance the independence of postdoctoral researchers and support their training and career development. The Korean Initiative for fostering Universities of Research and Innovation (KIURI) is focused on promoting the independence of postdoctoral researchers. Spain has created a programme allowing the recipient of a postdoctoral fellowship to choose the host institution. Japan is allowing young researchers employed on a research project to pursue their own research choices for up to 20% of their time. Belgium plans to increase the success rate of postdoctoral fellowships to 30%. Meanwhile, Portugal has created collaborative laboratories with the private sector, and provided fiscal incentives to employ doctorate holders.
- Gender equity: targeting funding to women in fields and seniority levels where they are under-represented; taking account of parenthood and other life circumstances in assessments for funding, recruitment and promotion; and, giving gender equality awards to institutions that demonstrate best practices. In Germany, the Women Professors programme provides targeted support for women in senior positions. In the United Kingdom the Athena SWAN charter recognises commitment to advancing the careers of women in science.
- Diversity, equity and inclusion: targeting funding at under-represented groups, defined by socio-economic status, ethnicity, language, indigeneity and disability; promoting the development and monitoring of equity, diversity and inclusion strategies at the institutional level; and collecting, analysing and publishing disaggregated data on doctorate holders by gender and other groups of interest (e.g. indigenous researchers in Canada and Australia).

Strengthening the links between academia and other sectors

There are many examples from the response to the COVID-19 pandemic where academic researchers have combined forces with other public and private sector actors to develop new knowledge and technologies (see Chapter 5). As described in the previous section, there are more doctorates working outside of academia than within and most of these work in the private sector. Nevertheless, moving out of academic research is not an easy option for many people and the two-way exchange of research personnel between sectors is minimal.

In the OECD as a whole, researchers working in higher education represented only 30% of total researchers, and those working in the government sector around 7% in 2016. Since 2005, the percentage of gross domestic expenditure on research and development (GERD) in the higher education sector has remained stable at around 17%, whilst that in the government sector has steadily decreased from 12% to around 10% in 2018 (OECD, 2020[17]). The reality is that only a minority of doctorate holders in many countries will continue in academia, even though doctoral training is still mostly focused on how to become an academic. While many postdoctoral researchers eventually find successful and satisfying alternative careers, they often report significant challenges in undertaking a transition associated with giving up long-held ambitions of an academic career and a loss of social identity (Vitae, 2016[5]).

Over the past decade, conditions have been favourable for employment in research outside of academia. While the total number of researchers has grown by 37% across the OECD, R&D expenditure per-capita

has grown faster, by 68% between 2005 and 2018 (OECD, 2020[17]). In 2017, there were 8.6 researchers per 1 000 people in employment, compared with 7.0 in 2005. Doctorate holders, especially those working in the private sector, enjoy on average an earnings premium relative to other graduates. However, opportunities greatly depend on the field of study, and there are wide differences among countries in the distribution of doctoral graduates by field of study.

Mobility between academia and other sectors can help promote effective interaction between research, education and innovation as well as opening up alternative career paths. However, it is not always clear how to facilitate exchange of early career researchers between sectors. On the one hand, doctorate holders who have been trained in academia may need further training and skills to meet the needs of other sectors. On the other hand, they often face obstacles to returning to academic research after working outside academia. Training and experience that may be valued in other sectors are often not aligned with expectations for an academic career. Inter-sectoral mobility, especially at an early stage of one's career can represent a one-way ticket out of academia, with little opportunity of returning. The result can be a permanent loss of talent in the academic scientific endeavour.

Countries can take a number of actions to promote the inter-sectoral mobility of researchers:

- Collaboration in doctoral education: preparing doctorate holders for diverse careers by changing the objectives and content of doctoral training, including providing more opportunities for institutional placements during doctoral education. Several countries, including Hungary and Portugal are promoting new types of doctoral programme in collaboration with industry.
- Professional development: investing and promoting the professional development of doctoral and postdoctoral researchers, including through career advice and mentoring. In the United Kingdom, UK Research and Innovation and the Wellcome Trust fund training programmes that offer recipients a wide range of development opportunities, including collaboration with non-academic partners, to prepare them for their future careers. In Korea, the KIURI provides postdoctoral researchers with opportunities to develop their careers in industry, and promotes their independence from their research advisers.
- Publication of data on labour-market outcomes of doctorate holders: In Belgium, the Observatory of Research and Scientific Careers provides this information; in the United Kingdom, Vitae publishes results of their surveys on research careers.
- Portability of acquired benefits: The European Union has developed RESAVER, a multi-employer occupational pension solution for research organisations that enables researchers to stay with the same pension plan when moving between countries or employers.

The insecurity of individuals on short-term funding in academic research has been growing. Core university and research funding is likely to decrease in some countries and some research fields after the COVID-19 crisis, and even more flexibility may be demanded of research personnel. There is also emerging evidence that small firms have been halting recruitment for highly-skilled jobs, including researcher positions, during the pandemic (Campello, Kankanhalli and Muthukrishnan, 2020[23]). These combined pressures make the exchange and sharing of research skills and promotion of inter-sectoral mobility even more necessary. It is vital to improve the resilience of the research workforce in an uncertain labour market in a way that is mutually beneficial for both academia and the private sector.

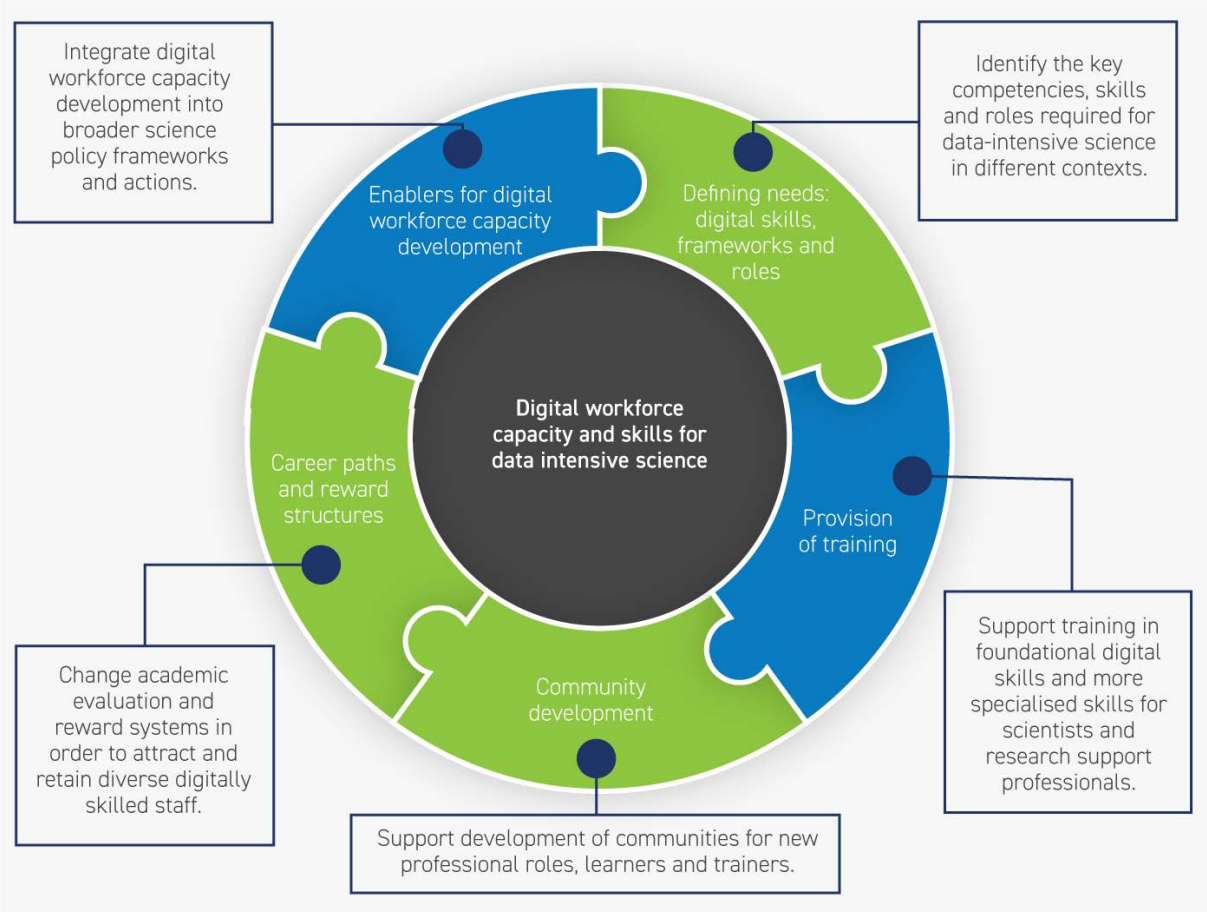
Digital transformation and data intensive science

Digitalisation is changing the practice of science and all fields of research are becoming increasingly data dependent. Digitalisation is also enabling a major shift towards open science, and increased public scrutiny is putting additional onus on ensuring the rigour and integrity of science (Dai, Shin and Smith, 2018[24]). As illustrated by the scientific response to COVID-19, these changes are happening rapidly (see Chapters 1

and 2). They present a major challenge for workforce development, particularly in scientific domains that have been historically less data-rich. Building digital workforce capacity is required at multiple levels, including: individual scientists, research teams, data service providers, research infrastructures and institutions. Traditional academic support roles, such as librarian or archivist are being re-imagined to take on some data management functions, while others are being taken on by researchers. At the same time, new professional roles are emerging, including data analyst, data steward and research software engineer (OECD, 2020[6]). Some of these are in research support roles, whilst others are actively involved in conducting research. Although different fields of research require different types and levels of digital expertise, the prevailing trend in most fields is towards working in large teams that involve a mix of researchers and research support professionals.

It has been estimated that up to 5% of the scientific research budget needs to be dedicated to the management of FAIR (findable, accessible, interoperable and re-useable) data and that 1 in 20 staff in the research workforce should be a digitally skilled research support professional (Mons, 2020[25]). In Europe alone, this means about 500 000 professionals of various kinds are necessary to support researchers through experimental design and data capture, curation, storage, analytics, publication and reuse. To achieve this workforce transition, action is required in 5 key areas, as shown in Figure 3.4.

Figure 3.4. Five key action areas and goals for capacity development in the digital research workforce



Source: OECD (2020[6]), "Building digital workforce capacity and skills for data-intensive science", OECD Science, Technology and Industry Policy Papers, No. 90, OECD Publishing, Paris, https://doi.org/10.1787/e08aa3bb-en.

National governments have an important role for to play in:

- recognising at the policy level the need for a digitally skilled workforce in research, and the importance of strategic planning that integrates the five key areas necessary to build and maintain this workforce, i.e. definition of needs, provision of training, community building, career paths and rewards, and broader enablers;
- analysing digital capacity needs in the national research workforce and the status (or preparedness level) of the research ecosystem to provide the training and other actions necessary to meet these needs; and
- facilitating and coordinating efforts to build workforce capacity at the speed and scale necessary to optimise the benefits of data-intensive science, including monitoring and assessment processes that keep pace with a changing landscape.

However, while leadership, planning and coordination are necessary at the national level, the most important actions in terms of implementation lie with universities and research institutions, which are the main venues for science education, training and research. There is an urgent need not only to train more digitally skilled scientists and research support professionals but more importantly to develop attractive and supportive academic research environments so that they do not all leave to take up better paid jobs in industry. This means developing new career paths as well as new evaluation and reward systems. The data and software outputs from research need to be considered on a par with publication outputs. More flexible career paths need to be implemented to enable people to move smoothly between different posts in academia, the public sector and the private sector at different stages of their lives, reversing the one-way outflow from academia that is draining hot research areas such as AI. At the same time, promoting diversity and lowering the obstacles to entry and progression for women and other population groups that are under-represented in the digitally skilled scientific workforce require urgent attention.

The scale and immediacy of the challenge of building digital capacity for data-intensive research, which is at the forefront of the scientific response to COVID-19, appears to be widely under-estimated. Nevertheless, a number of examples from different countries demonstrate how governments and funding agencies can successfully facilitate and support the necessary changes (OECD, 2020[6]). The German Council for Scientific Information Infrastructures has mapped out future digital educational and training needs at both vocational and scientific research levels (RfII, 2019[26]). In Australia, skilled workforce development and training is one of the five areas of activity of the Australian Research Data Commons, a national initiative supporting Australian research. The UK Arts and Humanities Research Council requires that PhD students undertake training in digital skills and provides a framework against which these skills are monitored.

Universities are also working together to address the challenges of building sustainable workforce capacity and skills for data-intensive science. In January 2020, the leaders of eight university networks from multiple nations signed the Sorbonne declaration on research data rights. The signatories committed to a number of actions including: “Encouraging our universities in setting up training and skills development programmes that create an environment to promote open research data management” (LERU, 2020[27]). At the institutional level, the Technical University of Delft in the Netherlands is funding data stewards embedded across the university and appointing researchers as data champions, as it spreads skills through peer networks as well as with training events and on-line learning facilities (OECD, 2020[6]).

Despite these and other examples of good practice, policy initiatives around digital skills and capacity tend to be ad hoc and short-term, with few examples of thorough needs assessments and longer-term strategic initiatives or structural changes to address identified gaps. This may reflect in part the diversity of public sector actors who need to work together to fully address these issues, including education and research ministries, funding agencies, and (largely autonomous) universities and academic bodies. As witnessed with regards to AI and COVID-19, the private sector also has a critical role to play, both as a supplier and a user of digitally skilled researchers and professional support staff.

Science to address societal challenges

As indicated at the beginning of this chapter and exemplified by the COVID-19 pandemic, scientific research is increasingly being called upon to address complex societal challenges. Disciplinary approaches, or indeed science alone, can only address these challenges to a limited extent. In many situations, transdisciplinary research (TDR), which combines different actors and sources of knowledge, is necessary. TDR requires additional skills and approaches and generates additional outputs to those that are normally valued in academic research.

While many young scientists are motivated to use TDR approaches and develop solutions for societal challenges, such as those embedded in the Sustainable Development Goals, it is not necessarily a good career choice for scientists wishing to establish themselves in academia. TDR is complicated, has a long lead-in time and is often conducted in large teams with no single disciplinary "home" or champion (OECD, 2020[7]). While scientific outputs and publications are important in TDR, a variety of other outputs are equally – if not more – important. These can include policy reports, public communication documents, new multi-stakeholder networks, and changes in practice, all of which are clearly required in the current pandemic response situation. Good communication and facilitation skills are essential for performing TDR, and, in larger scale projects, dedicated co-ordinators who have these skills are invaluable. However, such TDR outputs and skills are not what is normally expected to be listed on an academic CV. Even when a researcher's contributions to society are clearly excellent, it can be very difficult to get full recognition and support from peers and forge a long-term career in academia.

Recent OECD analysis (OECD, 2020[7]), including 28 in-depth case studies, indicates that governments, funding agencies and other actors in the research ecosystem have a critical role to play in providing the strategic leadership, support and enabling conditions for TDR. Specific policy actions include:

- introducing TDR learning modules in science education and postgraduate training courses;
- supporting early career researchers to engage in TDR projects (e.g. through jointly supervised PhDs) and developing more flexible career paths;
- providing individual support (e.g. fellowships) for outstanding individuals who can develop and lead TDR projects;
- extending funding and/or promoting collaboration with other donors to support capacity-building and the participation of non-academic stakeholders in TDR projects;
- allocating core resources, including personnel, to build long-term expertise in TDR methodologies and practice;
- changing peer review and evaluation processes, including by using multi-disciplinary and multi-stakeholder review processes; and
- changing evaluation and promotion criteria for individuals who engage in TDR so that they are judged not only on their scientific publications and citations, but also on their contribution to collective research outputs that are of value to stakeholders outside of science.

In response to COVID-19, a number of research funding agencies have rapidly implemented new schemes to support inter- and trans-disciplinary research, particularly with a focus on the socio-economic aspects of the pandemic (see Chapter 2). With a longer-term perspective, several countries have also been taking strategic actions to promote inter-and trans-disciplinary research (OECD, 2020[7]). For instance, the French National Research Strategy for 2014-20 is organised along a set of societal challenges and is being implemented by a series of programmes overseen by ad-hoc multi-disciplinary committees. The National research agenda in the Netherlands, which is itself the product of a major public consultation exercise (OECD, 2017[28]), is being implemented through the dedicated Research along Routes by Consortia programme, promoting partnerships between knowledge institutes and social partners.

A number of universities have also taken significant steps to break down disciplinary silos and work more closely with citizens and other stakeholders. A much-cited example is Arizona State University (ASU), whose overall mission is "advancing research and discovery of public value; and assuming fundamental responsibility for the economic, social, cultural and overall health of the communities it serves". ASU is organised into 17 colleges, with more than 170 cross-disciplinary centres and institutes. On a more limited scale, the University of Tokyo's Institute of Gerontology brings together researchers and students from different faculties and graduate schools with employees seconded from private companies and local government to promote research on the problems of an ageing society (see OECD (2020[7]) for more details of these and other examples).

While these examples are promising, they need to be diffused and scaled-up considerably if science is to produce the knowledge and technologies required to address both the complex challenges of today and those that are just around the corner. The COVID-19 pandemic provides a timely warning of the importance in this regard. Young researchers need to be encouraged to work across disciplines and sectors, rather than deterred by uncertain career prospects.

A new approach to scientific research training, evaluation and careers

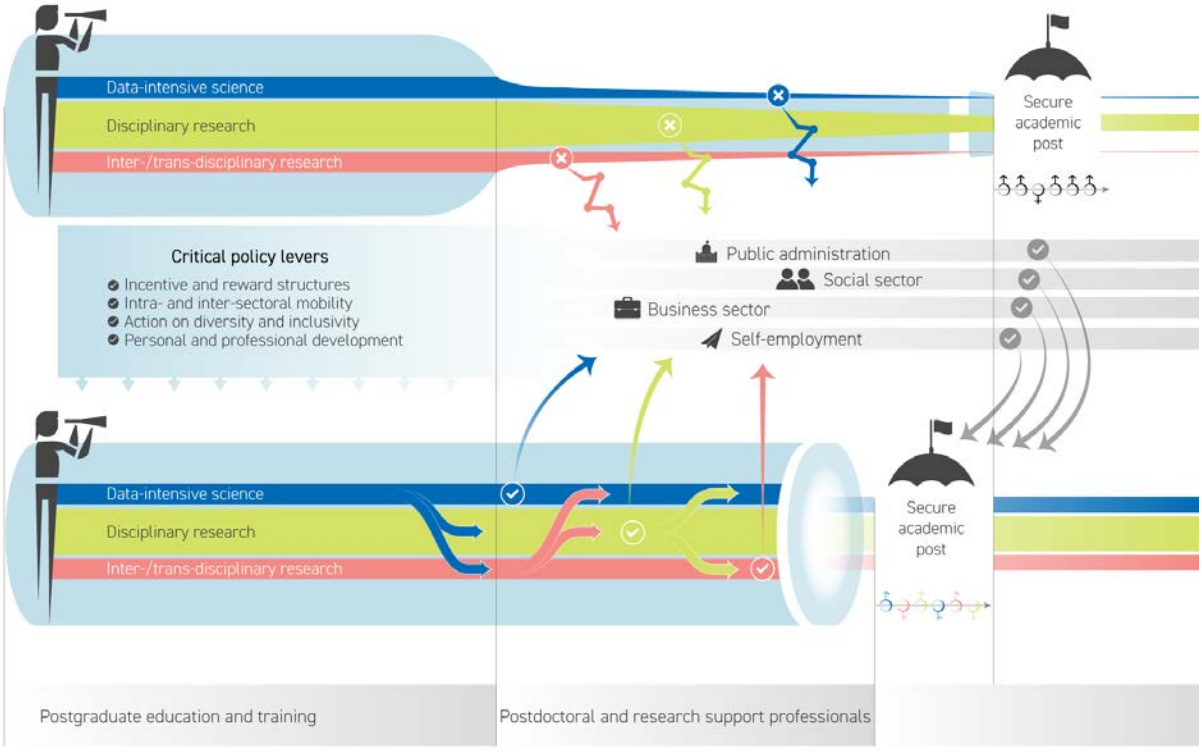
Disciplinary research, merit-based competition and a focus on excellence have proven their worth and enabled technological development, innovation and economic growth in OECD countries over many decades. These traditional approaches still have an important role to play in the future. However, as the COVID-19 pandemic has starkly demonstrated, science has a critical role to play in providing solutions to complex societal challenges, including those that are embedded in the Sustainable Development Goals. At the same time, digitalisation and big data are transforming the way science is conducted, with open science and data intensive research becoming the norm across all domains. While digital technologies, such as AI and robotics, will certainly have an impact on how science meets its multiple demands in the future (see Chapter 6), the individual and collective human contribution will surely remain paramount.

The academic research system depends on the constant through flow of large numbers of PhD students and postdoctoral researchers on temporary contracts, who have limited prospects of securing permanent academic posts. The pressure to publish and the hyper-competitive environment are weighted against women and represent an obstacle to workforce diversity. Growing evidence shows that the pressure on early career researchers poses a threat to their mental health and wellbeing and can distort behaviours, to the extent of undermining the integrity of research (Wellcome, 2020[10]). COVID-19 is making the situation, for a highly skilled and highly vulnerable population of early career researchers, even worse by emphasising the systemic weaknesses that already existed.

Research is at a crossroads. A number of recent policy projects from OECD, examining precarity in research careers, digital capacity and skills, and inter- or trans-disciplinary research have concluded that major changes need to be effected to the way scientists are trained, recruited, supported, evaluated and rewarded (Figure 3.5). The COVID-19 pandemic has strongly reinforced this message. There need to be multiple flexible career options within academia and opportunities for mobility between academia and other sectors at different career stages. Positive actions need to be taken to help women and under-represented population groups enter and sustain scientific careers. Research evaluation and career progression need to move away from their dependency on bibliometric measures. Other research outputs, including data, software and a variety of policy and decision support tools, which are critical for responding to crisis situations, should be equally valued. Being a good team player and a skilled facilitator or communicator should be recognised at the same level as possessing "intellectual capacities". Science is indeed a meritocracy but there is an urgent need to redefine those merits and what constitutes excellence in all its different guises. In a system where the supply of PhD students at the point of entry far outweighs the final demand (in terms of secure academic positions), it is critical to remove the stigma of failure associated

with leaving academia and support early career researchers in their different career choices. Doing so will help build more resilient research systems that are better able to deal with the aftermath of COVID-19 and other future shocks.

Figure 3.5. Towards a more diverse, healthy and effective research workforce: From bottleneck to pipeline



Note: The current bottleneck situation for academic research training and careers (top of graphic) favours disciplinary research and certain population groups, with those who leave to take up alternative careers having very limited opportunities for re-entry. In contrast, an idealised future pipeline (bottom of graphic) allows for more diverse career paths within academia and a rotating door to enable people to move in and out of other sectors during their career. The pipeline is also shorter for those who stay in academia to obtain a secure position and more attractive to women and social groups that are currently under-represented in academia. To move from the bottleneck situation to the pipeline, a number of critical policy levers need to be activated.

As illustrated by the examples provided in this chapter and in recent OECD publications on this topic, many institutions are taking actions to address the challenges for the present and future research workforce. Governments also have an important role to play in bringing together the various actors, who have a stake in the future of science to develop co-ordinated long-term strategies and actions. Many good practices and initiatives are under way in different countries, and much can be learned from international comparisons and dialogue. After all, science is a global enterprise, and a substantial share of academic researchers have worked in more than one country. The COVID-19 pandemic has brought to light both the strengths and the weaknesses of existing research systems. The post-COVID-19 period is likely to exert increasing pressure on young researchers, as research budgets get tighter, but it can also provide an opportunity to reconsider what is the real value in science, and what this means in terms of training and career paths for the future scientific workforce. COVID-19 can provide the stimulus to shift from an uncomfortable bottleneck in academic research careers to a more attractive, healthy and productive pipeline for researchers (Figure 3.5).

References

Bello, M. and F. Galindo-Rueda (2020), "The 2018 OECD International Survey of Scientific Authors", *OECD Science, Technology and Industry Working Papers*, No. 2020/04, OECD Publishing, Paris, https://dx.doi.org/10.1787/18d3bf19-en. [16]

Bello, M. and C. Sarrico (2020), "It's time to close the gender gap in research", *OECD Innovation Blog*, https://oecd-innovation-blog.com/2020/06/17/gender-gap-research-oecd-survey-scientific-authors. [19]

Campello, M., G. Kankanhalli and P. Muthukrishnan (2020), *Corporate Hiring under COVID-19: Labor Market Concentration, Downskilling, and Income Inequality*, National Bureau of Economic Research, Cambridge, MA, http://dx.doi.org/10.3386/w27208. [23]

Dai, Q., E. Shin and C. Smith (2018), "Open and inclusive collaboration in science: A framework", *OECD Science, Technology and Industry Working Papers*, No. 2018/07, OECD Publishing, Paris, https://dx.doi.org/10.1787/2dbff737-en. [24]

DORA (2013), *San Francisco Declaration on Research Assessment*, https://sfdora.org/. [8]

Forrester, N. (2020), "Diversity in science: next steps for research group leaders", *Nature*, Vol. 585/7826, pp. S65-S67, http://dx.doi.org/10.1038/d41586-020-02681-y. [11]

Gewin, V. (2020), "The career cost of COVID-19 to female researchers, and how science should respond", *Nature*, Vol. 583/7818, pp. 867-869, http://dx.doi.org/10.1038/d41586-020-02183-x. [22]

LERU (2020), *Data Summit in Paris*, https://www.leru.org/news/data-summit-in-paris (accessed on 8 June 2020). [27]

Mons, B. (2020), "Invest 5% of research funds in ensuring data are reusable", *Nature*, Vol. 578/7796, pp. 491-491, http://dx.doi.org/10.1038/d41586-020-00505-7. [25]

Nature (2020), "Postdocs in crisis: science cannot risk losing the next generation", *Nature*, Vol. 585/7824, pp. 160-160, http://dx.doi.org/10.1038/d41586-020-02541-9. [12]

OECD (2020), "Addressing societal challenges using transdisciplinary research", *OECD Science, Technology and Industry Policy Papers*, No. 88, OECD Publishing, Paris, https://dx.doi.org/10.1787/0ca0ca45-en. [7]

OECD (2020), "Building digital workforce capacity and skills for data-intensive science", *OECD Science, Technology and Industry Policy Papers*, No. 90, OECD Publishing, Paris, https://dx.doi.org/10.1787/e08aa3bb-en. [6]

OECD (2020), "Education at a glance: Educational attainment and labour-force status", *OECD Education Statistics* (database), https://dx.doi.org/10.1787/889e8641-en (accessed on 22 September 2020). [14]

OECD (2020), "Human resources in higher education", in *Resourcing Higher Education: Challenges, Choices and Consequences*, OECD Publishing, Paris, https://dx.doi.org/10.1787/d6f502d9-en. [20]

OECD (2020), *Main Science and Technology Indicators, Volume 2019 Issue 2*, OECD Publishing, Paris, https://dx.doi.org/10.1787/g2g9ff07-en. [17]

OECD (2020), "Using artificial intelligence to help combat COVID-19", *OECD Policy Responses to Coronavirus (COVID-19)*, http://www.oecd.org/coronavirus/policy-responses/using-artificial-intelligence-to-help-combat-covid-19-ae4c5c21. [3]

OECD (2019), *Education at a Glance 2019: OECD Indicators*, OECD Publishing, Paris, https://dx.doi.org/10.1787/f8d7880d-en. [13]

OECD (2019), *Preparing for the changing nature of work in the digital era*, OECD, Paris, https://www.oecd.org/going-digital/changing-nature-of-work-in-the-digital-era.pdf. [15]

OECD (2018), *International Survey of Scientific Authors*, http://oe.cd/issa. [18]

OECD (2017), "Open research agenda setting", *OECD Science, Technology and Industry Policy Papers*, No. 50, OECD Publishing, Paris, https://dx.doi.org/10.1787/74edb6a8-en. [28]

OECD (2015), "Making Open Science a Reality", *OECD Science, Technology and Industry Policy Papers*, No. 25, OECD Publishing, Paris, https://dx.doi.org/10.1787/5jrs2f963zs1-en. [9]

Pollitzer, E., C. Smith and C. Vinkenburg (2018), "Gender in a changing context for STI", in *OECD Science, Technology and Innovation Outlook 2018: Adapting to Technological and Societal Disruption*, OECD Publishing, Paris, https://dx.doi.org/10.1787/sti_in_outlook-2018-12-en. [1]

RfII (2019), *Digital competencies – urgently needed! – Recommendations on career and training prospects for the scientific labour market*, German Council for Scientific Information Infrastructures, Göttingen, http://www.rfii.de/download/digital-competencies-urgently-needed-october-2019 (accessed on 5 June 2020). [26]

The Royal Society (2019), *Dynamics of data science skills: How can all sectors benefit from data science talent?*, The Royal Society, London, https://royalsociety.org/topics-policy/projects/dynamics-of-data-science/. [4]

Viglione, G. (2020), "Are women publishing less during the pandemic? Here's what the data say", *Nature*, Vol. 581/7809, pp. 365-366, http://dx.doi.org/10.1038/d41586-020-01294-9. [21]

Vitae (2016), *What do research staff do next?*, Careers Research and Advisory Centre, Cambridge, https://www.vitae.ac.uk/vitae-publications/reports/vitae-what-do-research-staff-do-next-2016.pdf. [5]

Wellcome (2020), *What Researchers Think About the Culture They Work In*, https://wellcome.org/reports/what-researchers-think-about-research-culture (accessed on 15 January 2020). [10]

Woolston, C. (2020), "Pandemic darkens postdocs' work and career hopes", *Nature*, Vol. 585/7824, pp. 309-312, http://dx.doi.org/10.1038/d41586-020-02548-2. [2]

Notes

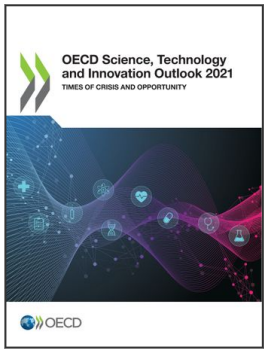
[1] This information comes from country responses to the policy survey of the OECD GSF project on reducing the precarity of research careers. The project was launched in October 2019 and the final report is scheduled to be published in 2021. Its webpage can be found on the OECD STI Outlook website (http://www.oecd.org/sti/science-technology-innovation-outlook/research-precariat/).

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

[3] See endnote (1) for the source.

[4] Approximately 12 000 responses from scientific authors were obtained. Although the survey response rate was only 7.55% the study's quality checks suggest that the results can be considered representative of the target population for the majority of countries and economies covered.

[5] See the OECD project on reducing the precarity of research careers. The project was launched in October 2019, and the final report is scheduled to be published early in 2021.



From:

OECD Science, Technology and Innovation Outlook 2021

Times of Crisis and Opportunity

Access the complete publication at:
https://doi.org/10.1787/75f79015-en

Please cite this chapter as:

OECD (2021), "Challenges and new demands on the academic research workforce", in *OECD Science, Technology and Innovation Outlook 2021: Times of Crisis and Opportunity*, OECD Publishing, Paris.

DOI: https://doi.org/10.1787/72f6f879-en

This work is published under the responsibility of the Secretary-General of the OECD. The opinions expressed and arguments employed herein do not necessarily reflect the official views of OECD member countries.

This document, as well as any data and map included herein, are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area. Extracts from publications may be subject to additional disclaimers, which are set out in the complete version of the publication, available at the link provided.

The use of this work, whether digital or print, is governed by the Terms and Conditions to be found at http://www.oecd.org/termsandconditions.

OECD