

Emerging from uncertainty

International perspectives on the impact of COVID-19 on university research



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Contents

1. Introduction	5
1.1 A pivotal moment for research	5
1.2 About this study	5
1.3 University research: the pandemic's hidden casualty?	6
1.4 A three-phased response	8
1.5 Acknowledgements	9
2. The impact of COVID-19 on researchers	11
2.1 Doing research during the pandemic	11
2.2 Research collaborations	1
2.3 Supporting postgraduate research students	3
2.4 Research careers in a COVID-world	4
2.5 Equality, diversity, inclusion and wellbeing	6
Key takeaways: the impact of COVID on researchers	8
3. Ensuring access to research information during the pandemic	10
3.1 Digitising access to information	10
3.2 The impact on library budgets	13
3.3 The impact on scholarly communication	14
3.4 Moving to 'digital first' infrastructure	16
Key takeaways: access to research information	20
4. The impact of COVID-19 on funding	22
4.1 Research funding to address the pandemic	22
4.2 Funding to support research capacity	26
4.3 Planning for uncertainty	27
4.4 Longer-term views on research funding	28
4.5 Research system sustainability	32
Key takeaways: securing research funding	34
5. Conclusions	36
5.1 From stabilisation to strategy	36
5.2 Prioritising a research-led recovery	37
References	39
Appendix A. Project contributors	45

1. Introduction

As nations look to scientists for a pathway out of the current crisis, this report presents the perspectives of 25 senior research leaders and managers, based in Australia, Europe, Singapore and the UK, on the impact of the COVID-19 pandemic. It explores:

- Implications of the pandemic for researchers themselves, the information infrastructure they rely on, and the funding on which they depend.
- The early interventions being put in place by universities, research funders and governments to safeguard the research enterprise.
- The actions that are needed to preserve and strengthen research capacity and capability, through the pandemic and beyond.

1. Introduction

1.1 A pivotal moment for research

The COVID-19 pandemic has put scientific research in the spotlight...

On 11 March 2020, the World Health Organization (WHO) declared the coronavirus outbreak to be a global pandemic.¹ With a total of 215 countries and territories affected worldwide, the world as we knew it changed beyond recognition in a matter of weeks. Since then, barely any aspect of society has been left undisrupted, and the economic and social repercussions continue to spread.

As governments, businesses and citizens alike await a vaccine against and effective treatments for the coronavirus disease, science has become mainstream, enjoying extensive media coverage and influence.²⁻⁴ The pandemic has also created an opportunity to stymie growing anti-expert sentiments, demonstrating unequivocally the fundamental role played by scientific research in our society.

... but is shaking its foundations

Yet the pandemic's effect on the research enterprise has been enormously disruptive. Social distancing measures have brought many research projects to a halt, slowing down most others. Postgraduate and early career researchers have been deprived of networking and publishing opportunities and face crumbling career prospects. Concern is growing over disproportionate impacts on groups with protected characteristics and the mental health of researchers. On the research information side, COVID-19 has accelerated the shift to digital but also placed existing infrastructure under strain. Open access and open data have gained prominence just as library budgets are being squeezed. For university research funding a double impact is looming. Potential cuts in external research funding (from government, charities and industry) risk compounding the damage done by precipitous declines in other institutional income streams (including domestic and international student tuition fees, accommodation and conferences).

1.2 About this study

A dynamic take on an unfolding crisis

Commissioned by Springer Nature, this report provides a preliminary evidence base on the current and long-term impacts of COVID-19 on research activities within universities. It focusses on two higher education systems, in the UK and Australia, which are particularly reliant on international student fees to cross-subsidise research. However, many of the findings are equally applicable to higher education and research systems globally, as are the risks of failing to protect investment in these systems over the coming years.

The immediate impact and subsequent interventions by government, universities and other stakeholders are examined. Beyond the emergency response, the report

considers the consequences for research in terms of its production and delivery, the information infrastructures that underpin it and the funding sources on which it relies.

Approach and methodology This study uses a mixed methodology. Firstly, the report is based on interviews with 25 experts and research leaders based in Australia, Europe, South-East Asia and the UK. While speaking in a personal capacity, interviewees shared their direct experience of dealing with the pandemic as research funders, higher education sector representatives, university leaders, academics, research management professionals and librarians. Detailed notes of the interviews were then subjected to thematic analysis⁵ to identify common themes and concerns, which are reflected in the infographics at the start of sections 2, 3 and 4. The views of interviewees were supplemented through a rapid evidence assessment of the available literature on the subject, as of September 2020, including (in large part) grey literature, news and opinion pieces from leading figures. A list of published material consulted is included in the references.

Limitations Study participants were gathered via convenience sampling, that is, we interviewed stakeholders who were available in August and early September, and willing to participate. Moreover, interviewees were limited to individuals based in UK and Australia, plus a small number from other countries. Our analysis is underpinned by qualitative coding and we note that this relies on analytical judgement and interpretation. While we have drawn on the literature to validate and contextualise the interview findings, it may therefore not be appropriate to generalise the findings of this study and outlying results may be over-represented.

1.3 University research: the pandemic's hidden casualty?

University research in context

The holistic combination of research and teaching, often referred to as the Humboldtian model,⁶ is central to the modern university. In practice the balance between these two activities varies widely both between and within national systems of higher education. In some countries, such as Japan, Germany and South Korea, the majority of research takes place outside universities, in industry, independent research institutes or government laboratories. In others, however, universities lie at the heart of the national research effort. In these cases, the funding of teaching and research becomes closely intertwined and a downturn in the former can represent a direct threat to a nation's research and innovation capability.

A crisis in international student recruitment

The relationship between teaching and research has attained fresh importance in light of the COVID-19 pandemic. With borders shut or international travel severely curtailed in many regions, a small number of countries' research systems are particularly exposed to a downturn in international student recruitment, as shown in Figure 1. Alongside Switzerland and New Zealand, the UK and Australia stand out, with both a

high proportion of international students, and a high share of researchers located within universities. This is projected to generate significant losses and have a direct and significant impact on university research in the UK and Australia (see section 4).

Figure 1. Higher education researchers as a percentage of national income and number of international tertiary students enrolled by host country^{7,8}



Figure 1. shows OECD countries excluding Luxembourg (outlier), Colombia, Israel, Lithuania, Slovakia and the United States (all with insufficient data). Data used is the for most recent year available from OECD.

The risk to research

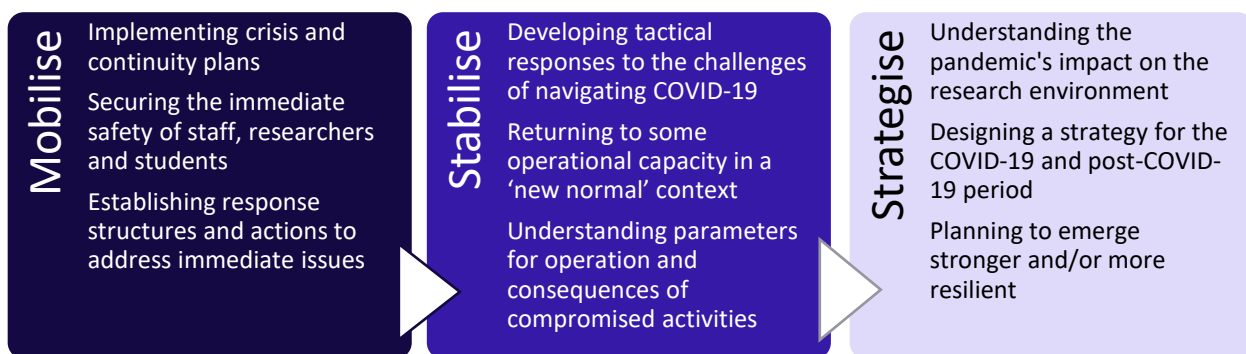
These losses matter for research, as in the UK (and, to a similar extent, in Australia), research funding is known to cover only about 70% of the full economic cost of research for universities. The remainder is cross-subsidised by universities through commercial activities such as accommodation, conferences and, most pertinently, international student fees. Losses will also not be distributed evenly within both countries' university sectors. Research-intensive institutions tend to be most successful in recruiting international students and are therefore most exposed to a downturn in recruitment.^{9,10}

1.4 A three-phased response

The three phases of the response to the pandemic

A recent PwC study identifies three phases in organisational responses to the COVID-19 crisis.¹¹ The first phase is mobilisation, during which organisations secure the safety of their workforce and establish appropriate response structures to continue basic operations. The second phase is stabilisation, when organisations develop tactical responses to the challenges of navigating the 'new normal'. The last phase is strategising, when they develop a strategy for emerging stronger in the post-COVID-19 economy.

Figure 2. A phased response to the crisis (adapted from: PwC 2020)¹¹



"The response to COVID-19 (at system and institutional levels) has gone or will go through a few phases: emergency in Spring; considering the Autumn restart and students' return; and the longer-term. Few systems or institutions have got to thinking about the longer-term yet."

Thomas Estermann, Director, Governance, Funding and Public Policy Development,
European Universities Association

The response of universities

Interviewees revealed that universities followed a very similar process in their responses:

- **Mobilisation:** in the early days of the pandemic, universities focused entirely on addressing the operational challenges needed to secure the health of students, researchers and staff. It was a phase of emergency planning, building closure and adapting to remote working.
- **Stabilisation:** at some point during the summer, universities switched from emergency mobilisation to 'contingent planning' for the new academic year, taking decisions like when and how to reopen facilities, whether to hold online classes, how to manage spaces and so forth.

- **Strategising:** as uncertainties persist on future social distancing measures and the impact of the pandemic remains largely unquantified, few universities have reached this stage yet. However, many institutions have already taken decisions to safeguard their financial sustainability, with hiring and expenditure freezes, and voluntary severance and restructuring schemes.

Universities move through these phases at different times and the process is not unidirectional. As public health restrictions keep changing, organisations that have not adequately planned for all scenarios might have to revert to the mobilisation phase and those that have started strategising might have to review and update their plans. The sector will have to continue be nimble and adaptable as the effects of the pandemic continue into 2021.

1.5 Acknowledgements

Our thanks

The project team at Research Consulting gratefully acknowledge the support of Springer Nature for this study, and particularly Steven Inchcoombe (Chief Publishing Officer), Harald Wirsching (Vice President Strategy & Market Intelligence), Dan Penny (Head of Market Intelligence).

Secondly, we owe a thank you to our project associates, Ian Carter and Mark Hochman, who were instrumental in conducting the interviews cited in this report, adding insights to our analysis, informing our methodology and navigating the complexities of this project.

Finally, we record our appreciation to the individuals who were interviewed throughout this project, both for their valuable insights and for their time, during a particularly turbulent period, without which this study would not have been possible. A full list of interviewees can be found in Appendix A of this report.

2. The impact of COVID-19 on researchers

The pandemic has had a major impact on research production. From lab and library closures to cancelled conferences, only research projects that could be continued online stayed largely on track. Negative impacts have had a disproportionate effect on early career researchers and risk reinforcing structural inequalities within academia. Moreover, by undermining the career prospects and financial stability of many researchers, the pandemic may also lead to a reduction in the talent pool, with a lasting impact on future research production. This section summarises the challenges faced by researchers in the first six months of the COVID-19 crisis and reflects on the implications for the future of the research enterprise in the UK, Australia and beyond.

2. The impact of COVID-19 on researchers

2.1 Doing research during the pandemic

Significant impacts on the ability of researchers to conduct research

The social-distancing measures put in place to address the pandemic have severely impacted on the ability to carry out research, delaying projects and creating uncertainty around time extensions and funding.¹² As lockdown measures ease but social distancing continues, research remains compromised in terms of access to campus facilities, information or research subjects, collaborations with partners and ease of travel. Rapid adoption of online communication tools has mitigated this, but there are growing concerns over the impact of the pandemic on researchers in terms of mental health, and disproportionate impacts for equality and diversity. Universities face significant challenges in opening campuses to students for teaching while continuing to support research activities in a safe way.

The pandemic has reduced access to laboratories, human subjects and libraries

The level of disruption has been unevenly distributed, however, with striking variations both between and within academic disciplines. Researchers conducting work in laboratories were heavily affected.^{13,14} In many countries, only labs dedicated to COVID-related research were able to remain active during the first wave of the pandemic and indeed many labs across the UK and Europe were repurposed to support vaccines research.^{15,16} For projects requiring clinical research or working with human subjects, physical distancing restrictions have reduced access to patients and population cohorts vital to progress their research.¹⁷ Similarly, research productivity has suffered for academics relying heavily on fieldwork, given restrictions to travels and freedom of movement.¹⁸ For many researchers in the arts, humanities and social sciences, disruption was caused by lack of access to facilities like libraries and museums, or to resources such as books and artefacts.^{18,19}

"Disciplinary differences can be seen for those subjects that require extensive or overseas fieldwork, or which involve a lot of social interaction. There are and will be uneven opportunities."

Professor James Wilsdon, Director, Research on Research Institute and Digital Science
Professor of Research Policy, University of Sheffield, UK

Case study: Research priorities at the University of New England

The University of New England (UNE), Australia has very strong links with Australian agricultural producers, in particular sheep, cattle and poultry and a considerable commercialisation income, mainly through genetic breeding rights. UNE researchers helped to keep Australia's sheep genetic resource flock from "going under" during COVID-19, with the nation's merino flocks producing about 90% of the world's super-fine apparel wool for clothing – all while adhering to COVID-related health requirements.

During the pandemic, UNE prioritised keeping research projects of strategic importance active, and minimising the impact on research collaborations with the agricultural and livestock sectors. Poultry-related research trials closed down for a while but research in sheep and cattle disciplines had to continue given the university's requirement to "be there for industry" and being an important stakeholder in maintaining a nucleus sheep flock for fine wool breeding. Through COVID-19, research on animal ethics and welfare protocols was not impacted and, as Professor Heiko Daniel, Deputy Vice-Chancellor for Research at the University of New England, said: "farmers kept farming, sheep and cattle kept growing!"

Productivity depends on the ability to shift research online

By contrast, projects that relied more on desk-based methods were less affected. Interviewees highlighted that COVID-19's impact on research productivity depends on the extent to which a project, or parts of it, can be successfully undertaken online. Many researchers have been able to adapt to using video-conferencing software in projects involving qualitative research with human subjects, and researchers with full access to online literature on their subject were advantaged. Moreover, some studies indicate that a desire to avoid overusing these tools has created growing expectations of "preparedness and decision-making" which encourages individual participation and efficient discussion.^{13,20} Digitisation of knowledge resources, a more flexible blend of online and offline research methods and use of remote communication tools emerge as key attributes for resilient research projects in the new COVID-19 world.

Universities have continued to provide effective research support

In both the UK and Australia, universities have continued to provide research support services during the pandemic – but not without problems. Interviewees noted how rapidly institutions have shifted operations online during the pandemic and how quickly staff have become accustomed to new working from home practices. Institutional research offices have been able to function remotely with few complaints regarding the service arising from researchers over the pandemic period, considering the challenging circumstances in which they operate.²⁰ At the same time, however, research support professionals felt under increasing pressure to meet deadlines and provide an effective service in a context of reduced responsiveness.

"We have operated a full RIS service over the period, with no decrease in the volume of applications."

Jennifer Stergiou, Executive Director, Research & Innovation Services, Northumbria University and Chair of ARMA, UK

Lack of physical space will be a barrier to research activities

Social distancing measures have also created a shortage of physical space for research on campuses as well as research institutes. The problem has affected all subjects. Interviewees noted the need for libraries to operate with reduced capacity, and similarly research labs have been operating at between 20% and 50% capacity, depending on the quality and layout of the space. While space utilisation on campus has always been a problem for universities, the pandemic has added significant additional pressure. This

pressure will only intensify in the coming months for those in the northern hemisphere, as universities expect to repurpose research facilities for teaching in the autumn.

Case study: University of Technology Sydney

The University of Technology Sydney (UTS) has endeavoured to stay open to research during the COVID crisis. UTS has modified its ethics assessment practices during COVID, taking a risk-based approach for protocols requiring changes, rather than a compliance-led approach, accompanied by a distributed local rather than centralised assessment. This has resulted in expedited ethics processes (whilst still maintaining rigour) that have allowed human and survey-based research to continue.

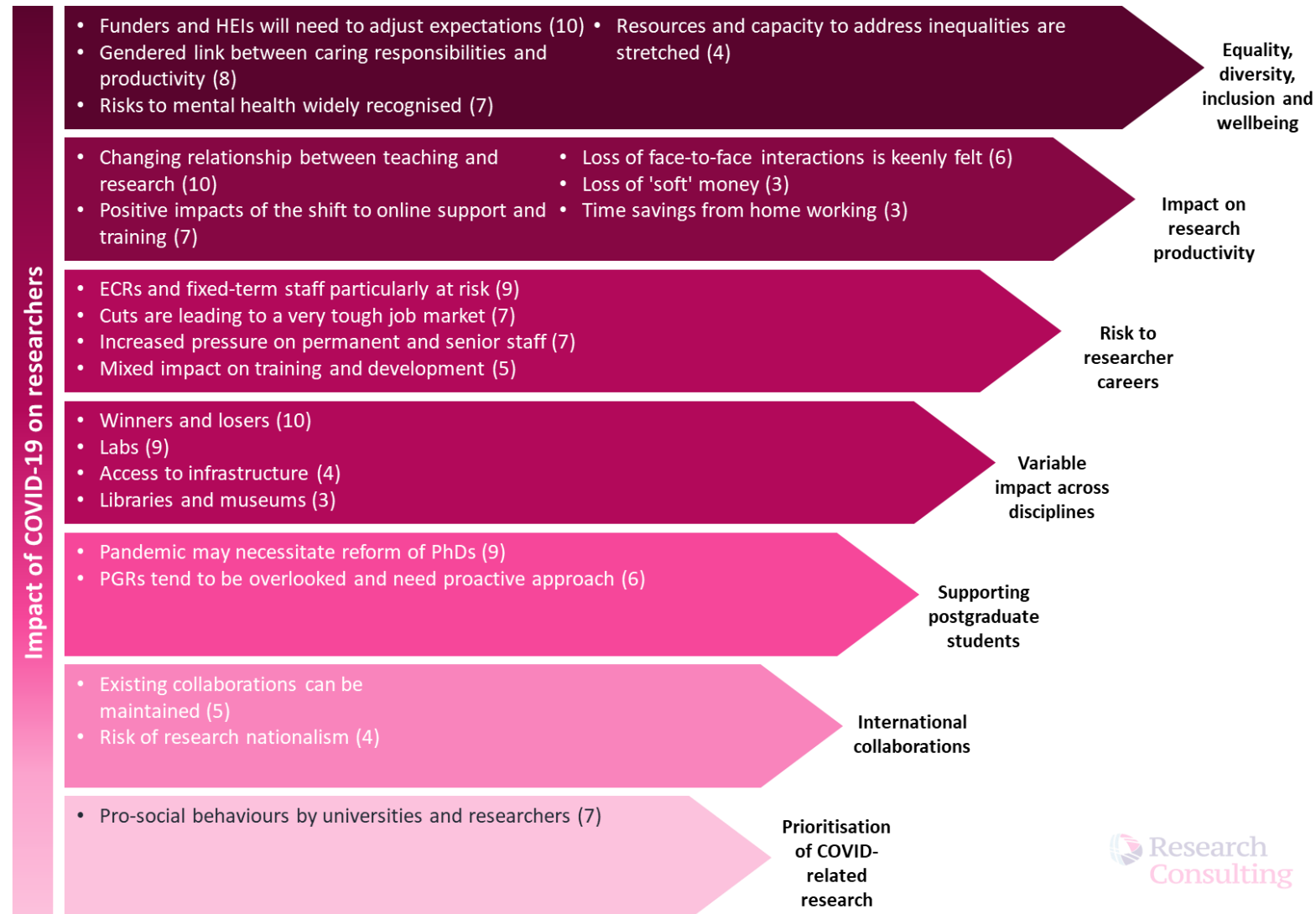
Coupled with this is the ongoing development of a training program for researchers who were previously doing “non-digital human research” on how to use digital tools to continue their work. Researchers have been introduced to different way of thinking about their research and encouraged to interact with human subjects in ways that may not have been available previously via face to face interviews. This, in turn, has generated an opportunity to bring disciplines together, broadening their research questions as their subject base became wider and more diverse.

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International perspectives on the impact of COVID-19 on university research

Figure 3. Categorical interview comments on the impact of COVID-19 on researchers.

Length of arrow reflects number of comments.



2.2 Research collaborations

Universities are working with industry to tackle the pandemic

The coronavirus outbreak has accelerated cross-sector partnerships to speed up the scientific responses and underlined the importance of collaborations between academia and industry, where the former contributes technical know-how and the latter brings materials, facilities and production processes.²¹ Universities are able to bring together different actors in a coordinated economic and productive response to the crisis, especially in regional environments where the local authorities are starved of resources or are too small.²¹

The immediate response from universities at the height of restrictions and crisis, was consistently a mobilisation of resources supporting *prosocial* behaviours and actions in support of local and national issues.²¹ In the UK, research equipment was moved and loaned to the NHS to augment testing, laboratories were re-purposed for NHS use, universities manufactured PPE, COVID-19 training measures were put in place for NHS staff, university staff and students (especially medical students) support delivery in the NHS and volunteered in local support actions and accommodation and car parking facilities were opened for key healthcare workers.

In Australia, universities are undertaking projects that are directly fighting the virus, understanding how the virus spreads and helping to design effective public health interventions.²² In Singapore, interviewees noted that past experiences with the SARS virus have enabled a systems approach to collaboration between universities, government agencies, hospitals and industry, resulting in rapid diagnostic tests and maintenance of the supply chain. While important from both the social and the public health perspectives, these prosocial measures have nevertheless diverted resources away from research.

"The community – academics, businesses, funders – have continued to be very active throughout this period. Demand for knowledge exchange is high."

Dr Sean Fielding, Director of Innovation, Impact and Business, University of Exeter and Chair of PraxisAuril, UK

Case study: UK universities actively contributed to the pandemic response

UK universities are actively involved across all stages of the pandemic response. In the early days of the outbreak, universities played a key role in rapidly prototyping and mass-producing personal protective equipment (PPE) in collaboration with local manufacturers. The Universities of Newcastle, Northumbria and Sunderland had started to collaborate to produce PPE using rapid prototyping. However, they soon found out that they would not produce them quickly enough at volume and that they needed to engage with local manufacturing capacity. This led them to co-ordinate that manufacturing capacity, bringing together the many players to solve these complex logistical problems at speed.

UK universities are also producing research to help authorities manage the pandemic. Experts at the University of Southampton are modelling the effectiveness and timing of COVID-19 interventions for different regions of the world. The research is helping the World Health Organization and the European Centre for Disease Prevention and Control with response efforts. Finally, universities are leading research to stop the pandemic. The

Universities of Glasgow and Edinburgh are collaborating on a £4.9 m (AU\$8.7 m) government-funded project to understand the impact of the virus on the human body. Using samples and data from 1,300 patients in the UK, the team hope to provide information to help control the outbreak and improve treatments. The University of Oxford is rapidly advancing the development of a vaccine, in collaboration with pharmaceutical companies, which is currently at the last stage of development (human trials).²¹

These examples demonstrate the key role university research plays in spearheading and coordinated responses across all stages of the pandemic.

The pandemic has hampered organic research collaborations

Despite these positive examples, however, the negative effects of the pandemic on communication and collaborations were evident to our interviewees. 'Water-cooler' conversations that stimulate new ideas or help address emerging issues have all but ceased and the ferment of ideas to be found at academic conferences and symposia cannot be fully replicated in a digital environment. International research collaborations have also suffered, with projects requiring international travel, field work or access to overseas facilities all but halted. Interviewees were in agreement that, while existing collaborations could continue in the virtual realm, the loss of face-to-face interactions was likely to inhibit the creation of new partnerships.

"Meetings have become more efficient, but they lack the side conversations that can stimulate new ideas or help to address emerging issues. Team-based development is also more difficult in a virtual environment with current tools."

John Westensee, Deputy University Director, Research Support and External Relations,
Aarhus University, Denmark

There are growing concerns over the risk of 'research nationalism'

The pandemic has highlighted political tensions that have long surrounded discussions of scientific research. Anti-China rhetoric emerging in the United States appears to have driven a wedge between China and Western countries,²³ an issue exacerbated by widely publicised scandals around the quality of scientific research emerging from Chinese institutions.^{23,24} Russia, Iran and China have been accused of attempting to hack British universities and scientific facilities to steal research related to COVID-19, including vaccine development.²⁵ Coupled with the ongoing tensions associated with Brexit, UK interviewees in particular see a need to guard against a potentially damaging move towards 'research nationalism', though others are more optimistic.

"I'm not concerned by the possibility of research nationalism. I think collaboration will continue, and is important for Aarhus, but academics will need to find new ways to network, as there will be many fewer face-to-face meetings."

John Westensee, Deputy University Director, Research Support and External Relations,
Aarhus University, Denmark

2.3 Supporting postgraduate research students

Research students are struggling to complete their studies

The coronavirus pandemic has reduced opportunities for training, networking, and other forms of professional development. Doctoral students have struggled to fulfil the usual requirements associated with the completion of their studies and defending their theses. For example, some students are required to complete a visiting period in another research lab, and some students will face difficulties in defending their theses online.¹⁹ In the UK there were calls for research students not to be forgotten (in comparison to taught students). While UKRI (UK Research and Innovation), the UK Government body that directs research and innovation funding, has responded by targeting first those PhD students in their final year,^{26,276,27} this has caused some negative feedback from PhD students and others.

UK universities have responded in different ways, depending on the size of their PhD population and on the strength of their finances. Some have chosen to 'mirror' the UKRI approach, supporting final year students in the first instance, and some have had to take a constrained approach, prioritising those with caring responsibilities or health and wellbeing issues. While relaxing registration extensions and waiving extension fees, many UK and Australian universities have had to constrain stipend extensions due to difficulties in securing the necessary funding. The position is similar in Europe, even though postgraduate research (PGR) students often have a different status from those in the UK. In Australia, some institutions have stepped in to underwrite salaries for early career researchers, but have found it difficult to access the government's JobKeeper wage subsidy program.

"We have to be honest about the uncertainties when we're in dialogue with students. Their PhDs could be disrupted for two to three years, so they need to plan for that."

Professor Andrew McRae, Dean of Postgraduate Research, University of Exeter, UK

PhD reform is expected to be a legacy of the pandemic

In a sign of how negative the prospects appear to be for postgraduate research students, some universities have already been looking at ways to encourage alternative career paths and a mindset that is more open to non-academic jobs, such as consultancy. But careers beyond academia are also at risk. The long-term impacts of the crisis are likely to include the loss of potential spin-off companies and increased difficulty in brokering industry collaborations.¹⁹ Interviewees anticipate that far-reaching reforms to postgraduate research training will be needed to prepare students for a wider range of potential career paths. Recognising this severe impact on individuals' future prospects, the European Council of Doctoral Candidates and Junior Researchers recently called for a post-pandemic plan to address these uncertainties.¹⁹

"Until now, the PhD was still fundamentally seen as a way to produce more academics. COVID could promote action on different models of higher degree research programmes focussed on careers other than the academy."

Professor Kate McGrath, Deputy Vice Chancellor (Research), University of Technology Sydney, Australia

2.4 Research careers in a COVID-world

Early career researchers are among those most heavily affected

Research staff, as employees, may have been subject to the wider job retention and business support measures introduced by governments. However, in the UK this turned out to be problematic, given the mixed funding that typically supports research staff and the specific rules of those mechanisms. Anecdotally, it seems that few research staff were furloughed.

However, early career researchers (ECRs) have been more heavily affected. Researchers across Europe have called for support in dealing with the uncertainty arising from the pandemic.²⁸ ECRs without a permanent position (such as post-doctoral researchers on short-term contracts or fellowships) face a particular challenge in trying to "ride out the storm". With hiring freezes and overwhelmed HR departments, interviewees stated that getting a job in academia is "next to impossible" at the moment. In the UK and Australia, the university workforce has long been comprised significantly of fixed-term and casual staff.²⁹⁻³¹ Forced adjustments to budgets arising from the disruption caused by the pandemic have put many of these staff at significant risk,^{29,30,32} as teaching assistants on short-term contracts are easier to lay off than their more senior colleagues.³³ Junior academics worry that their contracts will be terminated early or they will be denied expected renewals.^{17,19,34}

"I am most concerned about early career researchers, research students and those on fixed-term contracts, for both the more immediate financial consequences and the longer-term career effects."

Anonymous, UK

Permanent staff are likely to find time for research is squeezed

Academic staff who are fortunate enough to remain in employment are likely to come under additional pressure as a consequence of the budgetary position, as well as the need to adapt to different ways of working for both teaching and research. With the loss of teaching assistants, academics fear that time for research will be squeezed and that productivity will suffer accordingly. The intense demands placed on senior staff over recent months were also a recurrent theme in our interviews, with several individuals noting that expectations risk becoming unsustainable.

"I am concerned about workload issues on academic staff. The bought-in teaching support has had to be cut, we have a voluntary severance scheme in place, and there are more complicated arrangements for teaching. These additional pressures will either mean there is less time for research, or they could lead to staff doing their research in the evenings and weekends, with potential health and wellbeing consequences."

Professor Steve Rothberg, Pro Vice-Chancellor (Research), Loughborough University, UK

Career progression opportunities appear limited

While more senior academics are using their networks to adapt to the new reality, ECRs are those most at risk. Interviewees raised the point that existing training for researchers may not have been sufficient to prepare them for a post-pandemic world where working with partners, understanding commercial value or considering regional impact will be key to secure research funding. Interviewees noted that a sustained reduction in professional development opportunities could have detrimental impacts on researchers' abilities to secure funding or fellowships. Similarly, a reduction in the numbers of publications during the pandemic period could have a disproportionate impact on ECRs' career progression because it reduces opportunities to be recognised among their peers and affects their competitiveness for fellowship applications.^{18,35} However, this also gives the sector an opportunity to reinforce the principle that publication quality, not volume or the venue of publication, drives career progression.

"Those with established networks will work them hard, but it will be harder for those earlier in their careers without established networks."

Professor James Wilsdon, Director, Research on Research Institute and Digital Science
Professor of Research Policy, University of Sheffield, UK

The pandemic risks leading to a long-term reduction of the research talent pool

All these issues are creating a challenging environment for academics. So, while the worst impacts of the pandemic on research are yet to materialise, the long-term prospects for the sector are worrying.

Observers and interviewees from the UK, Europe and Australia, all raised serious concerns that this negative environment could lead to a loss of talent from the research pool.^{36,37} There is a fear that the lack of career options, a reduction in research funding and the lower quality of training put large numbers of individuals off pursuing a research career, especially in science, technology, engineering and maths (STEM) that many governments have been pushing hard to drive economic growth.

"For researchers training at the moment for a STEM career then the future could seem a bit gloomy. This could turn young people away from pursuing careers in STEM."

Dr Yee Lian Chew, Chair of University of Wollongong ECR Disruption Committee and
NHMRC Research Fellow, Australia

2.5 Equality, diversity, inclusion and wellbeing

Mental health concerns are exacerbated by the pandemic

Researchers' mental health has been a concern for some time, and ECRs report that the heightened uncertainty regarding their employment in recent months has led to increased anxiety and mental health strain.³⁸ Severe reductions in social interactions, increasing workloads, difficulty in managing online and in-person teaching and difficulty in balancing professional and caring duties weigh heavily on researchers. Some institutions are putting in place measures to support their student researchers by creating mental-health support clinics, fostering communication among postgraduate researchers and generally opening up the debate about mental health problems. But there are concerns that support services are too stretched to address a looming crisis.

Home working has levelled access to conferences and events...

The pandemic has had different impacts on different groups of researchers, reinforcing existing inequalities and worsening mental health problems. On a positive note, the shift to online has "levelled access" to research and networking opportunities, allowing more individuals to join discussions and events. Researchers with disabilities and those in low-middle-income countries have benefitted from the drastic reduction in travel and in-person meetings or classes.^{13,20,39} Researchers with long-term health issues have also reported some improvements in accessibility of support and information, as the need for physical attendance of classes has reduced.⁴⁰ However, they note increased feelings of anxiety in relation to their own health during the pandemic, and expressed concerns about being discriminated against in hiring and funding if they are unable to return physically to work when the peak of pandemic has passed.¹⁹

"I am concerned that groups with protected characteristics will be set back, just at a time when progress was starting to be made."

Professor Steve Rothberg, Pro-Vice Chancellor (Research), Loughborough University, UK

...but it penalises women and those with caring responsibilities

Over the pandemic period, male researchers have submitted more papers than average, while female researchers are submitting fewer.^{29,41} This is frequently attributed to the fact that female scientists are more likely to have young children as dependents than their male counterparts^{13,42,43} creating additional pressure when working from home.⁴¹ Several interviewees highlighted the negative impact that caring responsibilities have had for primary care givers, just as progress to reduce gender inequalities was starting to be made.

There are inter-generational differences in the pandemic's impact

The difficulty in balancing the demands of academic work and care giving responsibilities creates different challenges for researchers at different ages and levels of seniority.⁴⁴ Researchers with young children or aged care family members, usually at the early stages of their career, are more affected than older academics with mature children. Younger

researchers, who often tend to have heavier teaching loads than their senior counterparts, have struggled with the move to put courses online, adding to anxiety levels and making it difficult to concentrate on leading edge research. Seniority, as a proxy for age, also influences the economic condition of researchers, which in turn has a knock-on impact on their home-working environments. Senior researchers (and professional staff) would more commonly be able to afford larger houses with offices or studios to work from, an option that is often unavailable to junior staff members in shared and low-cost accommodation.

Ethnic minorities and researchers from poorer backgrounds suffer disproportionately

There is some emerging evidence that researchers from Black, Asian, and minority ethnic (BAME) backgrounds are more severely affected by staff cuts during the pandemic,⁴⁵ with women of colour being disproportionately impacted.⁴⁶ Expatriates are also identified as a vulnerable group because of a lack of social safety nets and visa restrictions.¹³ Researchers from poorer backgrounds have been impacted disproportionately due to the shift to online teaching, training, and meetings. Disparities in access to fast internet connections and computer have been barriers to making the shift to online.⁴⁷ These trends have spurred calls for the recognition of diversity in academia, and for national governments to support the sector in addressing structural inequality.⁴⁵

There is widespread agreement that expectations must be adjusted

Interviewees felt strongly that universities and funders must adjust their expectations in light of the personal circumstances faced by researchers. In the UK, postgraduate researchers have focused on securing extension for their projects, whether funded or self-funded, but the approach to this has been uneven across the country because the approach is driven by the University's budget. By contrast, A*STAR in Singapore has taken a blanket approach in extending bursaries by six months for all PhD students. Similarly, early career researchers have often struggled to meet funding calls deadlines or to meet expectations of fellowship sponsors. At this stage, no clarifications of any changed expectations have been issued and ECRs are thus proceeding on the basis that research performance expectations (mainly research outputs and meeting research milestones) are unchanged from initial grant conditions. Interviewees stressed the importance of universities and funders taking a concerted approach to resetting expectations when assessing research projects and career progression.

Key takeaways: the impact of COVID on researchers

Maintaining capacity is vital to the long-term health of the research system

COVID-19 has significantly impacted the ability of researchers to progress their work. Arrangements for opening campus facilities for research remain fragile, and are tied to wider operations for teaching, while there are growing concerns over researchers' mental health and wellbeing. Institutions, funders and policymakers must now begin developing strategies to safeguard research capacity for the long term.

Securing the future of research production

As universities and funders adapt to the new reality, it is imperative that they continue moving from short-term reactive measures to proactive, strategic actions that equip researchers with the skills, knowledge and resources to perform research in a difficult environment. Three areas stand out:

- 1) **Support digital research:** in the short term, this means equipping staff with tools and skills to perform research digitally, while in the longer term it means encouraging blended methods and scenario planning in case of reduced access to facilities or study participants.
- 2) **Re-assess training:** the pandemic puts new urgency on the need to review how researchers are trained, with more emphasis on network-building, achieving societal impact and developing a stronger set of professional and transferable skills.
- 3) **Rethink research careers:** the pandemic has highlighted the difficult financial and professional circumstances researchers face, especially those early in their careers, and the impact these have on mental health. A fairer system to evaluate career progression, more financial stability and more support for ECRs and disadvantaged groups are necessary to avoid a 'lost generation' of researchers.

Moving through the phases

Over the coming months, research stakeholders will have the opportunity to move to the 'Strategise' phase and articulate a long-term vision for the future of research in a post-COVID world.

Figure 4. Protecting research capacity.



3. Ensuring access to research information during the pandemic

COVID-19 has had multiple effects on research information. Libraries struggled with disrupted access and were forced to rapidly shift their services to digital. Downward pressure on budgets is now forcing many libraries to review their journal subscription agreements and prioritise content for teaching. Calls for open access have been strengthened by the crisis, as publishers made available COVID-related research that had a direct impact on health policy. But the digital infrastructure supporting the free exchange of research information and data is still not equipped for the scale-up required. This section explores the pressures created by the pandemic on research information, as well as the opportunities it creates to accelerate the shift to a more resilient, digital research information infrastructure.

3. Ensuring access to research information during the pandemic

3.1 Digitising access to information

The multiple impacts of COVID-19 on research information

The pandemic has created several challenges for research information. Reduced access to libraries forced a rapid transition to digital, highlighting the challenges for disciplines with fewer digitised collections. The case for open access and open data has been strengthened by the pandemic, but their adoption will require investment in supporting digital infrastructure and careful consideration of business models. This is all the more urgent given the added pressure library budgets will be under in a post-COVID world.

Physical access to libraries was disrupted

The pandemic created significant challenges for academic libraries. Lockdown forced libraries to step up their digital offering, as researchers were prevented from accessing physical resources and staff had to secure continuity of service from a remote setting. Librarians struggled to support blended learning alongside providing standard services. Interviewees noted that libraries continued to provide basic digital support for research including services relating to open access and institutional repositories, but the capacity to support research more broadly was severely constrained during the pandemic.

Like other research support professionals, librarians have faced significant operational challenges in ensuring continuity of service. Services were provided online and, when restrictions eased, the push to reopen was strongest from the research side of the university, for access to labs and facilities. The physical layout of libraries also generates unique problems for librarians and the need to keep some spaces off limits still affects access to entire collections. Research libraries have effectively become rationed resources for researchers throughout the pandemic, and the closure of these facilities continues to take a toll on researcher productivity.

“One encouraging point from COVID is that the physical library has been seen as an essential service with enormous pressure from academic staff and students to remain open. An optimistic view sees the library as being seen more positively as a core service of the modern university.”

Jill Benn, University Librarian University of Western Australia and Chair, Council of Australian University Librarians, Australia

Case study: Australian libraries faced fewer disruptions

In Australia, where restrictions were less severe and prolonged than in the UK, dips in usage were short-lived. At the University of Western Australia, daily visits fell from 12,000 to less than 2,000 during the pandemic but initial concerns that “no-one will ever come back to the library” proved unfounded, as visits climbed back up to almost 10,000 per day

as restrictions eased. Many students have been doing online tutorials from the library rather than from home.

The University of Technology Sydney put its effort into ensuring safe physical spaces for researchers requiring access to infrastructure, and researchers have generally been able to continue their research using primary data rather than meta data or review work. At the University of Wollongong, some research infrastructure has remained open but where machines need students to be trained in use, these items have been unavailable. Likewise, facilities that need regular maintenance for operation were closed, contributing to an inability to gather primary research data.

Library services shifted to digital delivery

The closure of libraries during the pandemic tested their digital resilience and their supporting infrastructure, leading to hastened audits of current capabilities (technical and staff) and to a “more deep-rooted consideration of the role of the digital, its relation to the physical”.⁴⁸ A recent report noted that while most UK libraries were able to rapidly transition to fully digital and online operations during the pandemic, the UK’s digital infrastructure has some unresolved vulnerabilities such as a reliance on physical spaces and terminals located within the library to access to digital collections. The COVID-19 crisis has emphasised the need to change how research libraries operate, facilitating a fuller transition to digital.⁴⁸

“Legal deposits and e-deposits can only be accessed from a set number of physical locations even though they are digital. They are only becoming available again as the spaces re-open (with restrictions), not because the restricted access has been resolved.”

Dr David Prosser, Executive Director, Research Libraries UK, UK

Case study: UK libraries plan amidst uncertainty

Over the long term, the shift to digital has the potential to alter the role of the library as a physical space.⁴⁹ Despite the increased reliance on digital resources, however, interviewees have not seen any evidence that the pandemic will reduce the need for libraries as physical spaces for research.

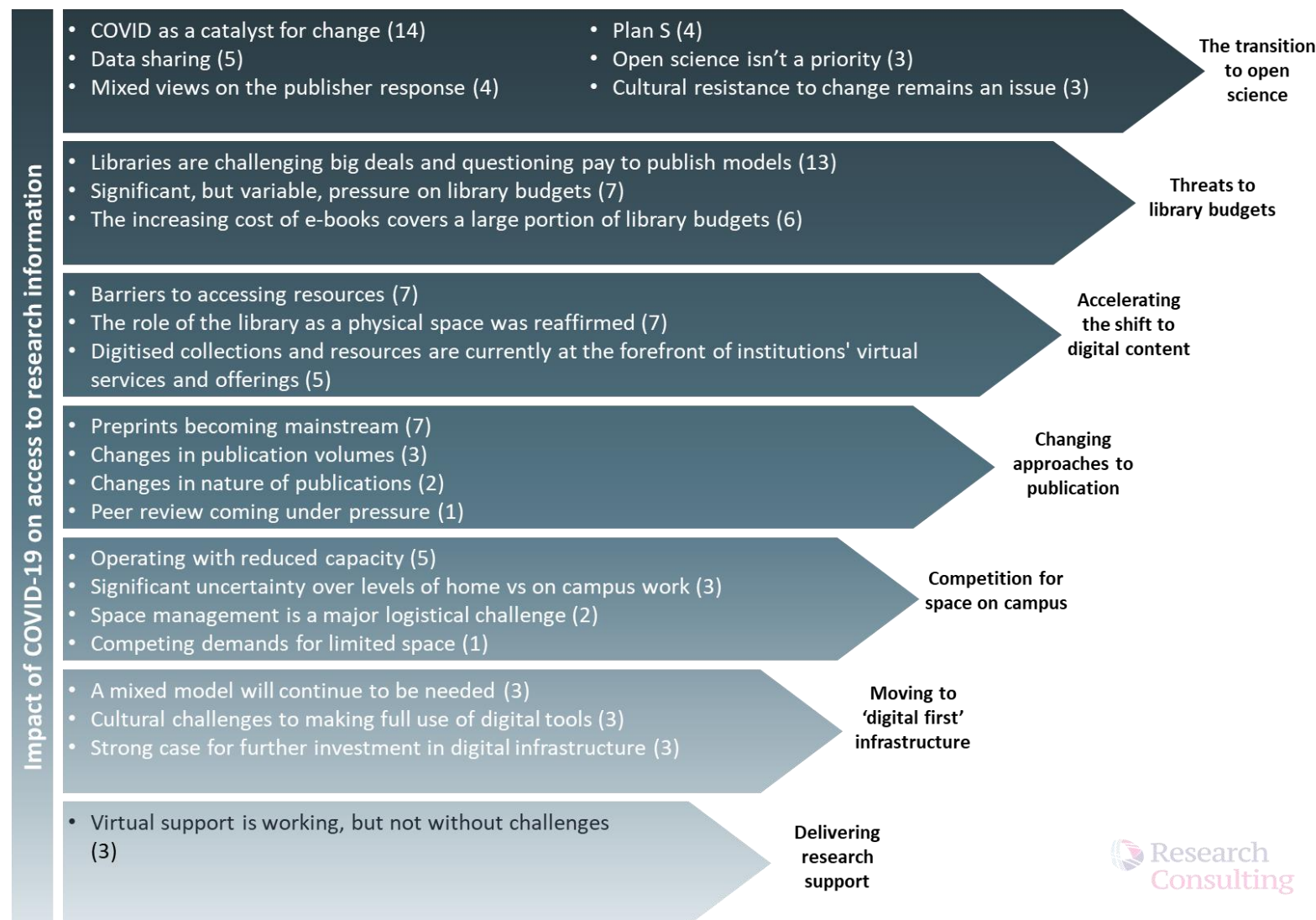
In the UK, where restrictions have been most severe, access to libraries was interrupted for a long time. The University of Aberdeen has gone through four phases, so far: (1) shutting down services rapidly in March; (2) budget planning, working out how to deal with the financial consequences; (3) preparing for the new academic year, trying to ensure physical access; and (4) dealing with a local lockdown in Aberdeen. The library is seeking to guarantee physical access to staff and students in the next academic year, but plans are affected by great uncertainty over lockdowns or other social distancing measures that can be put in place at short notice during the pandemic.

The Library at Imperial College has implemented a traffic light system to manage access by students and researchers. The traffic light system estimates available capacity in real time based on how many people a particular space can accommodate, and the number of entries and exits it records. Library users will be able to see how busy the Library is before deciding to go in. The traffic light system goes hand in hand with a wider piece of work to manage student density on all campuses, and it has been preferred to a booking system which would be more complex to manage.

Emerging from uncertainty

International perspectives on the impact of COVID-19 on university research

Figure 5. Categorical interview comments on the impact of COVID-19 on access to research information.
Length of arrow reflects number of comments.



3.2 The impact on library budgets

Reduced library budgets lead to increasing scrutiny of journal subscriptions

In the medium term, libraries expect face further challenges. The reduction in university income is expected to put downward pressure on library budgets. Recent data shows that the relative cost to UK libraries of journal content vis-à-vis of staff and operations has risen from 43% to 57% over the period 2000/01 to 2018/19.⁵⁰

"All libraries have been asked to make or to model cuts. No one is expecting not to have to make a cut; it remains a matter of the level required. Modelling has ranged from 2-3% up to 40%. At the same time, costs are rising because of the need to provide a fully hybrid service."

Ann Rossiter, Executive Director, SCONUL, UK

Both the literature and the interviews indicated that there are now limited opportunities to cut operational costs, and therefore university libraries will be forced to conduct close examinations of bundled journal subscription packages.⁵¹⁻⁵³ After prominent cases in the United States,⁵⁴⁻⁵⁷ universities in the UK and Australia are expected to review their subscription agreements and COVID-related pressures may accelerate moves to cancel or renegotiate 'big deals' with publishers.

"There is increasing disquiet among librarians about the bundling of subscriptions, which usually have one or two 'needed' journals and many not needed ones."

Anonymous, Australia

Case study: library cost-cutting measures

The librarians consulted all foresee possible cancellation of big deals, albeit institutions being at different stages in their budgeting and cost-cutting processes. The Australian higher education sector was impacted by the severe financial impact of COVID-19 at an early stage and CAUL was able to negotiate with many publishers to halt or reduce price increases significantly for the 2021 subscription year. This has saved the Australian sector millions of dollars in price increase avoidance which will mitigate the financial challenges within universities.

The University of Western Australia anticipates not renewing a significant amount of journal titles for next year due to decreases in revenue (mostly due to international students not being able to enter Australia). To date, it has started to cancel individual subscriptions, rather than big deals. It is hoped that in future some publishers may offer discounts on subscriptions to assist the university.

In the UK, libraries are also considering cancellation of 'big deals', and even those institutional libraries that were making a case for a real-terms uplift in their budget, over and above the subscriptions increases, are now facing the possibility of cuts – albeit applied in a more nuanced way than a standard cut across the board.⁵⁸ Institutions might hold off renewing, in particular when there are large increases in costs, and Library

Australia may move towards the 'pay to publish' model, but financial worries remain

Directors will be making the case to academic leadership. If one institution were to cancel, it might lead to a domino effect of cancellations. Decisions will commonly be taken when institutional budgets have been confirmed, around October or November.

Interviewees from Australia indicated that COVID may provide an opportunity to move to a "pay to publish" model and to "break the control currently held by a small number of publishers". Plan S, a European initiative to make publicly-funded scientific publications open access, is viewed favourably but some felt that it could increase costs for scholarly communication. Central budget allocations to pay for article publication charges (APCs), prevalent in some parts of Europe, are seen as an attractive option given the increased leverage it provides in budget negotiations. But the decentralised nature of library budgets in most Australian universities, where APCs are paid from a wide variety of sources (including departments, individual grants, researcher's professional development funds etc.) reduces bargaining power. Interviewees were also concerned about universities' ability to track APCs across the institution, which is seen as necessary to achieve better value for money.

"There is institutional and academic pressure to move, at speed, to full delivery of both physical and digital teaching resources. This will create pressure on libraries' content budgets."

Ann Rossiter, Executive Director, SCONUL, UK

Library budgets leave little room for manoeuvre

Faced with increasing journal subscription costs, librarians see little scope for budget cuts elsewhere. The monograph content budget is too small to be raided to meet rising subscription costs. On the contrary, in fact, the cost of e-books for teaching is expected to increase and, given the increased importance of teaching for university finances, journal subscription budgets risk being reduced to make space for e-books.

"The move from physical to e-books is potentially very expensive because of the way e-books are currently priced. It will put severe pressure on the library's budget and hence mean much less for other content."

Dr David Prosser, Executive Director, Research Libraries UK, UK

3.3 The impact on scholarly communication

COVID-related content has been made open access

After criticisms from the medical community about the ability to share data and publications during the pandemic, the lifting of paywalls on COVID-related publications has been welcomed by academics worldwide. In January 2020, the Global Preparedness Monitoring Board (GPMB) published a recommendation that 'all relevant information about the [COVID-19] outbreak is shared openly and rapidly'. This was later echoed by

the Wellcome Trust's open letter to scholarly publishers, which called for open access to all coronavirus research findings and underpinning data, many willingly complied.

Pleas from funders and policymakers were heeded by academic publishers, and the International Association of STM Publishers sought to coordinate and broaden these individual efforts to make research accessible through initiatives such as publisher hubs. As a result, scholarly content has been heavily used by doctors, researchers and members of the public. The American Medical Association reported 33 million views of 730 COVID-19-related pieces of content during the pandemic. This surge in traffic has come from social media, while Google (traditionally the biggest driver of traffic) slightly declined over the same time, and more traffic came from mobile devices instead of traditional computers and laptops. The commitment to keep COVID-19 literature open is not open-ended, however. Interviewees wondered whether such openness would be maintained and called for better systems, more interoperability, quicker and most efficient processes.

"If there is not an upside of COVID-19 to scholarly communications, we will have lost the biggest driver that we are ever likely to see in our lifetimes, and probably in many generations. This situation has made the case hugely for open access to research findings, to research data."

Chris Banks, Assistant Provost & Director of Library Services, Imperial College, UK

COVID-19 can be a
'catalyst for change'
towards open access

There is strong consensus that the pandemic can be a catalyst for change to accelerate the transition to open access (OA). International actors including the European Commission, the World Health Organisation and UNESCO have all issued strong calls for greater and more equitable access to research results in recent months.^{59–61} Interviewees from all countries recognised that the pandemic has raised awareness of open science among researchers that were previously unaware or not particularly sympathetic to it.⁶² At the same time, it has highlighted the importance of open research to decision-makers and the broader public.

"One of the positive outcomes we have seen through COVID has been an increased awareness by our senior researchers of the benefits of Open Access publications. This is a trend that we would like to encourage."

Julie Hockey, Deputy Director of Resources and Technical Services, University of South Australia Library, Australia

Open science is expected
to move up the agenda in
the coming months

UK interviewees highlighted that developments in scholarly communication have slowed down in recent months as the pressing challenge of dealing with the crisis has not left much time or energy for it. Similarly, in Australia, the challenge in getting "airtime" for conversations around moves to OA and open science in the current environment has only been magnified under current circumstances, whereby discussions tend to focus on immediate financial impacts and the effect of COVID on research and researchers.

As the dust settles, the expectation is that funders and open science advocates will use the pandemic as “the poster boy for open science”, providing new impetus towards change. This can in turn hasten the shift to open access in Europe and the UK. The European Commission, traditionally a strong proponent of open access and open data, notes that the achievement of a “Shared Research Knowledge System” by 2030 should build on the collaborative efforts to tackle COVID-19 and considers these as “testament to the innovative power of opening up science, sharing knowledge and collaborating.”⁶³ In Australia, the crisis is expected to place the issue on the national agenda.

“The pandemic might provide a possibility for more stimulus for Open Research, but developments have been slowed down because we have not got the time to think about it.”

Simon Bains, Head of Library Services, University of Aberdeen, UK

Preprints elevated the relevance and influence of science during the pandemic

The COVID-19 pandemic has created a new urgency to openly and rapidly share and review COVID-19 research, reflected in the launch of a cross-publisher rapid review and review transfer initiative.⁶⁴ The desire for faster publication also underpinned the use of preprints – scientific manuscripts that are publicly available in advance of formal peer review and publication⁶⁵ as a source of information and evidence throughout the pandemic. The emphasis on relevance and immediacy calls into question the importance of the location of the content and the so-called “prestige economy” of academic journals⁶⁶ and chimes with researchers frustrated with long peer review times.

“There has also been some progress in demonstrating that research can be debated and influence policy in real time, not determined by the location of the content.”

Dr Steven Hill, Director of Research, Research England, UK

Quality assurance matters, but peer reviewers are likely to be increasingly hard to come by

At the same time, observers noted that rapid publication and the use of preprints magnify the risks of putting out low-quality and potentially misleading information, which can spread fast and cause significant harm particularly when it concerns human health.⁶⁷ A few cases of article retractions, including a high-profile retraction on a study on Hydroxychloroquine, highlighted the importance of a strong peer-review process with access to a study’s underlining data as well as the manuscript.⁶⁸ But with increased competition for scarcer research funding and an additional teaching burden for permanent staff, interviewees cautioned that the ‘free labour’ researchers put into peer review could be at risk. With the global peer review system already creaking before the pandemic,⁶⁹ the goal of more rapid, quality-assured research may prove ever more challenging to deliver in practice.

3.4 Moving to ‘digital first’ infrastructure

Investment in online learning could squeeze spending on research

Amidst budget cuts driven by the COVID-19 pandemic, universities have had to make a range of immediate investments in digital infrastructure. These include, not only the purchase of items such as laptops and the increase in cloud computing capacity, but also tools for online teaching, which were already in place but were often not used on a regular basis. The European University Association (EUA) highlighted that, as learning and teaching adjust to digital delivery, “additional funds will be necessary for developing digitally enhanced learning and virtual mobility”.⁷⁰ While researchers will benefit from some of these investments, there is concern that IT investment will be focussed on student-facing services, to the detriment of investments in digital research infrastructure, such as high-performance computing and petabyte-scale data storage.

“Universities are starting to realise the gaps in their digital infrastructure, perhaps more so initially in the teaching areas. How much this has started to take hold in research is an interesting question. Are we now thinking enough about ‘digital-first’ infrastructure?”

Dr Steven Hill, Director of Research, Research England, UK

COVID strengthens the case for research infrastructure

The infrastructure that enables research data management (RDM) and sharing is increasing in importance as more researchers have to work from home and need to collaborate digitally: “people are demanding access to data, and do not want to wait”, said one interviewee. This points to broader concerns, such as the fact that research data management provision tends to be extremely diverse across universities and national boundaries and the limited coordination and join-up between service providers operating in this space. Finally, other issues around enabling and implementing privacy and personal data protection are key when it comes to transferring sensitive information across devices and beyond the physical walls of universities.

“The pandemic has revealed the damaging effects of years of chronic under investment in science infrastructure, both human and physical.”

Dr Ray Kent, Director of Research Administration, The Royal Veterinary College, UK⁷¹

The European Life Science Data Infrastructure (ELIXIR)

The European Life Science Data Infrastructure (ELIXIR), a membership organisation which brings together life science resources from across Europe, ramped up its operations during the pandemic. The goal of ELIXIR is to coordinate these resources, including databases, software tools, training materials, cloud storage and supercomputers, so that they form a single infrastructure. With a coordinating Hub located at the European Bioinformatics Institute, EMBL-EBI, on the Wellcome Genome Campus in the UK, this infrastructure is accessible across Europe and makes it easier for scientists to find and share data, exchange expertise, and agree on best practices.

ELIXIR’s priority during the pandemic has been to drive open and rapid access to data, tools and workflows for the European COVID-19 response and research. They have achieved this through alignment of national infrastructures, European research infrastructures and Horizon 2020 projects, and by bringing together national health

informatics infrastructures across Europe. This interconnected ecosystem will allow data from ongoing European projects as well as the many re-focussed national research programmes to be widely shared and reused.

A rapid response was made possible by opening data resources and supporting the annotation, deposition and access of data⁷² on coronavirus and its health implications. Open standards and open source, reproducible workflows and tools were critical for connecting researchers, data resources and facilities. By rooting this response in existing national and European infrastructures the strategy contributes to the development of a European data platform for health-related information exchange. ELIXIR actively supports collaborative efforts inspired by the COVID-19 response to create opportunities to link data and resources and help channel community efforts into long-term sustainable infrastructures.

The need for a coordinated research information infrastructure

Gaps in the digital infrastructure do not only concern universities. Interviewees stressed that the various service providers of digital research services need to be better integrated with one another and institutions need to develop a scholarly communications service that is agnostic to the service providers. The UK Government's Research and Development Roadmap, published in July 2020, has highlighted the importance of science and innovation to tackle the pandemic and has stated the government's intention to develop a long-term investment plan to support the growth of the national research infrastructure, as well as developing digital research infrastructure capability.⁷³ In Australia, many services that are part of the national research infrastructure (such as the National Imaging Facility and the Population Health Research Network) have been heavily relied upon to support COVID-related research during the pandemic.⁷⁴ This has further demonstrated the importance of investing in research infrastructure, which the Australian Government has committed to support with AUS\$2 bn (£1.1bn) over 12 years in line with recommendations of the 2016 National Research Infrastructure Roadmap.⁷⁵ Across Europe, the case of ELIXIR has shown the important role an interconnected research infrastructure can play to support research during the pandemic. Similarly, the European Commission has also created a European Data Portal to facilitate COVID-related information exchange and support research responses to the pandemic. The UK is heavily involved in both initiatives, demonstrating the importance of international collaborations in developing shared research infrastructures.

"The pandemic has shown where research information providers, whether within an institution or on a wider basis, are joined up and where there are gaps. We need to develop a scholarly communications service that is agnostic to the service providers. Is the infrastructure ready for that?"

Simon Bains, University Librarian & Head of Library Services, University of Aberdeen, UK

The European COVID-19 Data Portal

The European COVID-19 Data Portal, launched as part of the wider European COVID-19 Data Platform, brought together and continuously updates the relevant COVID-19 datasets and tools, such as the European Nucleotide Archive (ENA), European Genome-Phenome Archive (EGA), UniProt, Protein Data Bank in Europe (PDBe), the Electron

Microscopy Data Bank (EMDB), Expression Atlas, ChEMBL, or Europe PMC. The Wellcome-funded EMBL-EBI is also one of the main partners of this initiative. The portal will persist beyond the immediate COVID-19 outbreak, ensuring that scientists can access up-to-date research data on the virus and disease. It is envisaged as a one-stop shop for all COVID-19 related data and builds the basis for future European health data spaces and research data exploitation.

In order to facilitate this European-wide approach in a timely fashion, the EC has provided additional funding resources to existing EC-funded grants as extra funded Work Packages. So, the COVID19 Data portal has been built on previous EC grant-funded projects, and European countries are expected to build national instances of the portal and unite them in a federated system. This coordination will continue to allow access to national data in collaborative projects for future international responses.

Key takeaways: access to research information

Open scholarly communication requires investment and innovation

COVID-19 has exposed longstanding fault lines in the current system of scholarly communication. While the balance appears to have shifted decisively in favour of open science, tensions between rapid publication and robust quality assurance remain. Strategic thinking is needed to tackle a legacy of investment in digital infrastructure, redefine the roles of commercial and community actors, develop sustainable business models, and embed open science as the 'new normal' for research.

Securing the future of research production

The pandemic has given libraries and publishers an opportunity to find common ground on the future of scholarly communication. Three areas stand out:

- 1) **Transition from subscriptions to pay-to-publish:** as libraries reassess the budget implications of their subscription agreements, publishers and librarians face new urgency to find sustainable models that guarantees open access to scholarly communication without compromising the quality of publications.
- 2) **Strengthen the open science infrastructure:** the pandemic has focused the minds of researchers and the public on the importance of free access to scientific publication and data. This also requires investments in a strong research information infrastructure that facilitates the free flow of open data, text and media among researchers and with society at large.
- 3) **Provide timely access to scholarly outputs:** the pandemic has created a strong appetite from researchers and the broader public for immediate open access to publications; alongside this there is a need to look at innovative ways of making the peer-review process more efficient and to facilitate the use of preprints for more timely communication and greater impact.

Moving through the phases

The pandemic will create a new momentum towards open access. Publishers, funders and universities should proactively take action to shape a more open, transparent and sustainable research information infrastructure in a post-COVID world.

Figure 6. A sustainable model for open science



4. The impact of COVID-19 on research funding

The long-term impact of COVID-19 on research funding is unclear, but there are worrying signs:

- Research funding has been rapidly mobilised to tackle the crisis, but funder and government support schemes have proven difficult to access.
- Multiple funding streams are under pressure simultaneously and institutions have little forward visibility on which to plan.
- While governments in the UK and Australia have reaffirmed their commitment to invest in research and innovation, their commitment to universities is less certain.

The pandemic is expected to change research priorities, driving a move from basic to applied research focussed on economic recovery. But longstanding concerns over institutional and systemic sustainability are coming to the fore, with the risk of a permanent loss of research capacity.

4. The impact of COVID-19 on funding

4.1 Research funding to address the pandemic

Research funding has been mobilised to tackle the crisis

The research system has mobilised itself quickly to respond to the challenges of the pandemic. This included researchers and research groups, institutions and funders. Specifically, with respect to research funders, one of our UK interviewees characterised the situation in the following way:

- In the first wave (mobilisation), funders prioritised supporting research activities directly related to the disease, such as medical research.
- In the second wave (stabilisation), funders are focusing on activities related to the effects of the pandemic on the economy or on society, such as the delivery of care.
- In the third wave (strategising), funders have begun considering the impact of the pandemic on science, science funding and the broader research landscape.

These phases are not independent of each other and overlap in terms of timing; all three are on-going. Researchers and their institutions are seeking to engage with each of these strands, as appropriate to their areas of expertise. For example, one Australian interviewee reported that there has been an increase in Requests for Tender in areas such as mental health, family violence and child safety, while a UK institution has seen increased demand for apprenticeships.

Processes have been streamlined, but the need for administrative reform is clear

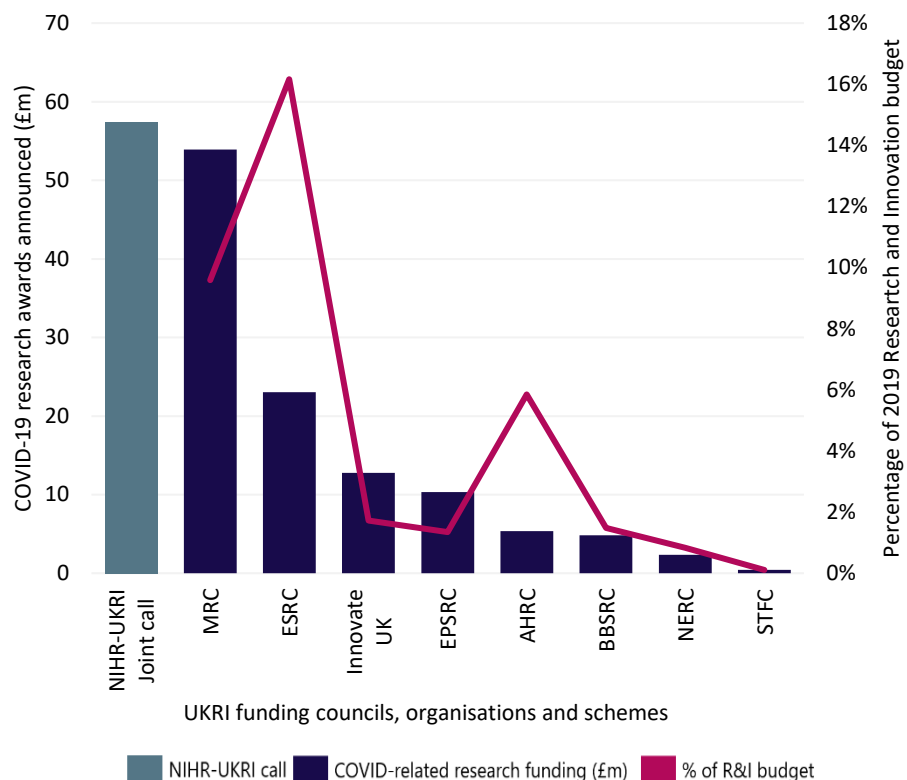
Funders, meanwhile, have also been modifying their processes in order to reduce the timescale of application to award and hence to research activity taking place. This has included reduced documentary requirements and rapid peer review. It has not all been plain sailing, but the community has responded. Whilst the changes have been welcomed, many researchers believe that the pandemic has exposed a lack of agility and responsiveness in the research funding system. These concerns predate the pandemic – a survey of UK Directors of Research in early 2020 found that the growing compliance and regulatory burden topped their list of concerns – but now seem to be finding a more sympathetic ear in government circles.⁷⁶

“Funders have responded rapidly, adjusting their strategies and processes, and funding more interdisciplinary research. However, everyone (in the system) is working very hard in creating this more responsive system, so it is not sustainable.”

Professor James Wilsdon, Director, Research on Research Institute and Digital Science
Professor of Research Policy, University of Sheffield, UK

Figure 7. UK funding for COVID-19 research

COVID-specific research awards funded, or part funded by UKRI and announced between February and September 2020.



Case study: UK funding for COVID-19 research

Responding to the COVID-19 crisis, UK Research and Innovation (UKRI), the umbrella organisation for research in the UK, released a series of calls seeking and awarding funding for research into COVID-19. Since February 2020 UKRI has announced £170m (AU\$305m) for new COVID-19 specific research awards (current up to 28th September 2020), supporting over 330 individual research projects. These are listed on a dedicated UKRI webpage⁷⁷ which allows the wider community to see and understand the nature of work UKRI has supported. The site also offers visualisation by research theme or key words to further enable the rapid communication of UKRI-supported work.

In addition to funding from the UKRI constituent organisations, principally via the Medical Research Council (MRC) and Economic and Social Research Council (ESRC), a joint call between UKRI and the National Institute for Health Research (NIHR)⁷⁸ has to date supported 55 projects totalling £57m (AU \$102.6m) in research awards as part of the wider investment being made by NIHR in support of COVID-19 research in clinical settings. The joint NIHR-UKRI call responded very quickly to the need for research into the pandemic, funding rounds in February and March 2020 awarded £24.6m (AU\$44.3m) into 27 research projects.

The breakdown of COVID-19 research awards is shown on the X axis in Figure 7. As an indicator of how significant the COVID-19 funding is to that funding organisation, the secondary Y-axis (right) plots the % of COVID-19 awards against the budget for that organisation's research and innovation spend (as set out in the UKRI 2019 Delivery Plan, using the Research and Innovation budget for 2019-20⁷⁹).

The chart reveals the importance and scale of funding for social sciences research into COVID-19 issues, and at 16% of their research and innovation budget, the ESRC's awards for COVID-19 are the highest proportion observed.

Some aspects of research activity continue

Although research activity has been severely affected, as outlined in section 2, some aspects have continued or even increased. Universities in both Australia and the UK report increases in the number and value of applications over the period and a suggestion that researchers were "finding things to do to occupy their time". However, the flow of awards has been affected, suggesting that funders are struggling to cope with the volume. Furthermore, with little or no new money on offer, the increased competition for funding could see grant success rates fall to historically low levels in the coming months and years.

"There have been the first signs of reduction in new research grant awards, accompanied by a huge increase in new applications, but it is too early to tell how this will settle out. I expect effects to be felt over the next five years."

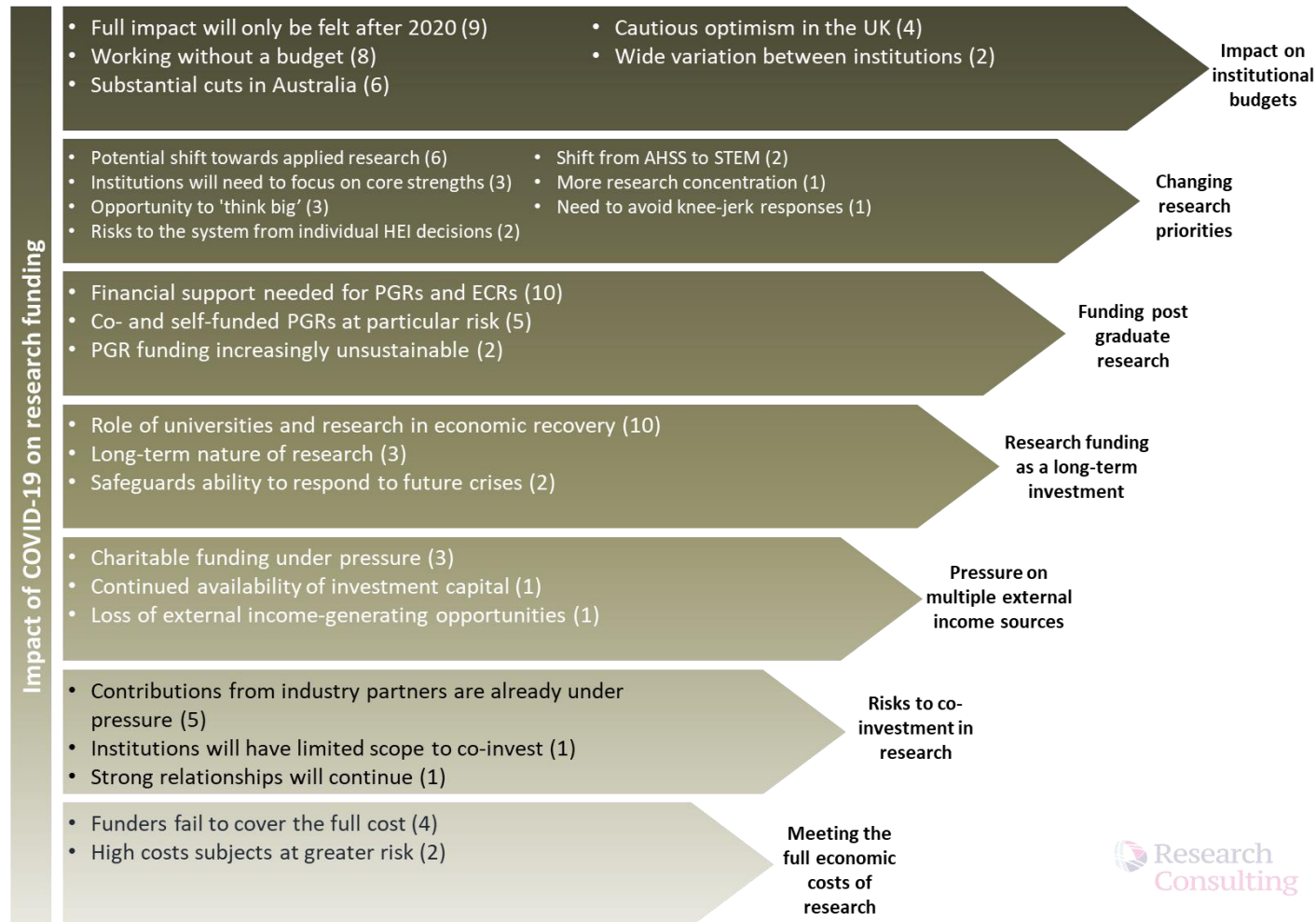
Professor Steve Rothberg, Pro Vice-Chancellor (Research), Loughborough University, UK

Emerging from uncertainty

International perspectives on the impact of COVID-19 on university research

Figure 8. Categorised interview comments on the impact of COVID-19 on research funding.

Length of arrow reflects number of comments.



4.2 Funding to support research capacity

Government support for research capacity

There have been widespread concerns about the long-term effects on research capacity, which were echoed by our interviewees. The UK government announced a mix of grants and loans for universities⁸⁰ and support for businesses.^{81–83} These have started to be made available, although not without their challenges, as one interviewee observed: “The UKRI scheme for extending grants is horrendously complex. The lack of flexibility makes it feel like we’re not in a trusted relationship.” The loan scheme for universities, full details of which are yet to be published, is specifically targeted to help meet shortfalls caused by a drop in international student fees, i.e. the root of many universities’ concerns.

For Australia, the COVID-19 situation comes at a time when there are already significant concerns over longer-term university funding, for teaching and consequential impacts on research funding.⁸⁴ Universities Australia²² suggests a potential deficit in 2020 of upwards of AU\$3 bn (£1.7 bn) and continuing for several years, and has called for immediate intervention. Yet there appears to be little recognition of the need for government support for universities. There are reports that the Australian Government will bring forward \$700m from future planned higher education revenues to boost research spending in 2021/2022, while observers expect that the new bill for higher education funding might cut \$2 bn a year from future university research budgets.

“Many European systems have a large proportion of their funding from public sources. This can lead to short-term additional funding, as we saw after the financial crisis, but the potential for that stimulus to disappear after a couple of years can itself be damaging.”

Thomas Estermann, Director, Governance, Funding and Public Policy Development,
European Universities Association

Effects on research funders vary by sector and source of income

Funding for research at universities comes from a range of sources: governmental, business and charitable, from both within the country and from outside it. Each sector has been affected by the pandemic, and hence their ability to continue to fund at the previous levels has been affected.

Public, governmental sources have tended to hold up, but the picture for other sectors has been mixed. Charities that depend on donations and commercial activities have seen significant downturns in their income, and hence in their ability to fund research, with the UK Association of Medical Research Charities forecasting a 41% decrease in medical research spend over the next year.⁸⁵ As one interviewee put it, “charities have been very hard hit”, though those that fund research from investment income, such as the Wellcome Trust, seem to be better placed.

Similarly for businesses, those sectors supporting the actions against the pandemic or focussed on the digital economy continue to commission research and development, whereas those affected by the lockdowns, such as travel and tourism, have had to constrain their research funding.

Effects on business collaboration and on investment capital

This is having effects on collaborative projects in both Australia and the UK, where multiple interviewees reported cases of business partners terminating projects or being unable to make cash or in-kind contributions, at least for the short term. Even where collaboration is able to continue, the prospects of widening or deepening it are not always positive, with doubts about the capacity of businesses to engage fully.

The picture on investment capital is equally mixed, with some UK reports of it still being available, whilst some Australian interviewees indicated that venture capital for research commercialisation is drying up.

"Investment capital is still available, helped by stimulus from the British Business Bank, but the skills needed to manage these funds are specialist in nature."

Dr Sean Fielding, Director of Innovation, Impact and Business, University of Exeter and Chair of PraxisAuril, UK

4.3 Planning for uncertainty

Stability will take years to come

Universities remain very much in a mobilisation phase, seeking ways to protect and support their researchers and their research capacity. The full impact of events of 2020 has not yet been felt, and institutions are working with interim or emergency operational budgets. Our interviewees, wherever they were located, did not expect to reach a position of stability for some time to come: "Some within the sector anticipate three to five years of disruption."

As discussed above, the drop in international student enrolment will have the most significant effect on university budgets. Early estimates suggested UK institutions could lose **£2.5 bn (AU\$4.4 bn)** in tuition fees and teaching grant income in the 2020/21 academic year alone, putting 30,000 jobs at risk.⁸⁶ Australian universities, meanwhile, face revenue losses of **AU\$3.1 bn to AU\$4.8 bn (£1.75 to £2.7 bn)** in 2020, threatening **21,000 full-time equivalent jobs**.⁸⁷ These losses appear similar in absolute terms, though the methodologies used in reaching these estimates are not directly comparable. However, the Australian system is less than half the size of the UK's, with **43** universities generating just over AU\$30 bn (£17 bn) in annual revenues, compared with over **160** UK institutions with aggregate revenues of £40 bn (AU\$72 bn). Both systems face a major financial shock, but for Australian higher education it risks becoming an existential crisis.

"The loss of international students is a huge threat to university research at the present time."

Professor Dame Nancy Rothwell, Vice Chancellor, The University of Manchester, UK⁸⁸

Uncertainty rules for universities

Whilst most attention within institutions is on what needs to be done now, consideration is starting to be given to the longer term. However, the situation varies between countries and the level of uncertainty makes planning difficult. At the time of our work, there was cautious optimism amongst some UK institutions that the worst-case scenarios for student recruitment may not come to pass. Many Australian institutions, by contrast, were fully expecting double digit falls in income, and saw little alternative but to downsize substantially. Interviewees in both countries, however, recognised the risk of knee-jerk reactions to a still-unfolding situation, with one UK interviewee noting that we are “nearer the beginning than the end”, and hence “we need to work our way through it”.

“Planning for the future is almost impossible in this state of events as financial modelling changes almost daily. In terms of strategy, there is simply nowhere to go.”

Professor Kate McGrath, Deputy Vice-Chancellor for Research, University of Technology Sydney, Australia

Case study: The University of Exeter

The University of Exeter has been very active during the pandemic, trying to minimise adverse effects on student staff as well as investing its own resources to support COVID-related projects. Internally, the university put in place several measures to support research during the pandemic. Since the beginning of the crisis, the University used dedicated COVID communications channel to communicate urgent messages to staff and students,⁸⁹ and improved web resources for research, such as a new page to its Research Toolkit dedicated to research and funding information.

To support research, the University established grant schemes and funds directed at staff and students. For example, the COVID-19 Response Small Grant Scheme⁹⁰ offered up to £5,000 (AU\$9,000) to assist students and staff for research projects that proposed creative and innovative educational interventions to mitigate differential educational experiences as a result of the pandemic and school closures.

The Emergency Assistance Fund⁹¹ provided financial support to students stranded away from home or facing particular hardship. Exeter has also supported businesses to deliver innovative solutions to address challenges raised by the coronavirus pandemic and manage the demand for PPE and other materials.⁹² And the recent Emergency Appeal raised funds to trial coronavirus antibody tests.⁹³

4.4 Longer-term views on research funding

Research as an investment

The ability of governments to fund research and development (R&D) at the same or higher levels than prior to the pandemic will depend on economic affordability and political desire: “System-level choices relate to both policy and to economic capacity.” As covered in the section below on national commitments to R&D, this differs between countries. What does seem to be common is that the argument that investment in

research also creates an economic benefit is shifting to one of investment because it creates an economic return.

An investment model for research appeals to industry,⁹⁴ but within academia it leads to fears about a shift towards more applied research with nearer-term socio-economic impact. Whether that would also mean STEM subjects would be favoured over Arts, Humanities and Social Sciences is a related concern of some. Neither is necessarily the case, as only the narrow-minded would invest solely for the short-term or not consider the cultural and behavioural aspects of modern society as well as of technology.

“There could well be restructuring of the economy. Whilst this could have effects on the funding of research (e.g. the balance between basic, applied, innovation, etc.), there is also scope for opportunities for research.”

Dr Steven Hill, Director of Research, Research England, UK

Levels of commitment to R&D - UK

The UK government has expressed a commitment to R&D, at both the budget in March 2020 and in the publication of its Research and Development Roadmap⁷³ at the beginning of July 2020. This is a direction of travel that pre-dates the pandemic, and builds on the previous government's Industrial Strategy.⁹⁵ The budget commitment is to an increase in public funding for R&D from £9 bn p.a. (AU\$16 bn) to £22 bn (AU\$39.3 bn) p.a. by 2024/25, hoping to stimulate an overall spend on R&D of 2.4% of GDP.⁹⁵

In the context of the pandemic, R&D is seen as a significant plank in the country's economic recovery. It is also part of the government's desire to 'level up' disadvantaged areas of the UK. Whilst the economic and fiscal situation may make this budget commitment challenging, the nature of the desired outcomes will also mean universities and researchers will need to think differently.

“The national picture is being shaped by the question, ‘What is research for?’ ... It is not enough to have an effect on the regional economy simply by existing. It needs the combination of research and innovation and education and engagement, and so on, to create a platform for regional success.”

Dr Sean Fielding, Director of Innovation, Impact and Business, University of Exeter and Chair of PraxisAuril, UK

The UK has a Roadmap, but the role of universities remains unclear

Notwithstanding this positive commitment, with details not yet complete, there remains some scepticism, including that the government has a contradictory stance with respect to universities: “Scaling up R&D without universities is crazy, given the concentration of UK publicly-funded research being in universities.” Other interviewees noted that the use of the additional funding “will require careful thought about how the R&D base works or might work.”

“There is a degree of scepticism among researchers about how the R&D budget might be spent. There’s a public and policy commitment by the UK government to increased investment in ‘science’, and now we have an R&D Roadmap, but there are still many details to be filled in.”

Professor James Wilsdon, Director, Research on Research Institute and Digital Science
Professor of Research Policy, University of Sheffield, UK

Case study: the UK
Aerospace Technology
Institute – increasing grant
rates for SMEs undertaking
industrial research

The UK’s Aerospace Technology Institute (ATI) was established in 2013 and is a £3.9bn (AU\$7m) joint government-industry programme, supported by nearly £2bn (AU\$3.6bn) in public funds. It aims to sustain and grow the sector through targeted investments in industry-led R&D projects. The ATI Programme has generated an extensive portfolio of cutting-edge collaborative R&D projects, partners include SMEs, large companies, research centres and academia.

In response to COVID-19 the ATI announced on 28th September increases to grant funding rates for businesses participating in industrial research projects. For SMEs and medium-sized businesses the grant funding rates will go up (from 50%) to 70% and 60% respectively, the maximum allowed under State Aid regulations for Industrial Research. The new rates will apply for at least one year, but may be extended by the ATI following review.

These changes recognised the difficulties facing the sector indicated the desire of the ATI to provide additional support so that vital R&D work continues. These rates will be available for one year and will cover the life of the projects who successfully apply during this period. Following a review, we may extend the period these rates are available for an additional year.

Levels of commitment to
R&D - Europe

Europe has also seen support for its research base, with variations across its countries. Again, there are concerns at a country level about core research funding mechanisms, as illustrated by the case study on Denmark below.

For the EU, the negotiations for its next Multiannual Financial Framework (2021-2027) continue.⁹⁶ That Framework includes the bloc’s primary research funding mechanism, Horizon Europe, the budget for which is currently proposed by the European Council (i.e. the member states) to be about €85 bn. This would be a small increase from the original figure of the previous seven-year programme, albeit that it would now be shared between 27 rather than 28 countries, given the exit of the UK, one of the largest recipients under Horizon 2020. Alongside this, the EU is planning a much larger recovery package, significant elements of which will be amenable to research and innovation.

“The EU’s recovery package (€750 bn) includes digital and green objectives. However, it can’t be assumed that national plans will include large sums specifically dedicated for

universities. They will need to deliver economic growth and recovery, often with or through others, rather than expect to be funded directly.”

Thomas Estermann, Director, Governance, Funding and Public Policy Development,
European Universities Association

Case study: Danish government funding for research

The Danish Government's budget for R&D is set at 1% of gross domestic product (GDP). This means that, if GDP drops by 10%, it will mean a consequent reduction in the absolute budget for R&D, which at the present time creates significant uncertainty for universities. In addition, the 1% includes funding won from EU programmes, rather than the latter being in addition to national funding. The drop in the absolute budget if the government sticks to the 1% (as observers believe it will) is currently estimated at around 700 m Kroner (£86.5 m, AU\$154.5 m). The government has suggested an increase in research investment in green transition (climate, sustainability) at the same rate in the form of a strategic research programme. The expectation is therefore that research funding will become more targeted and top-down. However, as John Westensee, Deputy University Director, Aarhus University, observes: "The money is not there yet – government has just started the budget negotiation in Parliament and anything can happen."

Levels of commitment to R&D - Australia

The picture in Australia seems to be somewhat different. The Australian Government announced that it will add AUS\$1 bn (£553 m) in new funding to support university research next year, which will help deal with the immediate disruption caused by COVID-19. However, a long-term financial support package will be needed to help universities survive the consequences of the pandemic, which is forecasted to cost universities up to AUS\$7.6 bn (£4.2bn) in the next 5 five years, and over 6,000 job losses among researchers.⁹⁷

Interviewees noted two reviews of Australia's research base: one on the sustainability of its research funding; and one on measures to encourage engagement with national priorities. Both topics are common to other countries and may lead to an acceleration of engagement and impact measures being included in Australia's university research block grant funding formulae, as well as full economic costing being under discussion (again).

Governments globally are making choices about the importance of R&D

This study has focused on Australia and the UK and touched on Europe. Whilst these show some contrasts, a broader international view further illustrates the differing choices being taken by governments around investment in R&D.

The South African Government announced significant budget cuts in July 2020, for example. The 2020/21 budget for the Department of Science and Innovation has been cut by 16%, net of funds reprioritised towards COVID-19 research. Initial reports suggested that this would equate to a reduction in PhD grants by a third and project grants by a quarter. In contrast, Singapore plans on a five-year framework, so budgets for science and technology were already locked in when the pandemic unfolded, and universities have been an integral part of the pandemic response.

"Singapore's response to COVID is unique and stems from its learning from SARS. Singapore has increased its R&D investment during the pandemic, leveraging the collaboration between universities, government agencies, hospitals and industry in its response."

Professor Andy HOR and Professor Huck Hui NG, Agency for Science and Technology Research (A*STAR), Singapore

4.5 Research system sustainability

Sustainability is key

The pandemic has brought to the fore the frailties of research funding, and in particular that a significant proportion of the costs of research are met from income from international student fees in both Australia and the UK. Research activity, not to mention the scholarly communication system, also benefits from 'donated' staff time, reflecting both the pressures on and the motivations of researchers.

Addressing this involves improving the resilience of research and innovation activity in universities, including how it is funded: "This might involve decoupling the financial models for education and research whilst retaining the academic coupling across the activities."

"A particular UK concern is that of the cross-subsidy from non-publicly funded teaching to research, and the dependency by some on charitable funding sources. There is now a better understanding of the cost and vulnerability of the research system."

Dr Steven Hill, Director of Research, Research England, UK

Sustainability requires co-ordination

Sustainability will only come about with the combination of cross-stakeholder commitment, aligned priorities, adequate funding mechanisms, and cost management. Sustainability of research also needs to be seen in the context of the sustainability of teaching and of the institution as a whole. High cost subjects may be more at risk, because of their higher cost and hence higher deficit if the cross-subsidy disappears. This would be contrary to a perception of the importance of those same higher cost STEM subjects. If many institutions were to decide that a particular disciplinary area is no longer viable, each decision can be seen to be valid, but the cumulative effect could be significant and negative.

UK sustainability

The deficit on UK university research activity has been reported consistently since the introduction of the TRAC (Transparent Approach to Costing) reporting requirement in the late 1990's. Despite costing and pricing requirements, and additional funding, the deficit has not improved, being £4,451 m (AU\$7,900 m) in 2018/19.⁹⁸

“The deficit on research activity has not been improving, exacerbated by the successful increase in charity funding, more match-funding expectations, and institutional and sector over-trading. I particularly wonder how to make PGR activity sustainable.”

Dr Steven Hill, Director of Research, Research England, UK

As noted by Steven Hill, PGR activity is particularly challenging, with recent estimates suggesting it covers less than 50% of its costs. There also needs to be more thought about the value of PGR students who are later in their careers, in terms of returns to the individual, their employer and the taxpayer.

Australian sustainability

As already noted, Universities Australia has called for immediate government action to make university research sustainable, pointing out that they are responsible for 90% of the fundamental research undertaken in Australia and 43% of the nation's applied research. The Federal Government's recent announcement that it will inject AU\$1 billion in research funding for universities represents a welcome reprieve for Australian research. But much bigger losses are expected in the years to come, and long-term support will be needed to maintain the competitiveness of the research system.

“The reduction in revenue from international education will have a serious flow-on effect to the capacity of Australia's universities to conduct research and development on behalf of the nation.”

2020-21 Pre-Budget Submission, Universities Australia²²

Maintaining global competitiveness

This study provides emerging evidence that the impacts of COVID-19 on national research ecosystems are not going to be even. This will have long-term implications for the competitiveness of national research systems. Just as a severe economic shock can lead to a 'scarring' of the economy, damage to the research system in the short-term also risks a permanent loss of capacity. There is evidence from past economic crises that strengthening tertiary education systems can boost the future productive potential, and competitiveness, of the economy, as well as lowering unemployment.⁹⁹ In the modern knowledge economy, the strengthening of universities must include investment in research as well as teaching if nation's are to preserve and enhance their global competitiveness.

Key takeaways: securing research funding

Public funding for research must support the transition to an innovation-based economy

Researchers and institutions are faced with a range of fundamental uncertainties that are inimical to strategic thinking, long-term planning, and, most importantly, excellent research. These challenges are global, but are particularly acute in those university systems, like the UK and Australia, where the sustainability of research relies on international student fees. This will place national research systems at risk of competitive disadvantage.

Securing the future of research production

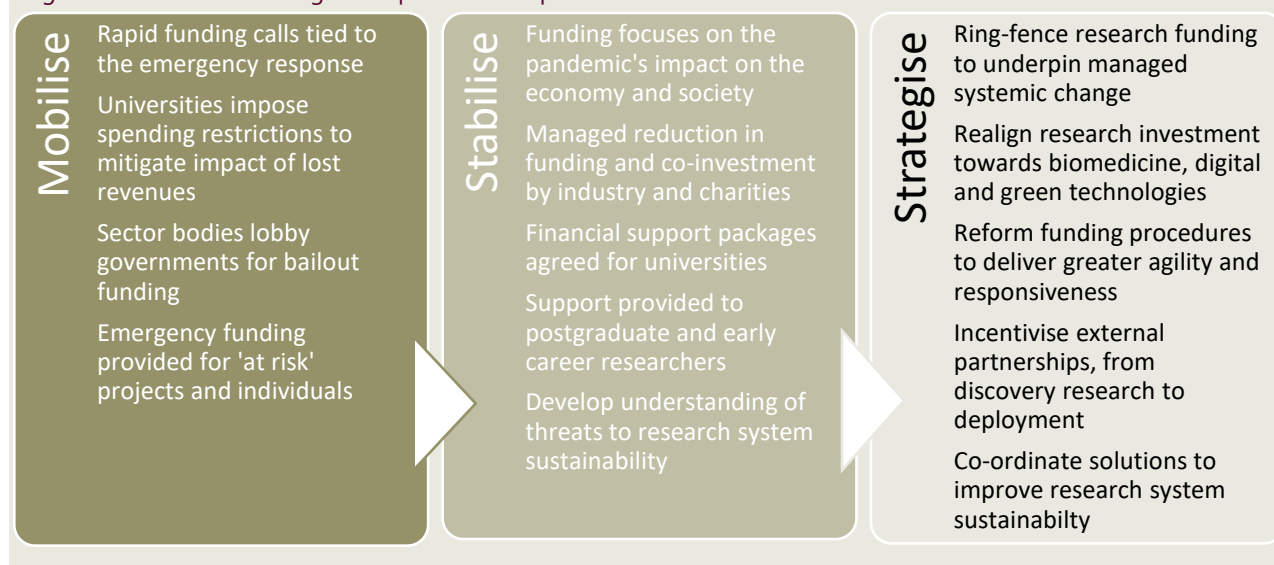
Governments, research funders and universities can mitigate the pandemic's damage, and maintain national competitive advantage, by taking proactive measures to secure the financial sustainability of the research enterprise. Three areas stand out:

- 1) **Secure research funding for the future:** as in other sectors, public funders need to step in to support research through this critical time. This support will need to continue over the coming years, as the full financial impact of the crisis unfolds.
- 2) **Manage the shift to applied research:** if funders want research funding to prioritise applied projects in area of national interest, changes should be part of a holistic strategy that acknowledges the role of blue-sky research projects and trains a new generation of researchers in understanding and driving societal impact.
- 3) **Improve the sustainability of the research system:** the dependency of university budgets on student fees is unsustainable. Universities and funders need to critically review the funding mechanisms for research to find a sustainable model.

Moving through the phases

COVID has undermined the financial stability of research. Whilst the brunt of the impact will only be felt over the coming years, funders and universities can and should start to address some of the structural weaknesses of the system before the crisis worsens.

Figure 9. The role of funding in the pandemic response



5. Conclusions

Universities mobilised rapidly to safeguard people and research in the early phase of the pandemic. Attention is now turning to stabilisation, but continuing uncertainty makes the development of long-term strategy challenging.

The demands on individuals and the strain on research institutions are rising, but they are not evenly spread. There will be winners and losers from the pandemic, and agile leadership will be required to best position institutions for the 'new normal'.

The risk is that national research capacities will be irrevocably damaged if support is not provided during a transitional period that will last many years. Scientific research offers the best hope for society to emerge from the pandemic. It must not become collateral damage along the way.

5. Conclusions

5.1 From stabilisation to strategy

Universities mobilised rapidly to safeguard people and research

Governments, funders and universities are slowly moving through the three stages of their response to the pandemic. The initial *mobilisation* saw emergency responses close campus facilities, move to online teaching, require immediate staff relocation to working from home. As this progressed universities adopted many prosocial actions supporting the efforts of government, healthcare systems and communities to mitigate the impacts of COVID-19. The protection of research staff was a priority consistently observed, with universities and funders implementing measures focused on those with fixed-term studies and projects. Rapidly developed support measures by research funders addressed short-term project and institutional financial instabilities, and at the same time funders launched calls for research into COVID-19.

Efforts are now underway to stabilise the system

All actors are currently in a *stabilisation* phase and are seeking to address the financial and operational challenges of continuing research and their wider teaching operations. But important differences remain. In the UK, as the first wave of the pandemic subsided over the summer, all actors started to prepare for the 'new normal' of the new academic year. By contrast, in Australia the coronavirus emerged at the start of the academic year, leaving the country's institutions particularly exposed to the downturn in international student recruitment and facing a more acute financial challenge than those in the UK. Widespread measures to mitigate the in-year financial impacts have already been adopted in both countries, including:

- cuts to capital build programmes;
- senior staff wage cuts;
- reduced working hours;
- voluntary severance or early retirement schemes; and
- scenario planning for reduced operational budgets.

The coming months will continue to place pressure on universities and funders to review and adapt their short-term plans, and to minimise the continuing impact of the pandemic on researchers, collaborations and funding. It is therefore likely that universities and funders will remain in a stabilising position for the next 6-12 months.

Strategies remain difficult to formulate but necessary

The complexity of change, uncertainty and fragility of current operating scenario makes developing *strategies* to successfully navigate the pandemic and secure future success very challenging. Most institutions and funders have yet to move beyond 'war-gaming' different future scenarios. And yet, strategies are urgently needed. Over the coming months, governments, funders and institutions will need to develop plans to prevent and mitigate the worst impacts of the pandemic, many of which will take years to unfold.

5.2 Prioritising a research-led recovery

Three priorities for a research-led recovery

University research has the potential to play a central role in the COVID-19 recovery. Fulfilling this potential relies on governments, policymakers and other stakeholders recognising and addressing the three priorities identified in this study: protecting research capacity in a fast-changing research landscape, supporting the transition to sustainable open science models, and providing continuity to research funding in the years to come. These priorities are mutually reinforcing and mutually dependent. In reality, concerted action in all these areas will be necessary to secure the a research-led recovery.

Priority 1 - Protect research capacity

The recovery plan should first and foremost seek to protect research capacity. This involves strategic interventions at different levels. At the level of research projects, attention should be paid to developing blended online-offline methods, increasing support for industry partnerships and actively promoting international collaborations. At university level, a review of training is needed to equip researchers for careers inside and outside academia, while also making academic career paths fairer and more attractive. At system level, governments and funders might be forced to prioritise how research capacity is deployed in the country, and what problems it is asked to solve.

Priority 2 - Transition to open science

The second priority area for the recovery plan is to strengthen open science. This involves the mechanisms, tools and infrastructure supporting the exchange of data, information and published knowledge within the research environment and with the broader public. The transition to open access and open data, long in the making, should be supported by all stakeholders – with a view to find sustainable business models. The peer review process remains critical, but innovative solutions should be found to make it faster, so as to increase the timeliness and relevance of published research. At the same time, and for the same reasons, preprints should become a more central part of the scholarly communication system. Finally, investments in digital technology, both within universities and at system level, are needed to increase the productivity, resilience and diffusion of research.

Priority 3 - Secure research funding for the future

The final priority is to secure and realign research funding. Funding underpins the other two priorities, and its deterioration over the coming years would jeopardise both the protection of research capacity and the transition to a more open and relevant research system. Governments should start by at least ring-fencing their funding commitments for the coming years, if not stepping them up to make up for the expected shortfall from private and charitable sources. This would be in line with government commitments in other sectors and would back up ambitions to create innovation-driven economies. Funding should also be nimbler and more flexible, with increased agility to respond to changing circumstances and emerging priorities. Finally, funding should be used strategically to support broader change at university level (reducing the dependency on student fees) and at project level (facilitating collaboration and supporting ambitious, impactful projects). These changes should be discussed and agreed by all stakeholders and be pragmatic rather than ideological.

15 strategies to equip research systems for the future

Drawing on the report findings, we have identified five strategies relevant to each priority. The 15 strategies are summarised in Table 1, with an indication of the key stakeholders responsible for their implementation in each case. Such strategies are a first attempt to articulate a response to challenges that are still evolving and might change as the crisis continues. We hope they can provide a valuable starting point for others to build on in equipping university research systems for a post-pandemic future.

Table 1. 15 Strategies to equip research systems for the future

Recovery strategy	Stakeholder group							
	Researchers	Universities	Research funders	Governments & policy makers	Learned societies & Academia	Research & E-infrastructure	Research libraries	Publishers
CAP1 - Rebalance research effort to tackle changing national and global priorities								
CAP2 - Develop blended online and offline research methods								
CAP3 - Strike new partnerships to counter 'research nationalism'								
CAP4 - Address instability and structural inequality in academic career pathways								
CAP5 - Reform postgraduate research training								
OS1 - Increase investment in digital infrastructure								
OS2 - Redefine roles for commercial and community actors								
OS3 - Enable innovation in peer review								
OS4 - Embed preprints in publication workflows								
OS5 - Adopt open science as the 'new normal'								
RF1 - Ring-fence research funding to underpin managed systemic change								
RF2 - Realign research investment towards biomedicine, digital and green technologies								
RF3 - Incentivise external partnerships, from discovery research to deployment								
RF4 - Reform funding procedures to deliver greater agility and responsiveness								
RF5 - Co-ordinate solutions to improve research system sustainability								

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Appendix A. Project contributors

We gratefully acknowledge the assistance of the following stakeholders who contributed to our work.

Table A1. Project contributors.

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Emerging from uncertainty

International perspectives on the impact of COVID-19 on university research

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