

Royal Society representation to the Comprehensive Spending Review 2020

The Royal Society is the national academy of science for the UK. Its Fellows include many of the world's most distinguished scientists working across a broad range of disciplines in academia, industry, charities and the public sector. The Society draws on the expertise of the Fellowship to provide independent and authoritative advice to UK, European and international decision makers.

Introduction

1. The UK's strength in science, research and innovation is a valuable economic and cultural asset. The estimated rates of return from investment in research and development (R&D) typically range from 20-30%, with some estimates as high as 85%¹.
2. UK science offers enormous potential to create new knowledge, innovations and jobs. Since the start of 2020, it has been critical to developing our understanding of COVID-19, informing the global policy response, and enabling aspects of the economy to continue to operate during the pandemic. If supported effectively, research and innovation will drive long-term growth and productivity, improve people's lives and opportunities, and help us achieve sustainable use of the biosphere and net zero carbon emissions by 2050. It will also secure the UK's position as a confident and influential scientific superpower.
3. The government has already signalled the value it places on R&D with a commitment to increase spending to £22 billion a year by 2025 and overall investment in R&D to 2.4% of gross domestic product (GDP) by 2027. This is an opportunity to build a highly successful research and innovation system that brings transformative long-term benefits to the economy and society. Realising this will require complementary action by multiple government departments and agencies and productive interactions with the private sector.
4. To maximise the potential of UK science, the government must:
 - Use research and innovation to improve people's lives
 - Support more people to become researchers and innovators in the UK
 - Take action to secure our status as a global science superpower
5. This submission suggests a number of specific policy actions that HM Treasury should consider in the Comprehensive Spending Review (CSR) to realise the greatest benefits from investment in research and innovation and deliver against the government's stated priorities.
6. The actions below to secure the health and harness the benefits of UK research and innovation remain pertinent in light of the government's decision to focus on its response to COVID-19 and the winter economy plan.

Strengthening the UK's economic recovery from COVID-19 by prioritising jobs and skills

Prevent a lost generation of researchers and innovators by addressing the effects of the pandemic on education and career progression and securing the health and strength of the research and innovation system they work within

7. Increasing the volume of R&D undertaken in the UK in line with the government's ambitions requires more people working across the research base. This is being undermined by the effects of COVID-19 on research and innovation in universities, businesses, and public and non-profit research organisations. Interruptions in research from paused or cancelled activities, the impact of

¹ <https://royalsociety.org/-/media/policy/Publications/2018/fresh-case/evidence-synthesis-on-the-distribution-of-benefits-of-research-and-innovation.pdf>

the pandemic on researchers' personal circumstances, and financial instability within institutions increases the risk of skilled people leaving science for good.

8. Measures have been taken by government already to stem the loss of income to universities, but further action is needed. Medical research charities, for instance, which account for half of publicly-funded medical research across the UK, are projecting a £310 million shortfall in their research spend over the coming year². A heavy reliance on short-term contracts in academia, particularly among postdoctoral researchers, means that financial pressures on funding quickly limit career opportunities, stalling progression and potentially forcing early career researchers to exit the market. PhD students and researchers in industry are also at risk in this context. The cumulative effect will be a reduction in UK's skilled workforce and its absorptive capacity for innovation and growth.
9. At a system level, securing stable long-term investment for UK research and innovation from diverse sources will put the sector on a strong and healthy footing from which it can employ and develop skilled people who can produce ground-breaking discoveries and world-changing innovations. While government support is critical, the UK will only maximise the benefits of increased public investment if it mobilises business R&D, which currently accounts for around two-thirds of the UK's total R&D spend.

Policy actions:

- The predominance of short-term contracts for early and mid-career researchers creates a fragile labour market deeply affected by the pandemic. The UK government should conduct a labour market review of the research and innovation workforce to inform mitigation measures to limit damage and secure the UK's absorptive capacity for economic recovery, innovation and growth.
- The government should consider existing policy levers by which it can boost the sustainability of the research and innovation system including through the distribution of quality-related (QR) block grant funding and the provision of a greater proportion of the full economic costs of research. The UK should also seek an association agreement for the next EU Framework Programme, Horizon Europe, to avert major disruption to the UK's science capabilities in 2021 (see paragraphs 32-33 below).
- The anticipated BEIS R&D Strategy should signal clearly to investors how increased public investment in R&D will be delivered, showcasing opportunities, providing confidence and informing long-term planning, to deliver a corresponding rise in private R&D investment. Getting this right will enable the UK to achieve and beat its 2.4% target.

Invest in technicians

10. Over 1.5 million technicians are employed in the UK across engineering, science, health and technology. They come with diverse expertise which is critical to the research and innovation system and to the adoption and use of new technologies in the face of rapid technological change³. COVID-19 has publicly highlighted the value of technicians' skills to the UK in areas ranging from the manufacture of personal protective equipment and hand sanitiser to COVID-19 research and the national testing effort⁴.
11. An ageing workforce means that 50,000 of the UK's technicians are retiring every year and forecasts show the UK will need as many as 700,000 more in the next decade to meet demand from employers⁵. Investing in this workforce now through high quality training and career pathways is fundamental to addressing the growing skills shortage and increasing the UK's R&D capacity.

Policy actions:

² <https://www.amrc.org.uk/news/50-mps-urge-chancellor-to-protect-vital-charity-research>

³ <https://www.gatsby.org.uk/education/latest/latest-report-highlights-the-critical-role-technicians-play-in-innovation>

⁴ <https://sciencecouncil.org/covid-tech/>

⁵ <https://www.gatsby.org.uk/education/programmes/raising-the-profile-of-technicians>

- The government should invest in the creation of a new generation of early career technical professionals at multiple entry levels to be trained by colleges, universities, research organisations and businesses in key technologies.
- New funded opportunities for technical careers, such as Technician Fellowships, should be considered along with other measures to raise the profile and career opportunities of the technician workforce.

Establish the UK as a leading data science research nation

12. The ability to understand and exploit data, and data-enabled technologies such as artificial intelligence (AI), is increasingly important. In certain industries, data analysis brings competitive advantage and has led to new applications of predictive analytics and machine learning to address complex business problems. COVID-19 has shown that neither the public nor the private sector has strong organisational competence in well governed access to data and its exploitation.
13. Over a five-and-a-half year period from 2013 to 2018, there was a sharp rise in UK job-listings for 'Data Scientists and Advanced Analysts' (+ 231%) driven predominately by increased numbers of vacancies for Data Scientists and Data Engineers⁶. This demand for data science skills is nationwide, and across all sectors. While there is considerable strength in UK data science in academic, industrial, charitable and government sectors, the UK needs a sustainable flow of expertise to become a leading data science research nation. There is a parallel need to retrain people and provide opportunities for lifelong learning for groups whose jobs are changed due to automation.

Policy actions:

- To meet the growing demand for data scientists, the government should support nimble and responsive training opportunities, develop data science as a profession, and foster collaboration between sectors to address skills gaps and shortages across the UK.
- Organisational data competence in public and private sectors is a competitiveness issue. The government should keep investing in its workforce and management competences in the way that HMRC has through its capability-building scheme for analysts and data scientists across the public sector.

Levelling up economic opportunity across all nations and regions of the country by investing in infrastructure, innovation and people – thus closing the gap with our competitors by spreading opportunity, maximising productivity and improving the value add of each hour worked

Use the UK Shared Prosperity Fund and other funding initiatives to preserve and build research strength across nations and regions and create the conditions that drive innovation and growth

14. Research and innovation clusters can bring substantial value, prosperity and jobs to the surrounding region. Catalyst, for example, formerly the Northern Ireland Science Park, has been critical in making Northern Ireland the second-fastest growing region of the UK⁷. The Centre for Secure Information Technologies, which sits in this cluster, has formed the centre of a local cybersecurity ecosystem that includes over 40 companies employing approximately 1,600 cybersecurity professionals and delivering £60 million per annum in salaries to the local economy. Other successes in the UK include the Cambridge life sciences cluster and the advanced manufacturing cluster between Sheffield and Rotherham.
15. Since the evidence suggests that 'creating a cluster' is a misguided policy objective⁸ the government should focus on creating the conditions that allow clusters to emerge. This includes taking measures to identify areas of absolute or comparative research strength, unlocking access to private and public funding, and developing supportive regulation and infrastructure.

⁶ <https://royalsociety.org/-/media/policy/projects/dynamics-of-data-science/dynamics-of-data-science-skills-report.pdf>

⁷ <https://wearecatalyst.org/wp-content/uploads/2019/08/Knowledge-Economy-Report-2018.pdf>

⁸ <https://royalsociety.org/-/media/policy/Publications/2020/2020-07-research-and-innovation-clusters-report.pdf>

16. European Structural and Investment Funds were an important factor in the development of regional R&D. Between 2014 and 2020, the UK was allocated €5.8 billion through the European Regional Development Fund and €4.9 billion from the European Social Fund, with less advantaged regions receiving a disproportionate share on a GDP per capita basis. Failure to replace this funding will have a negative impact on the R&D capacity of these regions and conflict with the levelling up agenda.

Policy action:

- The government should rapidly deliver the UK Shared Prosperity Fund to avoid a funding cliff edge that leads to a loss of research and innovation activity and capabilities. The fund must complement other new and existing initiatives at a national and devolved level which use data to target local strengths and excellence in research and build on different regions' comparative advantages including infrastructure and skills.

Attract foreign direct investment (FDI) by showcasing the breadth of the UK's strength in research and innovation

17. Investment by foreign-owned business makes up approximately 53% of UK private R&D expenditure in the UK⁹. This must increase to meet the government's 2.4% R&D investment target. The UK has attractive assets and can credibly become the R&D investment capital of the world, with regulation and institutional architecture geared to drive this as effectively as possible.
18. The photonics industry, for example, is worth £13.5 billion to the UK and is distributed across the country, with seven regions yielding an output of more than £1 billion. The UK is well positioned for laser, optics and quantum businesses and there is clear investor appetite in fields of photonics research such as micro-LEDs¹⁰.
19. Many impactful discoveries are made at the cusp of one discipline, as it interacts with another – for example, the convergence of genetics and statistics led to modern day genomics. One rationale for the creation of UK Research and Innovation (UKRI) was to incentivise greater interdisciplinary working¹¹. If realised effectively, this will be a major UK asset to attract private investment.

Policy actions:

- The government should produce an FDI strategy with the aim of showcasing UK assets internationally and attracting new R&D investment. This should draw on data from the Science and Innovation Audits¹², Local Industrial Strategies¹³ and other evidence sources to identify specific areas of local and regional strength.
- Government bodies responsible for economic development across the UK should work together on a targeted campaign to attract specific globally mobile R&D investors on the basis of UK investable strengths.

Enhance the diversity of organisations and investors to increase breadth and resilience in the research and innovation system

20. Public and non-profit research organisations fulfil multiple functions that can fall in between government, universities and businesses. This includes carrying out early stage applied research, supporting policy development, and developing standards, testing and regulation, which are essential for crossing the 'valley of death' that can preclude commercial innovation.
21. Compared with other countries, the UK has an unusually small number of these organisations and many of them are struggling financially. Moreover, the strategic rationale for organisations in some

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<https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/bulletins/businessenterpriseresearchanddevelopment/latest#majority-of-uk-business-expenditure-by-foreign-owned-businesses>

¹⁰ <https://royalsociety.org/-/media/events/2019/10/tof-photonics/Photonics-report.pdf>

¹¹ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/478125/BIS-15-625-ensuring-a-successful-UK-research-endeavour.pdf

¹² <https://www.gov.uk/government/collections/science-and-innovation-audits>

¹³ <https://www.gov.uk/government/publications/local-industrial-strategies-policy-prospectus>

research areas and not others is unclear and does not always best reflect UK research priorities and needs.

Policy action:

- The government should conduct a thorough review of public and non-profit research and innovation organisations to identify those most capable of contributing to UK innovation and how best to harness them to contribute to a coherent innovation strategy. This should include consideration of smaller institutes that have the agility to respond to a changing environment, achieve greater aggregate productivity than larger investments, and can act as catalysts to spur activity in new sectors and places. The Royal Society's mapping of the institutional landscape¹⁴ and Government Science Capability Review¹⁵ provide a starting point for this exercise.

Improving outcomes in public services, including supporting the NHS and taking steps to cut crime and ensure every young person receives a superb education

Establish a royal commission to reshape our education system to give the breadth of knowledge, experience, creativity, resilience and skills that are vital for everyone to thrive in the 21st century

22. A broad and balanced education enables people to make informed choices, empowers them to shape scientific and technological development, and equips them to work in an advanced knowledge economy. The UK's current post-16 education system, however, which encompasses a range of qualifications including A-levels, Highers, BTECs, and T-levels, is extremely narrow. Taking A-level qualifications as an example, the average number taken in England, Wales and Northern Ireland is now 2.7 per student¹⁶ and Scotland is similarly narrowing. This places students across the UK at a disadvantage.
23. COVID-19 has already significantly disrupted the education of young people and it is likely to entrench disadvantage further. To ensure that young people are prepared for the workforce of the future, the UK should move toward a broader post-16 education system for all.

Policy action:

- The government should establish a royal commission that can give parents, teachers, employers, civil servants and politicians the opportunity to reshape the education system to give the breadth of knowledge, experience, creativity, resilience and skills that are vital for everyone to thrive in the 21st century.

Establish an Office of Educational Research to coordinate and prioritise educational research

24. To deliver effective education policy, policymakers must continually adapt where, how and what is learnt in order to respond to new work patterns, lifestyles, technologies and knowledge. Educational research has evolved organically and as result has limited coordination, oversight or resources. Better mechanisms are needed to ensure that high quality educational research takes place and its findings are valued, taken up and used in teaching and learning practice across the country¹⁷.

Policy action:

- The governments of the four UK nations should jointly establish an Office of Educational Research to coordinate and prioritise educational research and ensure that it informs education policy and practice.

¹⁴ <https://royalsociety.org/topics-policy/publications/2020/uk-research-organisations/>

¹⁵ <https://www.gov.uk/government/publications/government-science-capability-review>

¹⁶ <https://royalsociety.org/~media/policy/topics/education-skills/Broadening%20the%20curriculum/education-datalab-report-post-16-qualifications-and-subject-mix-05-09-2017.pdf>

¹⁷ <https://royalsociety.org/topics-policy/projects/royal-society-british-academy-educational-research/>

Making the UK a scientific superpower, including leading in the development of technologies that will support the government’s ambition to reach net zero carbon emissions by 2050

Attract the best international talent and ensure that our researchers can work with the best elsewhere

25. Non-UK nationals comprise two-fifths of the UK’s academic workforce in science, technology and engineering and more than half of the postgraduate student population¹⁸. The estimated proportion of overseas researchers in industry ranges from 10-50%¹⁹. The ability of researchers to move in and out of country with minimal barriers is fundamental to increasing the volume of R&D undertaken in the UK and the economic and societal benefits that derive from it.
26. As a reciprocal arrangement with the EU, the existence of visa-free work and study rights was invaluable to the UK’s internationally mobile research community and its removal at the end of the UK-EU transition period represents a significant loss. The UK’s competitiveness is further impacted by the upfront costs of work and study visas which are up to six times more expensive than the average across leading science nations²⁰.

Policy actions:

- The government should seek reciprocal arrangements on inward and outward mobility as part of its future trade strategy.
- Immediate action should be taken to reduce the upfront costs of work and study visas in line with global competition.
- The government should use the newly established Office for Talent to promote the UK’s offer to overseas researchers and innovators and ensure that the UK remains an attractive destination for international PhD students.

Provide opportunities to research bold new ideas

27. Short-term funding tends to favour incremental science that builds on existing work. This incentivises researchers to be circumspect in their approach and at a system level inhibits the UK’s ability to pursue those ideas and technologies that could deliver transformative change. Long-term grants that allow exploration of bold ideas are essential for becoming a scientific superpower.
28. The European Research Council is a particularly successful model with the availability of five-year grants enabling time for deep exploration. The 2018 evaluation of completed projects found that 16% of ERC projects led to a “scientific breakthrough” and 59% to a “major scientific advance”.²¹ These funding decisions are not exempt from risk – a quarter of projects were not as successful as initially expected – but provide an excellent platform for researching bold new ideas.

Policy actions:

- The government must not lose its appetite for bold new ideas and the associated risk. It needs to specify its intentions for a high risk-high reward UK ARPA agency and indicate how the outputs will be harnessed and taken up in the market to support disruptive growth.
- The government should also increase its investment in discovery science through schemes such as the Royal Society’s Faraday Fellowship proposal submitted to the CSR separately through BEIS. Scientific discovery provides the crucial underpinning for innovation.

¹⁸ <https://royalsociety.org/-/media/policy/Publications/2019/international-visa-systems-explainer-july-2019.pdf>

¹⁹ <https://royalsociety.org/-/media/policy/projects/international-mobility/international-researcher-mobility-industry.pdf>

²⁰ <https://royalsociety.org/-/media/policy/Publications/2019/international-visa-systems-explainer-july-2019.pdf>

²¹ <https://erc.europa.eu/sites/default/files/document/file/2019-qualitative-evaluation-projects.pdf>

Drive global action on green recovery and other critical areas

29. The UK has committed to achieving net zero emissions to end its contribution to global warming. Action is required now to ensure that this goal is met. The UK's strength in research and innovation places it in a strong position to develop enabling technologies to deliver green growth.
30. The UK should use its substantial networks to drive the uptake of green growth technologies around the world and address known drivers of change over the next decade including the rapid loss of biodiversity. Opportunities to influence in the coming year include the UK's Presidency of the G7, its co-hosting of the UN Framework Convention on Climate Change 26th Conference of the Parties (COP26), and its participation in the UN Convention on Biodiversity 15th Conference of the Parties (COP15) to be held in Kunming, China, and in the G20 Summit.
31. There are many other shared global challenges that impact on us all and must be addressed at an international level. Science has an important role to play in understanding and responding to these challenges and in supporting delivery of the UN Sustainable Development Goals.

Policy action:

- The government should invest in technologies across the nations and regions that will enable the UK's transition to net zero. It must use the UK's substantial global networks to deploy these technologies globally and lead the related policy debate, thereby shaping and delivering a green recovery.
- The UK's strengths in research and innovation should also drive global action in areas such as biodiversity valuation and the safe and ethical management and exploitation of data. To do this, the government must invest in international collaborations, providing scientific evidence to support global policymaking, and encouraging adherence to values that create an excellent global research culture

Strengthening the UK's place in the world

Be an active participant in European and global science

32. Europe is the UK's largest and fastest growing scientific collaborator²². Associating to the next EU Framework Programme, Horizon Europe, will ensure that the UK keeps access to valuable networks that foster new frontiers of knowledge and innovation while continuing to attract international talent through prestigious schemes that are closed to non-associated countries. The UK should use science as a soft power asset to build European collaboration in key areas such as AI, climate change and low carbon technologies.
33. While maintaining a strong scientific relationship with the rest of Europe, the government must also broaden the range of instruments for collaboration with countries elsewhere and deploy these strategically alongside existing multilateral, bilateral, national and regional mechanisms. Science is increasingly global with 55% of UK academic publications the result of international collaboration in 2018, compared with 26% in 1998²³.

Policy actions:

- The UK should seek a full association agreement on Horizon Europe with the maximum possible engagement and influence. Funding for this purpose should be earmarked and considered additional to the £22 billion a year committed to UK R&D by 2025.
- At the same time, the government should seek ambitious new deals with established and emerging science nations around the world. This should include partnerships in areas of shared research strength, innovation and technology, infrastructure, and global challenges.

²² <https://royalsociety.org/-/media/policy/Publications/2019/horizon-europe-uk-association-position-statement.pdf>

²³ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/815400/International_comparison_of_the_UK_research_base_2019_Accompanying_note.pdf

Build a streamlined and flexible regulatory environment that supports research and innovation and has public confidence (see master narrative, p 14)

34. Having previously led the way on difficult and controversial regulatory issues, the UK is well placed to take the lead in developing safe and ambitious regulations that set the global standard. The recent work of International Commission on the Clinical Use of Human Germline Genome Editing²⁴ is an example of UK science responding to an international incident and is directly informing the activities of the World Health Organization. These types of intervention establish the UK as an attractive location to undertake ground-breaking science safely and ethically in a way that earns public confidence. Being at the forefront of international conversations about how research is applied and commercialised also brings considerable soft power.

Policy action:

- The government should seize opportunities for the UK to take a lead role in developing regulatory approaches that have international utility and can help to establish international norms that support mutually beneficial collaboration.

Improving the management and delivery of our commitments, ensuring that all departments have the appropriate structures and processes in place to deliver their outcomes and commitments on time and within budget

Better prepare for identified risks on the National Risk Register to mitigate their economic and social impact and build resilience to future shocks

35. Events such as the financial crisis of 2008, COVID-19, and increasing frequency of climate-related natural disasters demonstrate the need for better preparedness. While the near-term occurrence of a global pandemic was high on the UK's National Risk Register, the scale and nature of COVID-19 initially overwhelmed the government's ability to access and deploy the UK's operational science capabilities at sufficient speed. It is important that the UK learns from this experience to inform its preparedness in future and minimise the productivity impacts of future crisis interventions. This includes building in institutional mitigations to counter human reasons for lack of resilience such as the perceived financial inefficiency of stockpiling.

36. Part of building resilience for future shocks is making sure that government can access relevant evidence and expertise in a timely and efficient manner. During the pandemic, the Royal Society has mobilised three initiatives to improve access to information and enable better policy responses: Data Evaluation and Learning for Viral Epidemics (DELVE); The Rapid Assistance in Modelling the Pandemic (RAMP); and Science in Emergencies Tasking – COVID-19 (SET-C). These and other types of advisory mechanism should be formalised to enable quicker deployment of expertise in the event of future crises. Ultimately, it is not a choice between having an efficient flourishing economy or spending on resilience but a case of the latter enabling stable long-term growth and prosperity.

Policy actions:

- Informed by scientific advice, the government should take measures to prepare for the economic and social impact of events on the National Risk Register. It should invest now to establish sophisticated mechanisms for accessing a broad range of external evidence and expertise from the UK and international science community. This requires building better data systems to enable rapid and timely access to and analysis of data for policymakers in a way that is ethical, secure and privacy preserving.
- The Royal Society has separately submitted a detailed bid for a programme to help advise on how the UK should build resilience for both the longer-term aspects of this pandemic and to improve reactions and resilience against future crises.

²⁴ <https://www.nap.edu/catalog/25665/heritable-human-genome-editing>

Engage more widely to inform research and policymaking and ensure that policies are developed with public confidence

37. In addition to drawing on scientific expertise, decision makers should engage with the public to gather their input and opinion. Drawing from a diversity of people and perspectives will improve policy and instil greater public confidence in and awareness of interventions. Early and meaningful engagement enables policy in controversial and sensitive areas to be developed and implemented with public confidence, reducing the risk of delays and making the UK a more attractive location to conduct research and innovate. For example, public engagement by Sciencewise on Mitochondrial Replacement has helped to formulate advice given to government by the Human Fertilisation and Embryology Authority, bringing the public on board with the development of potential treatments²⁵.
38. The UK currently has a skilled workforce of organisations and professionals that support public engagement. COVID-19 has put the future of many of these, such as the Science and Discovery Centres, at risk²⁶.

Policy action:

- The government should continue to invest in skilled people and organisations that support meaningful public engagement with the challenging and sensitive questions that are raised by the progress and application of science and use this to inform policymaking.

For further information or queries, please contact public.affairs@royalsociety.org

²⁵ <https://sciencewise.org.uk/wp-content/uploads/2018/08/Mitochondrial-Replacement-Therapy-Case-Study-2.pdf>

²⁶ <https://future.sciencecentres.org.uk/>