Joint submission to the Science and Innovation Strategy

from the Academy of Medical Sciences, the British Academy, the Royal Academy of Engineering and the Royal Society

Overview

Research and innovation offer solutions to the UK's long-term economic, social, health and environmental challenges. The academies support the Government's efforts to develop a Science and Innovation Strategy to shape the future of UK research up to 2020 and beyond. The academies recommend that the strategy should:

- Provide a flexible long-term framework that enables the UK to collaborate and compete internationally by supporting a broad research base across all disciplines. This should sit at the heart of Government's industrial strategy and plans for growth.
- Be broad in scope to encompass the UK's richly diverse and integrated research and innovation system, including Government, industry, charities and other organisations nationally and internationally.
- Place excellence at the heart of decision making about research investment.
- Be ambitious in its vision and deliver effective results.

This joint submission summarises and supplements the academies' previous inputs and builds on the statement *Fuelling prosperity*[1] that sets out the academies' thinking about future UK policy for research. The submission addresses a number of over-arching messages regarding the whole strategy, before covering in more detail each of the key areas outlined by the consultation document. It concludes with some points about the international aspects of the strategy. Given the breadth of disciplines represented, individual academies may provide comments separately on specific points.

A long-term flexible framework

The strategy should consist of an ambitious and flexible framework for the long-term. The framework should aim to maintain a broad research base that provides the UK with the capacity to address current, emerging and as yet unknown challenges. While a five year strategy is welcome, the academies previously recommended a framework for at least ten years.[2] A ten-year strategy would provide the stability needed by industry, charities and academia, help to attract investment and talent from overseas, allow the training of skilled professionals, and reflect the time needed to tackle long-range challenges. The academies recommend that the strategy provides a ten-year framework comprising overarching principles and proposals for the initial period, to be periodically reviewed. This would allow flexibility with direction. One essential component of a stable investment framework should be a ring-fenced research budget protected in real terms.

Investment in research has been demonstrated to have long-term economic and social benefits, and recent evidence indicates that research activity scales with the level of investment.[3] [4] The UK's international competitors are increasingly recognising the opportunities presented by research and innovation, and are increasing their investment. In the UK in 2012, overall R&D expenditure from government, businesses and charities was 1.72% of GDP, a decrease from 1.77% in 2011 and 1.79% in 2000. That contrasts with our international competitors such as the US (2.79%), Germany

[1] UK national academies (2013), *Fuelling prosperity: Research and innovation as drivers of UK growth and competitiveness.* https://royalsociety.org/policy/publications/2013/fuelling-prosperity/

[2] UK national academies (2013), *Fuelling prosperity: Research and innovation as drivers of UK growth and competitiveness.* https://royalsociety.org/policy/publications/2013/fuelling-prosperity/

[3] For example, Health Economics Research Group at Brunel University, King's College London and RAND Europe (2014) *Medical Research: What's it worth?* http://www.acmedsci.ac.uk/download.php?f=file&i=29924

[4] Office of Health Economics and the Science Policy Research Unit at the University of Sussex (2014) *Exploring the interdependencies of research funders in the UK.* http://news.ohe.org/2014/07/02/interdependence-funding-medical-research-uk/

(2.98%) and Korea (4.36%), where investments have been steadily increasing since 2000.[5] A report published by BIS in 2014 stated that a level of overall R&D spend consistent with securing future economic success in the UK is likely to be closer to the 2.9% average of comparator countries, and that public sector expenditure may need to rise more sharply in the short-to-medium term.[6] The Government should commit to increased investment in research and innovation to keep pace with other leading scientific nations.

The UK research community has made effective efforts in achieving efficiencies, for example through equipment sharing initiatives such as the N8, M5, SE5 and GW4 groups of universities, and partnerships such as the Midlands Physics Alliance and the National Marine Equipment Pool. These initiatives are resulting in the pooling of capabilities and intelligence on asset management, and in time will have the power to change procurement practice. Public funders are increasingly evaluating the impact of their schemes, and in 2010-11 the higher education sector saved £462 million through efficiency measures.[7] The academies welcome efficiency initiatives, but their impact should be closely monitored to avoid harm to the research base.

Scientifically the UK is one of the most productive nations in the world. This is due in part to its characteristic features, such as the 'Haldane Principle' and the dual support system. The strong international reputation of UK research relies on the emphasis on excellence within the dual framework of regular and rigorous research assessment combined with competitive bidding for project-based funding. The strategy should build on the UK's strengths and ensure that excellence remains the primary criterion for investment in research. This is essential to ensure that the UK retains and develops its place as a world leader in research.

Scope

The UK's research landscape extends beyond those institutions supported by the 'science budget' in BIS. Across Government, the Department of Health, through the National Institute of Health Research (NIHR), the Ministry of Defence, the Department for International Development, the Department of the Environment, Food and Rural Affairs and other public bodies also invest heavily in research and innovation. Beyond the public sector, businesses performed research representing 63% of total UK expenditure on R&D in 2012, and every year medical research charities invest more than £1bn.[8] [9] As highlighted in a recent study, private and public sector research expenditures are not interchangeable but act in a complementary way that contributes to economic growth.[10] In addition there is an important international dimension to UK research, as outlined below.

The strategy should take into consideration the full breadth of government, business and charity-funded research to ensure they are complementary and to leverage additional investment from other sectors and from abroad. This will necessitate a broadening of focus from the supply-side measures controlled by BIS to encompass similar measures in other departments, such as the NIHR, and demand-side measures across Government and the research and innovation system as a whole, such as procurement and R&D tax credits. The academies recommend that the strategy should

[5] Data refer to overall Gross Expenditure in R&D (GERD), which includes expenditure by government, businesses, charities and direct foreign investment. OECD, *Main science and technology indicators.* http://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB

[6] Allas (2014), *Insights from international benchmarking of the UK science and innovation system.* https://www.gov.uk/government/publications/science-and-innovation-system-international-benchmarking

[7] Universities UK (2013) *Why government must invest in universities.* http://www.universitiesuk.ac.uk/highereducation/Documents/2013/WhyGovernmentMustInvestInUniversities.pdf

[8] Office of National Statistics (2014), *UK Gross Domestic Expenditure on Research and Development 2012.* http://www.ons.gov.uk/ons/dcp171778_355583.pdf

[9] AMRC (2013), *Research spend 2008-2013.* http://www.amrc.org.uk/our-members/sector-data/research-spend

[10] Haskel et al (2014), *The economic significance of the UK science base.* http://www.sciencecampaign.org.uk/UKScienceBase.pdf

reflect the importance to the UK's research and innovation performance of matters such as regulation, taxation, procurement, immigration, education and foreign policy (see below).

Infrastructure

The academies submitted a joint response to the consultation on science and research capital investment.[11] An essential interdependence exists between capital and resources, and the academies welcome the Government's commitment to accompany the existing ring-fenced 'science budget' with capital investment over the next five years.[12] However, while capital investment has been restored to pre-2010 levels and guaranteed in real terms for the next five years, a flat-cash arrangement has led to the erosion by inflation of the 'science budget', which provides the recurring resources. The 'science budget' should be at least similarly protected to create maximum value from the interaction of the two budgets. Excellence should be the primary guiding principle for decision making within a wider strategic vision of investment in research capital, and investment is required across the whole spectrum of research projects.

The academies' response also highlighted the need for comprehensive operational planning to support research infrastructure. Building a laboratory, developing the architecture of a data system, or buying a piece of equipment are merely the beginning of the life cycle of infrastructure. Any such initiative will require ongoing funding for maintenance, staffing, refurbishment, insurance and upgrades. These requirements, alongside a description of how they will be provided, should be clearly detailed at the outset in a business plan. This has to take into account maintenance and running costs, the provision of a skilled workforce to create maximum value, and the potential for efficiency savings through sharing. These concerns do not only apply to new capital projects; existing capital projects require ongoing financial commitment to provide sufficient maintenance, upgrades and staffing. This will ensure that the UK continues to benefit from previous capital investment and that our research infrastructure remains internationally competitive.

As research becomes ever more interdisciplinary, the boundaries between different types of research fields, and thus their capital requirements, are likely to become ever more permeable. The academies also recommend that the UK support research capital that is useful across a wide range of disciplines, as such capital projects may not be sufficiently prioritised within any single discipline. The academies further recommend that, when making investment decisions, 'hidden capital' such as the infrastructure underpinning major longitudinal studies, software, and research libraries and archives, is considered alongside the need for research equipment.

Business investment

When making decisions about R&D investment, businesses and charities take account of the whole research and innovation system in which they operate. Public investment in research underpins and attracts private and charitable investment in R&D. A strong public research base supported by stable, long-term investment is therefore a key foundation for business investment.[13] [14] The science and innovation strategy should be linked to the UK's industrial strategy to ensure a coherent approach across Government, with research and innovation sitting at the heart of plans for long-term recovery and growth.[15]

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[11] UK national academies (2014), Response to BIS Consultation on Proposals for Long-Term Capital Investment for Science and Research. https://royalsociety.org/policy/publications/2014/consultation-response-long-term-capital-investment-science-research/

[12] *Government Response to the House of Lords Science and Technology Committee Report: Scientific Infrastructure, http://www.parliament.uk/documents/lords-committees/science-technology/ScientificInfrastructure/GovtresponseScientificInfrastructure.pdf*

[13] Falk (2006). What drives business research and development intensity across OECD countries? Applied Economics 38

[14] Haskel et al. (2014), *The Economic Significance of the UK Science Base.* http://www.sciencecampaign.org.uk/UKScienceBase.pdf

[15] UK national academies (2013), *Fuelling prosperity: Research and innovation as drivers of UK growth and competitiveness.* https://royalsociety.org/policy/publications/2013/fuelling-prosperity/

Innovation and research in the private sector are increasingly open, and opportunities to collaborate with academic talent are a crucial factor in business R&D investment decisions.[16] Simple ways exist to increase business investment in collaborative research. An example is the 5% limit on the amount of commercially sponsored research that can be carried out in a building before VAT has to be paid on the entire building, which discourages universities and business from working together and should be reviewed.[17] The overall financial and tax environment are also important for business. The newly introduced Patent Box has the potential to attract internationally mobile business R&D investment to the UK, but needs to be carefully monitored to ensure value for money.[18] [19]

SMEs can be very innovative, but may have limited capacity for understanding and taking advantage of Government initiatives. The Technology Strategy Board has a number of initiatives in place that support SMEs and should aim to increase awareness and uptake of them.[20] To allow time for companies to become familiar with them, maintaining stability in the support available to SMEs is also important. The Small Business Research Initiative has had some success in leveraging the Government's substantial procurement budget to support SMEs, and should continue to aim to do this to the fullest possible extent.[21] There should be stronger recognition in such schemes that many SMEs are part of a supply chain headed by larger companies.

The strategy should encompass the whole of the UK economy and should not neglect stable, innovative and important sectors. For example, the service sector is vital to the UK economy, contributing 79% of GDP and helping to address major business and economic challenges.[22] Innovation in the service sector benefits from the supply of highly skilled people trained in research. To generate such high-quality human capital the UK needs to foster world class research and researchers in its academic institutions. Companies in the service sector also benefit from informal knowledge exchange with academia, and the Royal Society has previously suggested specific initiatives for the TSB and the Research Councils to stimulate the contribution of STEM disciplines to the service economy.[23]

Talent

People are the most important resource for research. The strategy should include concrete proposals to develop, retain and attract the skilled individuals the UK will need. This will need aligning with the broader skills agenda in the UK to ensure a pipeline of future research and technical staff.

While academic qualifications can be a gateway to a research career, many who undertake such studies move on to work in other professions such as financial services, heritage or information technology. Transferable skills gained from academic study are among the research base's most important contributions to society and the economy. To ensure that academic courses are responding to the requirements of employers beyond academia, more emphasis could be

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[16] Royal Society (2012), *Science as an open enterprise*. https://royalsociety.org/policy/projects/science-public-enterprise/Report/

[17] Royal Society (2014), Response to the House of Commons Business, Innovation and Skills (BIS) Committee consultation on business-university collaboration. https://royalsociety.org/~/media/policy/Publications/2014/response-to-bis-consultation-business-university-collaboration-20140430.pdf

[18] Royal Society (2010), *The Scientific Century: securing our future prosperity*. https://royalsociety.org/policy/publications/2010/scientific-century/

[19] Levy and O'Brien (2013), Will the Patent Box boost the UK innovation ecosystem? Policy Briefing. *http://www.biginnovationcentre.com/Assets/Docs/Patent%20Box%20Final.pdf*

[20] Royal Society (2014) Response to the House of Commons Business, Innovation and Skills (BIS) Committee consultation on business-university collaboration. https://royalsociety.org/~/media/policy/Publications/2014/response-to-bis-consultation-business-university-collaboration-20140430.pdf

[21] Tredgett and Coad (2013). The shaky start of the UK Small Business Research Initiative (SBRI) in comparison to the US Small Business Innovation Research programme (SBIR). *http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2205156*

[22] Office for National Statistics (2014), *An International Perspective on the UK - Gross Domestic Product*. http://www.ons.gov.uk/ons/dcp171766_360847.pdf

[23] Royal Society (2009), *Hidden Wealth: the contribution of science to service sector innovation*. https://royalsociety.org/policy/publications/2009/hidden-wealth/

given to a collaborative approach to learning between universities and non-academic employers. Transferable skills programmes could be further developed and their integration in researcher career development ensured.

The UK higher education sector is a major source of earnings worth almost £60bn in jobs, exports, innovation and added value that has historically performed well in attracting talent from overseas.[24] The UK is a centre for talent development, but is competing in an increasingly global market for both international and domestic students and researchers. Global competition for excellence makes it essential that the UK remains an attractive place for the most talented individuals and
teams to work, whether they are from home or from elsewhere in the world. It is essential to minimise real and perceived barriers to the flow of talented people by broadly articulating and supporting the need for inward researcher migration, and ensuring that migration and visa regulations do not prevent researchers from accessing the best research across the world.[25]

The academies are concerned with excellent research wherever and by whomever it is done. A lack of diversity across the research community reflects a potential loss of talent to the UK, and the strategy should ensure access to research careers to the most talented. To better understand the diverse makeup of the scientific workforce, ongoing collection of demographic datasets should be encouraged and facilitated, and their future analysis should be improved.[26]

Reaping the benefits

Research can lead to great benefits for society and the economy, but the routes to impact for curiosity-driven and more applied research are complex and unpredictable. The distinction between 'basic' and 'applied' research should not be over-emphasised, because each supports the other in an iterative and non-linear process.

Impact, which comes in many forms, should always be an aim of research, and should be one of a set of broad and flexible measures used to judge research success. This should be reflected in the strategy. Impact is not always easy to define, evaluate or predict, and it is too early to offer a firm conclusion about the effect of including impact criteria in the most recent REF assessment. The academies look forward to the results of the independent review of the role of metrics in research assessment commissioned by HEFCE.[27]

One route by which research can, and often does, achieve significant impact is through cross-sector collaboration. Mobility between academia and industry or other sectors, such as the health service, promotes effective knowledge exchange. Bi-directional and prolonged exchanges are crucial for building mutual understanding, trust and a shared language. Improving mobility of individuals and permeability between different sectors would improve collaboration. Informal knowledge exchange is also important and is typically underplayed in policies.[28] [29]

[24] Figures quoted by Lord Mandelson, The Future of Higher Education', Dearing Lecture, Nottingham University, 11 February 2010. Full text available at: webarchive.nationalarchives.gov.uk/+/http:/www.bis.gov.uk/News/Speeches/mandelson-dearing-lecture

[25] Royal Society (2011), *Knowledge, networks and nations. Global scientific collaboration in the 21st century*. https://royalsociety.org/~/media/Royal_Society_Content/policy/publications/2011/4294976134.pdf

[26] For further discussion see Royal Society (2014), *A picture of the UK scientific workforce*. https://royalsociety.org/policy/projects/leading-way-diversity/uk-scientific-workforce-report/

[27] For further details see http://www.hefce.ac.uk/whatwedo/rsrch/howfundr/metrics/

[28] Royal Society (2009), *Hidden Wealth: the contribution of science to service sector innovation*. https://royalsociety.org/policy/publications/2009/hidden-wealth/

[29] Royal Society (2014) Response to the House of Commons Business, Innovation and Skills (BIS) Committee consultation on business-university collaboration. https://royalsociety.org/~/media/policy/Publications/2014/response-to-bis-consultation-business-university-collaboration-20140430.pdf

The TSB has been a welcome addition to the funding landscape in the UK and can help translational research to have high impact. For example, each £1 that the TSB invests in collaborative R&D between business and researchers typically returns around £7 in Gross Value Added.[30] The positive role played by the TSB in supporting industrial collaboration with the academic research base, which relies on the strength of the UK research and innovation system as a whole, should be recognised. The strategy should ensure the TSB is adequately resourced to fulfil this role without redirecting funds away from other parts of the research and innovation system. The Catapult Centres are a welcome initiative, and their resources should not be spread too thinly. The academies look forward to seeing the results of the Hauser mid-term review of the centres.

A flexible approach to defining priorities for investment is needed, as over time these priorities will need to be adapted to new knowledge and challenges. Policies that pick winners and prescribe solutions are rarely successful.[31] Establishing well-defined priorities, which leverage a broad research base maintained by a long-term flexible framework, can be a useful means by which to pull research towards shared goals without prescribing a specific route. This approach would reflect the differences between 'priority-driven' research and broader research. Identifying problems protects the space for free enquiry by asking the scientific community to identify solutions that meet societal needs. To ensure that societal priorities are taken into account, the public should be involved in informing research priorities.[32]

Research offers broad and deep expertise to inform evidence-based policy, which Government should ensure is fully incorporated into its work. A substantial proportion of strategic research is funded through Government departments and Public Sector Research Establishments (PSREs). This research can be world class in its own right and it underpins innovation in other areas. Cross-government research coordination and an appropriate level of funding are necessary to maximise the impact of this strategic research. The 'science budget' cannot substitute for reductions in departmental research budgets, and *vice versa*.

International dimensions of the strategy

The UK is a global hub for research and innovation, attracting talent and investment and successfully collaborating internationally. The UK is second only to the USA in attracting international students. Overseas funding made up 20% of R&D expenditure in the UK in 2012 and UK bodies received 15% of the European research budget, more than the 11% it contributes.[33] [34] In the same year, 47% of the UK's scientific publications had a non-UK co-author, up from 33% in 1999. The impact of these internationally co-authored publications, measured by citations, is significantly higher than the UK average.[35]

International activities and collaboration should be embedded in the strategy so that the UK research base is better placed to benefit from the intellectual and financial leverage of international partnerships. European engagement should be explicit in the strategy. The global influence of the European Union, the degree to which it legislates for the

[30] See https://www.innovateuk.org/documents/1524978/1866950/Press+briefing+-+The+Technology+Strategy+Board+at+a+glance/d03376c9-e7f5-4fe8-b658-6bc2e9b1653e

[31] European Commission (2009). The Role of Community Research Policy in the Knowledge-Based Economy: Report of an Expert Group to the European Commission. http://bookshop.europa.eu/en/the-role-of-community-research-policy-in-the-knowledge-based-economy-pbKINA24202/

[32] Stilgoe et al. (2013), *Developing a framework for responsible innovation*. http://www.sciencedirect.com/science/article/pii/S0048733313000930

[33] Office of National Statistics (2014), *UK Gross Domestic Expenditure on Research and Development 2012*. http://www.ons.gov.uk/ons/dcp171778_355583.pdf

[34] See http://europa.eu/rapid/press-release_SPEECH-14-83_en.htm

[35] Elsevier (2014). International Comparative Performance of the UK Research Base – 2013 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/263729/bis-13-1297-international-comparative-performance-of-the-UK-research-base-2013.pdf

UK, and the progressive development of the European Research Area provide imperatives and opportunities for the UK to continue to help shape European policy.

The UK is a world leader in the use of evidence in policy making. Promoting the principles and practice of evidence-informed policy in governments through regional and multilateral policy fora should be a primary objective for the UK. Many global challenges will require broad, multidisciplinary approaches. Supporting a breadth of excellent research, rather than targeting resources too narrowly, is therefore crucial. Recognising the interconnectedness of global challenges, funders should devise ways to co-ordinate their efforts, share good practice, minimise duplication and maximise impact.[36]

Research is a source of soft power, and 'science diplomacy' should feature in the strategy, building on the UK's research strengths and reputation of its research institutions.[37] The research community often works beyond national boundaries on problems of common interest, and so is well placed to support emerging forms of diplomacy that require non-traditional alliances of nations, sectors and non-governmental organisations. If aligned with wider foreign policy goals, these channels of intellectual exchange can contribute to coalition-building and conflict resolution. Interactions between UK and European scientists and institutions are strong and provide a useful, but presently underexploited, source of soft power.[38] National academies and learned societies are an important source of deploying research for soft power, as well as providing independent evidence-based advice to national and international policymakers.

There are also considerable leadership opportunities for UK research to shape the research trajectories in other countries and to help develop human capital in those other countries in ways that offer scope for recurrent collaboration. International capacity building is crucial to ensure that the benefits of research are shared globally. Researchers and funders should commit to building research capacity in less developed countries to help improve their ability to conduct, access, verify and use the best research, and to ensure that they can contribute to global scientific debates and develop local solutions to global problems.[39]

Systematic monitoring and analysis of developments in overseas research investment, output and policy are essential to inform both domestic and international policy decisions. Traditional metrics do not fully capture the dynamics of the emerging global science landscape. Global science is increasingly characterised by bottom-up, researcher-led networks. To capture the transformative impact that these scientists and their networks are having on international science, more sophisticated measures are required to provide a richer understanding of the available knowledge. Government should work closely with UNESCO and other agencies such as the OECD to investigate new ways in which trends in global research can be captured, quantified and benchmarked, in order to help improve the accuracy of assessments of the quality, use and wider impact of research, as well as to gauge the vitality of the research environment.

[36] Royal Society (2011), *Knowledge, networks and nations. Global scientific collaboration in the 21st century*. https://royalsociety.org/~/media/Royal_Society_Content/policy/publications/2011/4294976134.pdf

[37] British Academy (2014), *The Art of Attraction: Soft Power and the UK's Role in the World,* by Christopher Hill and Sarah Beadle. *http://www.britac.ac.uk/intl/softpower.cfm?frmAlias=/softpower/*

[38] Royal Society (2013) Response to the House of Lords Select Committee on Soft power and the UK's influence.

[39] For example, Academy of Medical Sciences (2012), *Building institutions through equitable partnerships in global health: Conference report.* http://www.acmedsci.ac.uk/viewFile/53d79ed38b19a.pdf

About the academies

The **Academy of Medical Sciences**, the **British Academy**, the **Royal Academy of Engineering** and the **Royal Society** are working together to highlight the value of research and innovation to the UK, and to support researchers, industry and policymakers to make the UK the location of choice for world class research, development and innovation. We are working with our research communities to maximise the value of research funding and to support the translation of knowledge into benefits for individuals and society at large. We look forward to working with policymakers, industry and broader society to create the conditions that will secure the UK as the best place in the world to explore, discover and innovate.

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