THE ROYAL SOCIETY

Investing in the UK's intellectual capital

Summary

Science, technology and innovation are increasingly crucial for the health and wealth of nations. The UK's research base is a national asset that has for many years been envied throughout the world. However, UK investment in research has been failing to keep pace with other leading nations and risks eroding the UK's capacity to carry out the work needed to help drive our economy and improve the quality of our lives. Bold leadership and decisive action are required now if we are to make the UK one of the best places in the world to carry out the discovery research and innovation required for the future benefit of the country. To secure prosperity and improve productivity the Government should place research and innovation at the heart of its plans for long-term economic growth. To bring this about the Royal Society is calling on the UK Government to increase its investment in R&D to at least match the OECD average of 0.67% of GDP[1] by 2020.

Research, innovation and prosperity

High quality research and innovation advance our economy, develop our society and improve our health. Scientific research is the most reliable way to gain knowledge about ourselves and the natural world. It provides the foundation for discoveries, applications and new companies that for advanced economies, like the UK, are a major source of competitive advantage and productivity growth.[2]

Research plays a powerful role in ensuring that the UK is an open and enquiring society capable of taking on future challenges. Decision makers in business and government draw on expertise and advice from UK research to tackle national and global problems from water scarcity to terrorism, from population change to the effects of new technologies on our everyday lives. Research also helps promote the delivery of efficient, high-quality public services such as health and social care.[3]

Building on scientific strength

Research is a jewel in the UK's crown; it offers a great resource that should be nurtured and developed for the good of our country.

The UK is acknowledged as a leader in research throughout the world, with expertise and capability across the spectrum of intellectual endeavour, and with effective linkages between the academic and commercial sectors. With 0.9% of the global population and 4.1% of global researchers the UK has 11.6% of global research citations and 15.9% of the world's most highly cited research articles.[4] International benchmarking places the UK 2nd in the world for the quality of its scientific research institutions,[5] 2nd for innovation[6] and 4th for university-industry collaboration in R&D.[7]

With a strong research base the UK is well placed to exploit the fruits of knowledge and creativity. The UK is already home to some of the world's most innovative large and small companies, including leading names such as Rolls-Royce and GSK, and a wealth of small and medium enterprises. Our largest public

[1] OECD (2015). *Main science and technology indicators*. http://www.oecd.org/sti/msti.htm. For the purposes of this paper the term 'OECD average' refers to the 'OECD total'. This is effectively a weighted average, with weighting for size of economy and government financed expenditure on research and development.

[2] 51% of UK productivity growth between 2000 and 2008 was attributable to innovation. BIS (2014). *Our plan for growth: science and innovation. Evidence paper.* https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/388015/14-1247-science-innovation-strategy-evidence.pdf

[3] For example, research can help tackle dementia that is experienced by two thirds of care home residents and one quarter of those occupying hospital beds NIHR (2014). *NIHR Annual report*. http://www.nihr.ac.uk/documents/about-NIHR/NIHR-Publications/NIHR-Annual-Reports/NIHR%20Annual%20Report%202013_2014.pdf

[4] Elsevier (2013). *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

[5] World Economic Forum (2014). *The Global Competitiveness Report 2014-2015.* http://www3.weforum.org/docs/WEF_GlobalCompetitivenessReport_2014-15.pdf

[6] Johnson Cornell University, Insead and WIPO (2014). *The Global Innovation Index 2014. The Human Factor in Innovation.* https://www.globalinnovationindex.org/userfiles/file/reportpdf/GII-2014-v5.pdf

[7] World Economic Forum (2014). *The Global Competitiveness Report 2014-2015.* http://www3.weforum.org/docs/WEF_GlobalCompetitivenessReport_2014-15.pdf

service, the NHS, offers unique potential for innovation and the UK's excellent medical research charities invested over £1.3 billion in health research in the UK in 2013.[8]

The UK's long history of high quality science, openness and freedom encourages entrepreneurship and innovative thinking. These strengths have helped make the UK responsible for the development of one eighth of the world's most popular prescription medicines[9] and the development of technology found in 95% of smart phones.[10]

Keeping pace with other leading knowledge economies

It is strongly welcomed that the Chancellor has made science a "personal priority". Other countries have also identified that science should be a priority and are pursuing prosperity through investment in knowledge and research excellence. These countries increasingly recognise the transformative potential of research and innovation, and are investing substantially in these areas. Speaking about German science in 2014, Angela Merkel said "…only by breaking new ground, only if we are prepared to leave well-trodden paths and encourage people to do this, will we be able to maintain and increase our prosperity."[11] Early in 2015, Indian Prime Minister Narendra Modi said "Science and technology will determine India's future, just as it has played a crucial role in bringing our nation to where we are today."[12]

Across the developed and developing world, such political vision is being matched by investment. In 2013, the average level of government financed expenditure on R&D in OECD countries was around 0.67% of GDP,[13] while in the UK it was 0.49%.[14] In the US, government financed expenditure on R&D amounted to approximately 0.76% of GDP, while in both Korea and Sweden it was over 0.9%.[15] Annex 1 shows how the UK compares with the top ten OECD government investors in research and development.

In terms of total R&D investment, Chinese spending has risen more than sevenfold in real terms since the beginning of the new millennium.[16] Brazil nearly tripled R&D spending between 2000 and 2008,[17] and Israel's investment has stood at over 4% of GDP for most of the last decade.[18] Meanwhile, total (public and private) investment in the UK lags behind at 1.67% of GDP.[19]

The commitment to invest in research capital is welcome but 'flat cash' settlements over the last Parliament have meant that the cumulative erosion of the ring-fenced science resource budget grew to over £1 billion.[20] As budgets declined across government during the last Parliament, some departmental R&D budgets declined particularly steeply and disproportionately to other funding lines.[21] Generous investments in research by governments across the world, coupled with austerity at home and the opportunities for global mobility risks losing our scientific talent elsewhere.

There is a span of support within which the research system operates well and uses resources efficiently. If it is too high, then there is a risk of wasting resources with too much support chasing too little ground-breaking activity. If it is too low then the system runs the even greater risk of becoming dysfunctional. The UK Government-funded research endeavour is one of the most cost efficient in the world, and the Society believes that the reductions imposed over recent years due to flat cash settlements for resource combined with increasing costs as a result of inflation, have now moved the system to the lowest region of the effective span. There is a significant and growing risk of dysfunctionality that will lead to reductions in cost

[8] AMRC (unknown). *About us*. http://www.amrc.org.uk/about-us
[9] ABPI (2014). *Delivering value to the UK*. http://www.abpi.org.uk/our-work/library/Documents/delivering_values_dec2014.pdf
[10] ARM (unknown). *Company profile*. http://www.arm.com/about/company-profile/
[11] Angela Merkel, Berlin, 8 November 2014. http://www.bundesregierung.de/Content/EN/Reden/2014/2014-11-08-rede-bkin-falling-wall_en.html;jsessionid=979EB8EAE3C6BC66482CDAE65E986421.s1t2?nn=393812
[12] See: https://twitter.com/narendramodi/status/571482821774073858
[13] OECD (2015). *Main science and technology indicators*. http://www.oecd.org/sti/msti.htm
[14] CaSE (2015). *CaSE Briefing on UK Gross Domestic Expenditure on R&D.* http://blog.sciencecampaign.org.uk/wp-content/uploads/2015/04/CaSE-RD-investment-briefing-April-2015.pdf
[15] OECD (2015). *Main science and technology indicators*. http://www.oecd.org/sti/msti.htm
[16] OECD (2015). *Main science and technology indicators*. http://www.oecd.org/sti/msti.htm
[17] US NAS (2012). *Rising to the Challenge. US Innovation Policy for the Global Economy.* http://politiques-innovation.org/wp-content/uploads/2013/07/2012-Wessner-STEP-Rising-to-the-Challenge-U.S.-Innovation-Policy-for-Global-Economy.pdf
[18] OECD (2015). *Main science and technology indicators*. http://www.oecd.org/sti/msti.htm
[19] ONS (2015). *UK Gross Domestic Expenditure on R&D, 2013.* http://www.ons.gov.uk/ons/dcp171778_398876.pdf
[20] CaSE (2015). *CaSE Budget Briefing*. http://sciencecampaign.org.uk/CaSE2015BudgetBriefing.pdf
[21] CaSE (2014). *CaSE analysis of departmental R&D spend 2011/12.* http://sciencecampaign.org.uk/documents/2014/DepartmentalR&Dexpenditure2011-12.pdf

efficiency, wasting resources and resulting in a reduction in the effectiveness of the research endeavour, the costs of which would outweigh the benefits of savings made by reducing support.

Making the UK the best place in the world for discovery and innovation

The Royal Society encourages the Government to realise its commitment to make the UK the "best place in the world for science and business"[22] by creating a world class research and innovation environment that is attractive to the brightest talent, collaboration and investment from industry and from overseas.

The Royal Society is calling on the UK Government to increase its investment in R&D to at least match the OECD average of 0.67% of GDP by 2020. Closing the investment gap with other knowledge economies will help build an environment in which research and ideas will prosper and our country flourish.

To fully realise the benefits of research, the Government needs to provide consistent leadership and coordination over time. Uncertainty in funding disrupts discovery and innovation, hampers long-term approaches needed to deal with challenges such as energy and climate change, and makes it difficult to capitalise on past investments. Unpredictable funding also risks internationally mobile researchers, companies and capital switching country or sector.

The 2014 Science and Innovation Strategy should be the starting point for the development of an ambitious, flexible, long-term framework to support research across Government, industry and charities, and could help the UK to maintain its place at the centre of world-leading research, contributing to growth and improved productivity in our economy.

Attracting investment

Industry is a major engine of the UK economy and is responsible for performing nearly two thirds of UK research and development.[23] High quality research and development fuel economic growth and the creation of skills, high-value jobs and entrepreneurial businesses in our knowledge-driven economy.[24] Research is crucial not just to manufacturing, but also to the creative, financial, legal and technology sectors[25] that will shape our future and will ensure the UK has a vibrant economy and society.

In 2014, the Confederation of British Industry (CBI) said that "the public and private sectors must invest more in R&D to prevent us falling further behind our international competitors"[26] and in 2015 the Federation of Small Businesses called for increased public investment in R&D.[27]

Public investment is crucial in leveraging private and charitable funding from home and abroad. For example, economists have argued that an extra £1 of public funding will give rise to an increase in private funding of between £1.13 and £1.60.[28] Public investment 'crowds in' further private and charitable investment.[29]

Public investment in research also leverages EU funding. The strength of our research base means that the UK is the second largest recipient of funding from the EU's flagship research programme.[30] Total R&D

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[22] BIS (2014). *Our plan for growth: science and innovation* https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/387780/PU1719_HMT_Science_.pdf?utm_source=Home_Page&utm_medium=FlexSlider&utm_campaign=UK_Governments_plan_for_growth

[23] ONS (2015). *UK Gross Domestic Expenditure on R&D, 2013.* http://www.ons.gov.uk/ons/dcp171778_398876.pdf

[24] For example Immunocore's "base paint" to fight cancer or Artemis Intelligent Power's innovative off shore power. See Royal Society (2015). *Inspiring innovations*. https://royalsociety.org/about-us/industry-innovation/inspiring-innovations/

[25] Such as Dundee's computer games cluster. See Royal Society (2015). *Inspiring innovations*. https://royalsociety.org/about-us/industry-innovation/inspiring-innovations/

[26] CBI (2015). *Pulling together. Strengthening the UK's supply chains.* http://www.cbi.org.uk/media/3576042/cbi_supply_chain_report.pdf

[27] Federation of Small Businesses (2015). *Be the voice of small businesses. FSB Business manifesto.* http://www.fsb.org.uk/pressroom/assets/fsb_a4_manifesto_final_web.pdf

[28] Economic Insight (2015) *What is the relationship between public and private investment in science, research and innovation* https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/438763/bis-15-340-relationship-between-public-and-private-investment-in-R-D.pdf

[29] Frontier Economics (2014). *Rates of return to investment in science and innovation*. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/333006/bis-14-990-rates-of-return-to-investment-in-science-and-innovation-revised-final-report.pdf

[30] European Union (2015). *Seventh FP7 Monitoring Report, European Commission*, https://ec.europa.eu/research/evaluations/index_en.cfm?pg=fp7-monitoring

financed from overseas has increased over the last decade and is significantly higher in the UK than in most other countries.[31]

Maintaining a robust research system

It is not just the magnitude of investment that is important to the vitality and performance of the UK's research system but the way in which it is spent. To realise fully the benefits of research the total spectrum of inquiry needs to be supported. Applied investigation needs a constant stream of ideas from discovery-oriented work, and benefits of curiosity driven research are often unforeseen but can transform our lives. For example, mobile phones would not work without the knowledge of the underlying principles of fundamental physics.

Public funding for UK university research flows through two complementary streams, one supporting specific research projects and the other providing the underpinning institutional funding. This diversity of approach contributes to the effectiveness of government support for research.

The 'science ring fence' offers stability and a degree of certainty in turbulent fiscal times. However, a significant part of the funding that is important to the research base lie outside the ring fence and reductions in Britain's public finances will put pressure on overall UK research capability. The ring fence should be maintained but also the Government should avoid reductions elsewhere that jeopardise the research endeavour.

To capitalise on its scientific strength, and public and private investment, the UK needs a comprehensive strategic approach for deciding on research priorities, flexibly focusing resources where needed and establishing a national network of capabilities that is strategically aligned with regional and business priorities.

Research and innovation as drivers of productivity growth and competitiveness

Research creates new knowledge and technological innovations, which can improve productivity by supporting the development of new processes and approaches. Evidence shows that 51% of UK productivity growth between 2000 and 2008 was due to innovation, with 32% attributable to changes in technology resulting from science and innovation.[32] Moreover, economists have suggested that public R&D increases private sector productivity.[33]

The Society welcomes the Government's attention to productivity and the emphasis placed on long-term investment in its recent Productivity Plan.[34] It particularly welcomes the prominence of science, innovation and education in the Plan. However, as long as the UK continues to underinvest in R&D, it will struggle to fulfil the Productivity Plan's ambition of becoming 'the richest of all the major economies by 2030'.

Investing in the UK's intellectual capital

Decisions made now will shape the UK's future for years, possibly decades, to come. Increasing government financed investment in R&D to 0.67% of GDP would help to develop new and existing capabilities that would keep the UK at the forefront of discovery science and innovation. Failure to invest risks ceding scientific and economic leadership to the UK's competitors.

Rebuilding UK research: Successive flat cash settlements for resource funding have eroded science funding and capability in the UK. The Government's commitment to increase capital funding is welcome but resource funding is also needed to make efficient use of buildings, equipment and resources so they are used cost effectively. Failure to rebuild the UK's scientific capability now would threaten the UK's position at the vanguard of global science and risk our long-term economic health. The science and innovation ecosystem is fragile: hard to build and maintain but easy to damage.

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[31] BIS (2014). *Annual innovation report.* https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/293635/bis-14-p188-innovation-report-2014-revised.pdf

[32] BIS (2014). *Our Plan for growth. Evidence paper.* https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/388015/14-1247-science-innovation-strategy-evidence.pdf

[33] Goodridge et.al (2015) *The contribution of public and private R&D to UK productivity growth*. Imperial College Business School, London. http://spiral.imperial.ac.uk/bitstream/10044/1/21171/2/Haskel%202015-03.pdf

[34] HM Treasury (2015). *Fixing the foundations*. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/443898/Productivity_Plan_web.pdf

Multidisciplinary and interdisciplinary research: Many of the major challenges that society faces today will require solutions developed through innovative interdisciplinary research and cross-disciplinary collaboration. Improving support for and addressing the barriers to this work will contribute to scientific advances at the interface of disciplines, spur the development of new technologies and ultimately support the economy and develop novel solutions to societal challenges.

Increasing agility: To stay at the forefront of global science, the UK needs to maintain existing research strengths but also needs the flexibility to respond quickly to developments at constantly shifting scientific frontiers. The ability to adapt existing funding mechanisms or deploy funding through new channels, would give the UK research base greater agility and allow teams of researchers to be assembled quickly.

Capacity building in strategically important emerging fields: There are areas of UK research that are too small to be strongly competitive but are, or might become, strategically important. Excellence should generally be the primary criterion for research funding but there is also the need for approaches that allow the development of capacity building in areas where UK research is weak, so our ability to respond to new developments is increased. Research funders should increase horizon scanning of UK and international science to identify areas of discovery research which should be developed in the UK.

Regional development: There are opportunities for research funders, institutions, cities and businesses to work together to cluster facilities and expertise and embed strategically important research centres across the UK. Aligning the planning and resourcing of science and regions could help turn regions into hubs of excellence with distinctive opportunities for investment from the UK or overseas, including partnering within Europe.

Securing the UK's future prosperity

To ensure that the UK can exploit all that its knowledge and innovation base has to offer and remain an economic powerhouse, it must keep investing in and building a world class research environment. Research and innovation are major routes to the revival of sustainable growth in this country, and, with sustained increased government investment that at least matches the OECD average, they can help to secure extraordinary improvements in prosperity and wellbeing for the UK and its citizens.

In this context, the Government and UK science are both approaching a pivotal moment. The UK economy is returning to growth and the Government is planning to run a surplus before the end of the Parliament. The Conservative Party's Parliamentary majority gives it the opportunity to set out and realise a bold, ambitious, inspirational vision of the future.

Ground-breaking advances in research can be harnessed to transform society, revitalise the economy and improve our health and wellbeing. They can also enable us to tackle major national and international challenges such as food security and building a green economy.

Please contact Tony McBride (tony.mcbride@royalsociety.org or 020 7451 2228) if you have any queries.

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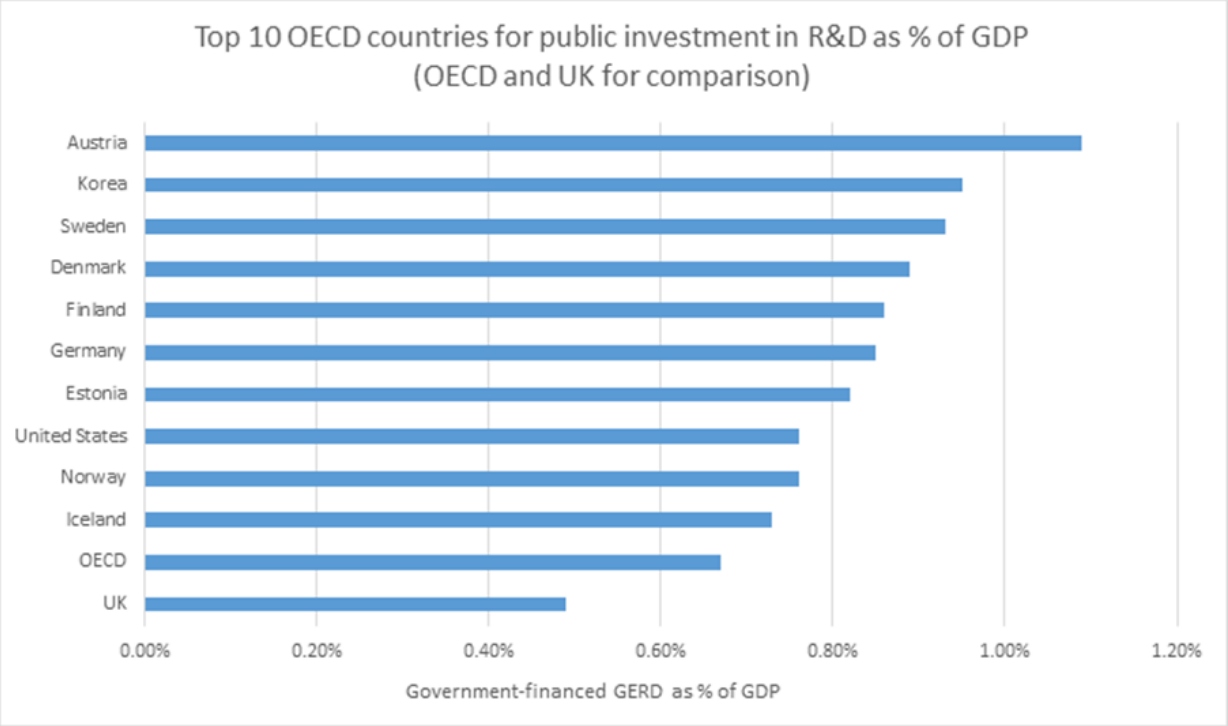
Annex 1



Source: all data is from the OECD Main Science and Technology Indicators except data for the UK (derived from ONS GERD data). Data for Austria, Denmark, Sweden, USA and OECD is provisional and/or based on estimates. Only data from countries where data is available has been used. All data from 2013. For the purposes of this paper the term “OECD” refers to the “OECD total”. This is effectively a weighted average, with weighting for size of economy and government financed expenditure on research and development.