Science Budget 2015

House of Commons Science and Technology Select Committee

Submission from the Royal Academy of Engineering

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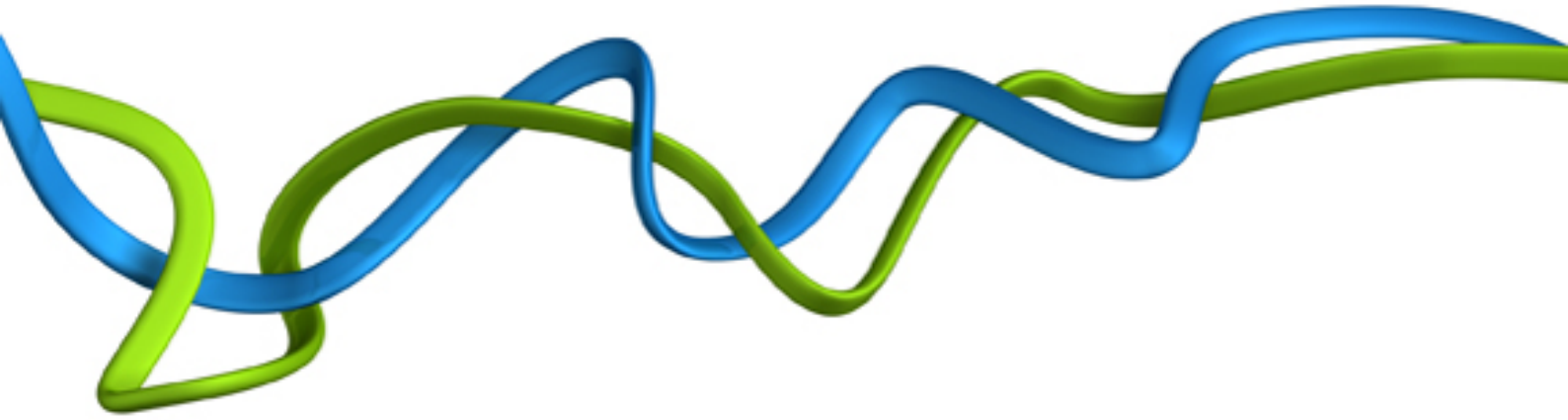

About the Royal Academy of Engineering

As the UK's national academy for engineering, we bring together the most successful and talented engineers for a shared purpose: to advance and promote excellence in engineering.

Royal Academy of Engineering Response to the House of Commons Science & Technology Committee Inquiry into the Science Budget 2015

Summary

The UK has world-class universities, an excellent and highly productive research base, an extraordinary history of invention and innovation and many world-leading science and engineering-based companies. However, international competition is stronger than ever and set to increase in years to come. Despite the maintenance of the science 'ring-fence', the science budget has been falling in real terms since the last Comprehensive Spending Review, with inevitable consequences for the health of the research base. Moreover, the UK suffers from a history of under-investment in innovation, which persists today. This matters because innovation plays a crucial role in unlocking the economic and social potential of the research base, by delivering new products, processes and approaches that create wealth and offer improvements in well-being and quality of life.

The current financial pressures facing the government cannot be ignored but investing in research and innovation can help to create high-value jobs and growth, strengthen productivity and improve the efficiency, effectiveness and resilience of public services. Failure to adopt this strategy will put at risk the UK's competitiveness and its ability to attract high-quality investment and talent. In today's highly interconnected world, companies – including those headquartered in the UK – have to make global choices about where to site their high-value activities.

The Academy therefore calls on government to aim for an R&D investment level of at least 2.8% to bring it into line with other leading knowledge economies, accompanied by strong and well-targeted innovation support. It also recommends that government adopt a systems view of its investments in research and innovation, simplifies the public support mechanisms on offer and makes better use of procurement as a lever to stimulate innovation, in order to maximise the value delivered from these investments.

Q1 The extent to which the current ring-fence arrangements, and the separate arrangements for determining 'resource' and 'capital' allocations, have produced coherent UK science and research investment

1.1 Set against the backdrop of the severe pressures on public spending over recent years, the maintenance of the science ring-fence and the flat cash settlements secured for science and engineering in the Comprehensive Spending Review (CSR) 2010 and Spending Review 2013 were widely considered to be positive outcomes for the research community. Indeed, the ring-fence is considered by many in the research community to be a powerful symbol of government commitment to continued investment in R&D. Nevertheless, these settlements represent a real-terms decrease of over £1.1bn in the ring-fenced science budget over a period when key competitor countries have been increasing their expenditure on R&D, demonstrating that the ring-fence offers only limited protection from cuts.[1]

1.2 From the perspective of the engineering community, it is essential that investment in innovation, much of which is outside the ring-fence, is considered in tandem with investment in R&D – a strong underpinning research base will not be able to deliver the anticipated social and economic benefits to the UK without a coherent and effective innovation system funded at an appropriate level. While innovation budgets have risen

[1] *Science and Engineering Investment,* Campaign for Science and Engineering, 2014 http://sciencecampaign.org.uk/CaSE2015InvestmentBriefing.pdf

over the past CSR period, they remain insufficient and out of step with other leading nations. This is discussed further under question four.

1.3 The Academy has welcomed recent increases in capital investment and the development of a capital roadmap.[2] Capital investment can be a 'sticky' form of public investment, working as an attractor for inward investment and talent flows. Investing in state-of-the-art capital also helps to keep research ideas at the leading-edge, underpins invention and accelerates innovation, thereby supporting future economic growth. It is crucial that consideration is given to the sustainability of investments in capital. Existing and new capital assets require operating budgets to run and maintain them and it is not realistic to expect recurrent costs to be met primarily by already stretched Research Council baselines and institutional budgets.

1.4 A further dimension that needs to be considered is the relationship between capital investment and skills. Capital, skills, research and innovation are all interdependent and core infrastructure is the foundation on which the next generation of leading researchers are trained. Delivering value from cutting-edge facilities requires skilled professionals to operate it, access it and interpret the results derived from it. Due regard must therefore be given to ensuring that appropriately skilled people will be available to operate, and attracted to using, the relevant facility when it becomes available. Regrettably, the arrangements for decisions on capital and resource spending over recent years have not lent themselves to a joined-up, long-term approach. While the government's response to the consultation on the long-term plan for capital acknowledges the importance of these issues, it remains to be seen whether this integrated approach to planning investments will be routinely implemented in future.

Q2 The extent to which science and research expenditure in Government departments (outside the Science Budget) complements or competes with the Science Budget

2.1 As intimated above, best value will be achieved from public investments when policymakers adopt a systems view of the science and innovation base. This requires investments within the ring-fence to be seen in the context of those outside, including funding and incentives targeted at promoting innovation, skills and productivity. It is not clear where the locus is in government for taking a 'birds-eye' view of support for science and research expenditure and its overall impact and effectiveness. The Government Chief Scientific Advisor (GCSA) and his network of Departmental Chief Scientific Advisors (DCSAs) are playing a very valuable role in looking at scientific and engineering issues across government but they do not necessarily have the mandate or mechanisms at their disposal to directly influence spending across different departments.

2.2 By way of example, decisions on supporting energy-related research could be made within a variety of government departments (including the Departments for Business, Innovation and Skills; Energy and Climate Change; Communities and Local Government; and International Development) as well as by a range of Research Councils, Innovate UK and the devolved administrations. The Academy would not wish to see the independence of arms' length bodies curtailed but recognises that there may be value in adopting a 'portfolio management' approach to ensure that public resources for science and innovation are used as effectively as possible.

[2] *Creating the future: a 2020 vision for science and research*, BIS, 2014, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/383439/14-1248-science-capital-consultation-response.pdf

2.3 There is, however, little evidence that science and research expenditure outside the ring-fence competes with the Science Budget. In fact, the available data suggest that departmental R&D budgets have been in decline, with departmental expenditure on science, engineering and technology as a percentage of GDP decreasing by over 50% between 2002 and 2013.[3]

Q3 The need for and rationale for any adjustment to the trajectory of future Government expenditure on science and research, and what would be gained from an increase (or lost from a reduction) compared with current expenditure levels

3.1 The undisputed quality and productivity of UK researchers and higher education institutions make them attractive partners for the best researchers, innovators, investors, universities and companies in the rest of the world, thereby making a crucial contribution to UK competitiveness. However, this leadership position rests heavily on past investments and must not be taken for granted.

3.2 In times of austerity, it is important that spending in all areas comes under scrutiny and efficiency gains are sought, but the UK is already considered to be the most productive nation in the world in terms of its scientific output,[4] and the research community has made large savings through efficiencies such as equipment sharing and team science over the past CSR period.[5] Furthermore, key competitors such as Japan, Korea, the United States, Germany and France have been increasing investment and introducing ambitious strategies to reinforce their positions as leading knowledge economies at the same time as the UK has endured a real terms cut in funding for research: the UK was the only one of these countries with an R&D budget that was lower in 2010 than 2007.[6]

3.3 Looking specifically at engineering, there is much evidence of the world-class status of UK engineering research. For example, 70% of research outputs submitted to the five engineering-related Units of Assessment in the Research Excellence Framework 2014 (REF2014) were classified as 'world-leading' or 'internationally excellent'. In addition, at over one and a half times the world average, the citation impact of UK engineering research has been particularly strong over the last decade relative to comparator countries such as the US, Germany, Japan and Canada, despite the activity level of engineering research in this country being only half the world average, and well behind emerging economies like China and India. A higher level of activity would undoubtedly enable even greater achievements for the UK, if funding was available to support it.[7]

3.4 A recent review jointly commissioned by the Academy and the Engineering and Physical Sciences Research Council (EPSRC) estimated that UK businesses invest at least £9.5 billion per year in engineering R&D while the UK government spends an estimated £1.5 –3.1 billion per year. These data would seem to indicate that the UK achieves

[3] *Building a stronger future*, Academy of Medical Sciences; British Academy; Royal Society; Royal Academy of Engineering, 2015, http://www.raeng.org.uk/publications/reports/building-a-stronger-future-research-innovation-and

[4] *Ibid*

[5] *International Comparative Performance of the UK Research Base – 2013*, Elsevier, 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

[6] *Plan I*, Nesta, 2012, http://www.nesta.org.uk/sites/default/files/plan_i.pdf

[7] http://www.raeng.org.uk/publications/reports/engineering-for-a-successful-nation

significant leverage on its public investment in engineering research, which in turns generates substantial wealth for the nation.[8]

3.5 The high quality of UK engineering research has also helped the UK to attract substantial high-value inward investment from Europe, the US and the Far East which is contributing to new economic activity and employment throughout the UK, often in conjunction with regional growth initiatives. Recent examples include an investment of £7.5 million by Borg Warner to put in place the Turbocharger Research Institute in Bradford which serves as an engineering centre for Jaguar Land Rover, and Siemens' £160 million investment in wind turbine production and installation facilities in Yorkshire.[9]

3.6 In terms of the broader contribution to the economy, engineering accounted for an estimated £280 billion in gross value added (GVA) in 2011, which is 20% of the total UK GVA.[10] In addition, engineering-related sectors exported goods and services valued at around £239 billion, some 48% of the total value of exports.[11] Each engineering-based manufacturing company exports, on average, £9.3 million, which is more than double that for all other manufacturing companies, at £3.9 million.[12] Collectively, this evidence of the economic impact of engineering research and training suggests that further investment in this area could deliver significant benefits for the UK.

3.7 The UK's ability to develop, attract and retain people with the right skills and capabilities will be one of the most critical factors in determining our future competitiveness. It is therefore worrying that the UK faces an engineering skills crisis, needing more than a million new engineers and technicians by 2020.[13] Decreasing our investment in science and engineering could significantly undermine our ability to tackle this skills deficit. It is also worth noting that evidence suggests that engineering graduates, and especially postgraduates, provide the social networks, skills and absorptive capacity to not only undertake engineering tasks but also to drive business development more generally - engineers can be found at the heart of almost any new product development initiative across most sectors of the economy.[14] Consistent with this, sectors with a higher concentration of graduate engineers all report higher than average levels of innovation activity and innovation-related income, as well as levels of labour productivity above the national average.[15]

3.8 In view of this dynamic and pervasive contribution to the UK's economy, there is a strong case for continued support for research and innovation. This requires maintenance of the science ring-fence as a minimum and a recognition that UK investments in research and innovation must be commensurate with the scale of its ambition as a knowledge-driven economy.

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[8] *Assessing the economic returns of engineering research and postgraduate training in the UK*, Technopolis, 2015, http://www.raeng.org.uk/publications/reports/assessing-the-economic-returns-of-engineering-rese
[9] *Ibid*
[10] *Ibid*
[11] *Ibid*
[12] *Ibid*
[13] *The Universe of Engineering*, Engineering the Future 2014, http://www.raeng.org.uk/publications/reports/the-universe-of-engineering
[14] *Assessing the economic returns of engineering research and postgraduate training in the UK*, Technopolis, 2015, http://www.raeng.org.uk/publications/reports/assessing-the-economic-returns-of-engineering-rese
[15] *Ibid*

Q 4 Whether the current distributions of the budget between particular types of expenditure and between different organisations is appropriate for future requirements, and achieves an appropriate balance between pure and applied research

4.1 The Academy welcomes the fact that Innovate UK's budget has increased in recent years but the UK has a history of under-investment in innovation - and this continues to be the case. This matters because innovation is instrumental in delivering the economic and productivity gains associated with investment in R&D, as well as enabling the development of new tools and approaches for tackling major societal challenges and improving quality of life. Approximately half the UK's productivity growth in the decade leading up to the financial crisis was attributable to innovation and there are clear benefits at the level of individual firms.[16] Innovative businesses grow twice as fast as non-innovators,[17] are less likely to fail,[18] are more likely to still be active after 8 years,[19] fair better during periods of economic turmoil,[20] and influence how innovative their high-growth neighbours are.[21]

4.2 In addition to the support provided via Innovate UK, the Higher Education Innovation Fund, administered by the Higher Education Funding Council for England, (and the equivalent funding streams in the devolved nations) plays a useful role in stimulating university knowledge exchange activities. The Academy believes that support of this nature is of value and should be continued, as recommended by the Dowling Review of Business-University Research Collaboration.[22]

4.3 Innovation is not a linear process: it requires feedback from the market, timely and appropriate investment at critical development points and the interaction of a variety of actors. There is a complex interplay, including multiple feedback loops, between fundamental research and use-inspired research. They can both play key roles in driving innovation and provide rigorous intellectual challenges. It can therefore be unhelpful to conceptually compartmentalise research into 'pure' and 'applied'. This also underlines the importance of close collaboration between Innovate UK and the Research Councils.

4.4 Within the context of a thriving research and innovation system, engineering has a specific role to play in creating new and better products and services that can generate wealth and improve quality of life. Strategic investment in engineering can yield a significant return on investment for the UK since engineers draw on scientific advances produced all around the world in developing innovations that create wealth for the UK. This is not to say that funding should be diverted away from other disciplines into engineering, nor from research into innovation. Engineering and innovation draw on insights from fundamental research and in turn can open up new avenues for fundamental research – the relationship is symbiotic.

[16] *Our Plan for Growth: Science and Innovation Strategy*, BIS, 2014
[17] *Business Growth and Innovation*, Nesta Research Report, Mason, Bishop & Robinson, 2009
[18] *Innovation, Innovation Strategy and Survival*, Research Paper No 17, Enterprise Research Centre, 2014
[19] *Ibid*
[20] *Innovation, skills and performance in the downturn*, An analysis of the UK Innovation Survey 2011, 2014
[21] *Innovation and UK high-growth firms*, Nesta Working Paper 13/12, Sena, Hart & Bonner, 2013
[22] *Dowling Review of Business-University Research Collaboration,* 2015, http://www.raeng.org.uk/dowlingreview

Q5 What level of Government expenditure on science and research is needed to significantly drive the overall level of such expenditure in the economy, through synergies between government and private sector investment (including overseas investment); and to optimally balance its benefits against the opportunity cost of government expenditure foregone on other public services.

5.1 It is difficult to provide a specific answer to the question: how much should government spend on R&D and innovation? Nevertheless, it has been repeatedly pointed out that UK is currently well below the top ten OECD investors in R&D, with a total of 1.7% GDP invested in R&D, comprising 0.5% GDP in government investment and 1.2% GDP from the private sector. The leading nine countries (including the United States, South Korea and most of northern Europe) invested 2.8% or more of GDP on R&D, with private sector levels approximately twice the public.[23] Aiming for R&D investment levels of at least 2.8% GDP (of which public investment should comprise approximately a third) would therefore seem a reasonable starting point.

5.2 There has been a long-running debate over whether government funding for R&D and innovation crowds-out support from the private sector. In fact, there is a substantial evidence base showing that public support crowds-in private sector support, with a recent report concluding that an extra £1 of public R&D funding gives rise to an increase in private funding of between £1.13 and £1.60.[24] Firms receiving significant support from government have large and statistically significant results on all measures of innovation activity and output, and receiving a public sector grant doubles a company's spending on innovation.[25]

5.3 Collaboration, the importance of which was highlighted by the Dowling Review, further enhances the benefits associated with public support: firms that receive a grant for innovation are more successful in terms of outputs than peers that don't receive such support but their success is increased if there is an element of cooperation with the public sector, whether via universities, Public Sector Research Establishments (PSREs) or government agencies.[26]

5.4 The EU provides a major source of funding and partnerships for UK R&D and innovation, as well as being a critical market for UK businesses. While UK academics have been exceptionally successful in attracting European funding, the picture is less positive for UK businesses: income drawn down by UK businesses from FP7 is 63% of that achieved by German industry and tends to be clustered in smaller, niche themes rather than the larger, better-funded themes.[27] This emphasises the importance of simplifying the user interfaces for businesses seeking to engage with the research base,

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[23] *Building a stronger future*, Academy of Medical Sciences; British Academy; Royal Society; Royal Academy of Engineering, 2015, http://www.raeng.org.uk/publications/reports/building-a-stronger-future-research-innovation-and

[24] *What is the relationship between public and private investment in science, research and innovation?* Economic Insight, 2015, 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

[25] *Estimating the effect of UK direct public support for innovation*, BIS, 2014, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/369650/bis-14-1168-estimating-the-effect-of-uk-direct-public-support-for-innovation-bis-analysis-paper-number-04.pdf

[26] *Ibid*

[27] *Government Review of the Balance of Competences between the United Kingdom and the European Union – response from the National Academies*, Academy of Medical Sciences; British Academy; Royal Society; Royal Academy of Engineering, 2013, http://raeng.org.uk/societygov/policy/responses/pdf/RD_Joint_National_Academy_Submission_Final.pdf

a key conclusion of the Dowling Review, which noted that the problem was particularly acute for SMEs.[28]

5.5 It is also important that investment is provided over a long-term horizon. Notwithstanding the differences between the German and UK research and innovation systems, the Fraunhofer network in Germany, which has grown organically with consistent public support over a sixty year period, serves to illustrate the tremendous benefits that can be derived from stable and sustained investment.

5.6 The Academy fully recognises that the government faces extremely difficult choices about which areas of public spending to grow, protect and cut. The Academy's call to protect research investment and boost innovation spend reflects the centrality of these areas to delivering near-term economic recovery and long-term economic stability. In addition, innovation offers a much-needed opportunity to increase the efficiency, effectiveness and resilience of public services. Moreover, smarter use of procurement and simplification of the structures for public research and innovation support could actually result in cost savings, as well as delivering better value.

Q6 Whether the Government's expenditures on aspects of science and research are consistent with other government policies, including the Industrial Strategies and the Eight Great Technologies and fiscal incentive policies for research investment;

6.1 The Academy has been strongly supportive of the development of modern industrial strategy in the UK since it provides a welcome signal to business (both domestic and overseas) that government is committed to providing a stable policy framework for key sectors and technologies. The aerospace and automotive industries provide excellent examples of what can be achieved through effective sector leadership councils with strong political and industry buy-in, creating business confidence and a clear vision for the sector. It is therefore unfortunate that there is a risk of momentum being dissipated as a result of the uncertainty around the current government's industrial policy.

6.2 The Academy has also welcomed the focus brought by the identification of the Eight Great technologies, though government might benefit from broader engagement with the academies and other key stakeholders in future prioritisation exercises to ensure that the selection is as robust as possible and that the wider research and innovation community understands the rationale behind the prioritisation. It is also important to consider the balance between maintaining excellence in current areas of strength and identifying emerging topics where the UK has the potential to take a lead in a future global market. In such cases, the public sector can play a crucial role in incentivising others to invest by offsetting some of the risk they incur. In addition, there is a need for clearer identification of areas where the UK needs to maintain strategic national research capabilities, for example in relation to security, energy and health. The loss of the UK's nuclear skills base provides an example of our failure to do this successfully in the past.

6.3 Government is pivotal to the creation of a conducive environment for research and innovation. The wider investment and regulatory context can have a major impact on the ability of the UK to reap the benefits of its investments in R&D. Regulations and standards can act as either brakes on growth or drivers of innovation and well-functioning product, labour and risk capital markets and bankruptcy laws that do not overly penalise business failure can all raise the returns to investing in knowledge-based assets.[29] However, a stable and consistent policy environment can be as important as

[28] *Dowling Review of Business-University Research Collaboration,* 2015, http://www.raeng.org.uk/dowlingreview

[29] *Supporting Investment in Knowledge Capital, Investment and Innovation*, OECD, October 2013

the specifics of the policies in place – the evidence demonstrates that a lack of policy stability can substantially undermine the effectiveness of otherwise favourable policies.[30]

6.4 Once again, a systems view is needed to ensure that direct government expenditure is well aligned with other policies intended to contribute towards a positive environment for research and innovation. The opportunities to stimulate innovation offered by government procurement have already been highlighted; other relevant areas of policy include skills, infrastructure, immigration and the tax regime. The impact of government interventions can be undermined if policies act at cross-purposes. An example of this is the levying of VAT on the construction costs of publicly-funded and charity research institutes if greater than 5% of the activity undertaken is attributable to industry, which can thwart efforts to create shared spaces for industry-academia collaboration.[31]

Q7 The extent to which any increase or reduction in Government expenditure on science and research will have an impact on the UK's relative position among competitor states

7.1 The arguments for investing in R&D and innovation set out in this paper have been embraced by the UK's global competitors. As a result, the UK faces stiff competition for talent and investment and many countries are attempting to strengthen their position in the global innovation race by launching aggressive strategies targeted at boosting their innovation performance, including China, Singapore and Finland. With the continual reshaping of global supply chains, a highly mobile labour force and improvements in communications, most companies, including those headquartered in the UK, have to make global decisions about where to situate their high-value activities. In this highly competitive and internationalised environment, it is more important than ever that the government reinforces its commitment to long-term investment in R&D and innovation.

7.2 The UK already attracts unusually high levels of R&D investment from foreign companies, with 20% of the UK's R&D investment coming from overseas in 2012, compared to 4% for Germany and the United States and 1% for China.[32] This situation has both advantages and disadvantages. On the one hand, companies investing in and siting their R&D activities here benefits the UK economy through the creation of jobs and resource consumption, and there is evidence that this type of foreign direct investment (FDI) can boost the productivity of domestic companies, for example through exposure to new knowledge, networks and capabilities.[33] On the other hand, the high levels of FDI may mask underinvestment by UK businesses and render the UK especially sensitive to changes in international capital flows (both human and financial). Further reductions in our R&D expenditure could send damaging signals to international investors about the attractiveness of the UK as a location for knowledge-based activity.

7.3 The global landscape for R&D and innovation is changing, with several emerging powers now prioritising investment in R&D and innovation as a key determinant of future economic and geopolitical influence. It is therefore crucial that the UK commits to building partnerships at scale with the countries whose investments, talent, infrastructure and industry will make them world-leaders in R&D and innovation in the future, as well as with the scientific and engineering superpowers of today. This may

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[30] *Ibid*

[31] *Dowling Review of Business-University Research Collaboration,* 2015, http://www.raeng.org.uk/dowlingreview

[32] *What is the relationship between public and private investment in science, research and innovation?* Economic Insight, 2015, 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

[33] *Does Inward Foreign Direct Investment Boost the Productivity of Domestic Firms?*, NBER Working Paper No 8724, Haskel, Pereira & Slaughter, 2002

require more funding for international collaborations, more effective tackling of barriers to collaboration, more active involvement in European and international funding schemes and more enlightened interpretation of the Research Councils' national remit. The UK will certainly need to compete more proactively for the best international talent than has been the case to date.

7.4 The Newton Fund offers a potentially powerful mechanism for strengthening relationships with emerging economies, as well as building capacity and delivering knowledge and innovations that will help address the needs of poor people in developing countries. However additional mechanisms are needed to allow UK businesses as well as academics to collaborate with international counterparts in lead sectors and technology areas. It is also important to ensure that the UK has clear metrics that will enable it to understand the performance of its research and innovation system – including with regard to the wider regulatory and investment environment – against international comparators, and takes targeted action to intervene where performance is lagging.

7.5 Finally, it is worth noting that the Higher Education sector generates substantial value for the UK and helps reinforce the perception that the UK is a leading knowledge economy. Engineering research and postgraduate training also have an enormous influence on engineering internationally. Many UK consulting engineering companies, including Arup, Atkins, Mott MacDonald and numerous others, are extremely successful in countries throughout the world because they are applying the high quality engineering research and postgraduate training available in the UK.[34] These strengths provide the UK with substantial opportunities for growth and development. At this pivotal juncture, government needs to ensure that its investment decisions build on these strengths rather than undermining them.

[34] *Engineering for a successful nation*, Royal Academy of Engineering and EPRSC, 2015, http://www.raeng.org.uk/publications/reports/engineering-for-a-successful-nation