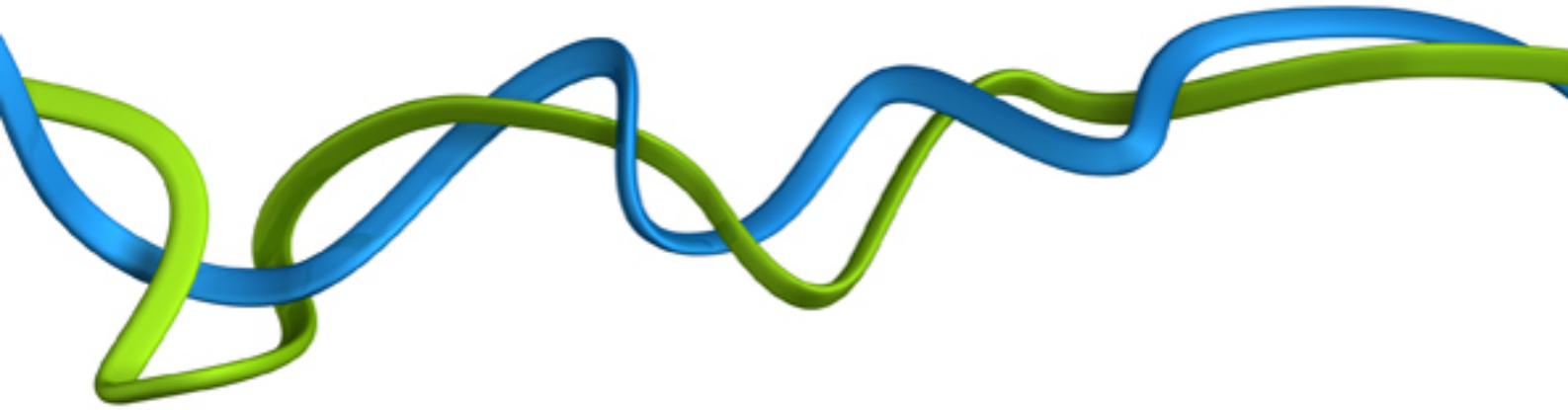
ROYAL ACADEMY OF ENGINEERING

Balance and effectiveness of research and innovation spending

House of Commons Science and Technology Select Committee

Submission from the Royal Academy of Engineering

September 2018



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.

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Introduction

1. The Royal Academy of Engineering welcomes the opportunity to submit evidence to the House of Commons Science and Technology Committee's inquiry into balance and effectiveness of research and innovation spending. The Academy's submission has been informed by the expertise of its Fellowship, which represents some of the nation's best practising engineers, including leading researchers, industrialists, innovators and entrepreneurs.

2. This is a period of unprecedented change for the UK's research and innovation system, including the establishment of UK Research and Innovation (UKRI); the recent introduction of several new funding streams; the development of an Industrial Strategy; and the changes introduced to the next Research Excellence Framework (REF) due in 2021. These changes apply across all facets of the system and they occur against the backdrop of the government's commitment to increasing R&D spending to 2.4% of GDP by 2027 and the UK's departure from the EU.

3. A well-balanced research and innovation portfolio is vital for the UK's global reputation, economy and international competitiveness. The UK has historically under invested in innovation and the Academy welcomes the direction of travel in the Industrial Strategy with the increased focus on innovation. A strong innovation system, with extensive business participation, is necessary to reap the returns from the UK's investment in research – maintaining this trajectory of increased investment will be critical to maximise returns and create an environment that encourages businesses to invest in research and innovation. This is particularly important in light of the target of 2.4% of GDP invested in R&D and the important role businesses have to play in this.

4. The creation of UKRI offers the opportunity for an agile research and innovation system that invests strategically in areas of future growth and brings greater coherence to research and innovation funding. While the Academy welcomed the enshrining of the Haldane and balanced funding principles into legislation following engagement with the research and innovation community, it is important to maintain a high level of engagement and transparency in ongoing strategic decision making. This is particularly relevant in the context of new governance structures and the creation of new funds. The agility of government is to be commended in establishing new funds but speed should not come at the cost of a clear, strategic and transparent process, both in terms of strategic decision-making in their inception and in the processes and criteria for their delivery.

5. The Academy has been working with its sister national academies (the Academy of Medical Sciences, the British Academy and Royal Society) to better understand the existing evidence for the range of benefits that research and innovation bring to the UK, the geographic distribution of those benefits, how they are achieved and how best to measure them to inform future decisions on investment in research and innovation. The findings from this work will be published shortly. The national academies are also producing resources and holding events to encourage wider conversations about the value of creating

a more research and innovation intensive economy in the UK to all UK citizens, and how best to invest resources wisely and efficiently in the national interest.

Balance and effectiveness between:

- **individual research disciplines, Research Councils and cross-disciplinary schemes**

6. Engineering is vital to a vibrant economy, with engineering industries estimated to have generated £420.5 billion in gross value added (GVA) in 2015, equivalent to 25% of the total UK GVA.[1] Strategic investment in engineering yields 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, benefitting from the contributions of many disciplines, and in turn can open up new research avenues – the relationship is symbiotic.

7. In a world economy where technological expertise drives economic growth, investment in engineering and innovation is vital if the UK is to continue as a world-leading nation. It is estimated that UK businesses invest at least £9.5 billion per year in engineering R&D against £1.5 – 3.1 billion per year estimate of public investment.[2] As the UK drives towards the 2.4% target, it is important to build on this by committing to further investment so as to capitalise on this leverage and ensure engineering can convert excellent research into new and improved products and services that contribute to the economy.

8. The Engineering and Physical Sciences Research Council (EPSRC) is the Council with the primary responsibility for engineering research, yet engineering is inherently interdisciplinary. Engineering and technology form part of the activities of other Councils, from Science and Technology Facilities Council (STFC) and Biotechnology and Biological Sciences Research Council (BBSRC) to Innovate UK, and their application is also important to Economic and Social Research Council (ESRC), Medical Research Council (MRC) and Arts and Humanities Research Council (AHRC). Improved support for interdisciplinary and multidisciplinary research was a key driver for establishing UKRI, and with promising innovation often occurring at the interface between disciplines, this emphasis is welcomed. However, interdisciplinary research must also remain a responsibility for all Research Councils.

9. Any future decisions concerning research investment must consider the current levels of funding received from EU programmes and how these may change following the UK's exit from the EU. Four engineering disciplines across UK universities feature among the top ten that received most income from EU government bodies in 2014/15[3]: IT, systems sciences & computer software engineering (£46 million); Electrical, electronic & computer engineering (£39 million); Mechanical, aero & production engineering, (£34.5 million); General engineering (£28 million).

[1] The state of engineering, Engineering UK, 2018
[2] Engineering for a successful nation, Royal Academy of Engineering and Engineering and Physical Sciences Research Council, March 2015.
[3] The role of EU funding in UK research and innovation, Royal Academy of Engineering, Royal Society, British Academy and Academy of Medical Sciences, May 2017.

- **the two research funding streams of the 'dual support' system**

10. The 'dual support' system has undoubtedly contributed to the UK's research success, underpinning the academic research base. Therefore, the Academy welcomed the introduction of the 'balanced funding principle' into legislation as part of the Higher Education and Research Act.[4] In light of the increased investment in R&D, including the introduction of the Industrial Strategy Challenge Fund (ISCF) and the Strength in Places Fund, strategic consideration needs to be given to ensuring that the two components of the dual support system are adequately resourced and balanced to ensure the ambition of the government's new investments can be achieved. These considerations extend beyond UKRI's remit and must include balance across Funding Councils in the devolved nations.

- **the 'golden triangle' and the rest of the UK**

11. The Academy does not believe that regional balance should guide Research Council funding decisions: excellent research should be funded wherever it is found. However, the Academy recognises the importance and potential benefits of considering 'place' and the potential for stimulating innovation and long-term capacity across the whole of the UK. The Academy welcomes the exploration of novel funding mechanisms and approaches that leverage existing local excellence and capacity with the goal of promoting regional prosperity such as the Strength in Places Fund.

12. Regions have different innovation characteristics, and understanding and recognising such differences allows the development of policies which are most effective for a particular area. Science and Innovation Audits go some way towards addressing this need of mapping the landscape, but the data available is still limited and there is more to do. Government should build on the Science and Innovation Audits to develop more comprehensive mapping of local industrial capabilities, including skills, and innovation ecosystems, which would necessitate more industrial engagement in the audits than has sometimes happened.

13. European funding, particularly the European Regional and Development Fund (ERDF), has played a significant role in enabling regional investments in support of research, innovation and associated activities. Over the period 2014 to 2020, the planned ERDF spend for 'research and innovation' in the UK is €2.5 billion, rising to €3.8 billion for 'competitiveness of SMEs'[5]. As the UK proceeds with the negotiations to leave the EU, it is essential that measures are put in place to ensure there will be no gaps and that similar support is made available.

- **Global challenges and other national priorities**

14. The Academy believes it is important that the UK takes the lead in addressing global challenges, such as access to clean water and meeting the needs of an expanding global population. The Academy acts as a delivery partner for the UK's Newton Fund and the Global Challenges Research Fund, which help develop our ability to deliver cutting-edge research as well as partnerships that promote economic development and welfare of developing countries.

[4] Royal Academy of Engineering responds to government amendments to Higher Education and Research Bill, 2017
[5] Data from European Structural and Investment Funds Data, See https://cohesiondata.ec.europa.eu/countries/UK (accessed 30 August 2018).

15. The Academy supports prioritisation as an essential component of any strategy, including the Industrial Strategy and its associated Challenge Fund. However, it is essential that the public and private sectors work together to shape such strategies and ensure that best value is delivered from their collective resources. 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, a clear vision for the sector and catalysing collaborations. Furthermore, the development of the Industrial Strategy, the ISCF, the Grand Challenges and 'sector deals' also make clear the need for an overarching system view to ensure effective delivery.[6]

- **pure and applied research**

16. Conceptually, compartmentalising research into 'pure' and 'applied' can be unhelpful. Research, like innovation, is not a linear process and there are no discrete boundaries between different types of research. The Academy believes 'use-inspired research' is a more helpful concept. Driven by challenges faced by users, whether in industry or elsewhere, 'use-inspired research' is just as intellectually challenging as fundamental research and can be truly excellent. This type of research also has the benefit of developing a breadth of skills for researchers, particularly at the early stages of their careers.

- **Block funding, responsive mode funding and directed funding for Industrial Strategy**

17. A diversity of funding mechanisms is required to support the UK's research and innovation base. Block funding, responsive mode funding and directed funding all have important but complementary functions, each reinforcing different elements of the UK's system. Block funding is vital for ensuring universities can make long-term strategic decisions and investments, responsive mode funding addresses opportunities defined by researchers, while directed funding for the Industrial Strategy addresses national strategic needs and opportunities.

- **research and innovation**

18. The case for continued investment in our research base as a means of fuelling future prosperity is compelling. However, this needs to be accompanied by a strong focus on our innovation investment and performance if we are to reap the full benefit from the potential in our research base, both public and private. Innovation is the process by which ideas are converted into value — in the form of new and improved products, services and approaches. It often draws on R&D and may involve commercialisation, but it is not synonymous with either.

19. The UK consistently ranks within the top ten in most international innovation league tables. However, interrogation of the relevant indicators reveals strengths relating to the UK's research base and universities, but relative weaknesses in indicators related to innovation outputs. For example, the UK ranks fourth overall out of 126 countries in the Global

[6] Engineering an economy that works for all, industrial strategy Green Paper response, Royal Academy of Engineering and Engineering the Future, April 2017

Innovation Index 2018, yet ranks 24th for knowledge absorption and 30th for knowledge diffusion.[7] While an excellent research base undoubtedly provides the UK with a comparative advantage as a knowledge-based economy, a strong research base does not reflect innovation performance per se and will not deliver the benefits associated with innovation if other aspects of the innovation system are weak.

20. The arguments for public support for innovation have been widely accepted by the UK's global competitors. As a result, the UK faces stiff competition for talent and investment. In this highly competitive and internationalised environment, the role of government in providing an assertive, effective and long-term commitment to innovation and the support of effective translational policies, mechanisms and organisations is more important than ever, including through international collaboration.

21. The UK has historically underinvested in innovation. The ISCF and the developing Industrial Strategy more broadly are important steps in readdressing the balance between investment in research and innovation. However, this should not be at the expense of, or prevent, Innovate UK from expanding its core activities. The recent research and innovation budget allocations show a decrease in Innovate UK's core budget, from £714 million in 2017-18 to £695 million in 2019-20 (these figures exclude allocations to Innovate UK to administer the Wave 2 of the ISCF).

22. Innovate UK is well regarded by the engineering community. A close connectivity to its primary customer base of business and entrepreneurs is essential to its success. As such, the Academy welcomed the strengthening of the language regarding its unique business facing function in the legislation. Innovate UK's grant schemes encourage applicants to participate in R&D activities they otherwise would not have done, spread risk and build connections. These schemes show substantial leverage with an average £7.30 returned to the economy in gross value added for every £1 invested.[8] While a diversity of approaches to innovation support is necessary, there remain serious concerns about whether innovation loans will incentivise the type of risky innovative activities that grant funding does. While Innovate UK has a unique function within UKRI, it is important to remember that responsibility for innovation within UKRI does not lie exclusively with Innovate UK. Research Councils and Research England both have crucial roles to play in facilitating knowledge exchange and supporting innovation (equivalent agencies have similar joint roles in the devolved nations, e.g. Scottish Funding Council and Scottish Enterprise)
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23. Research and innovation organisations, such as public sector research establishments, which are publicly funded bodies that carry out research in support of government policymaking or regulatory functions; independent research and technology organisations which are mainly private non-profit research performers or commercial research enterprises providing R&D services, both to government and business; and the Catapult Centres (and the Scottish Innovation Centres), are also important components of the UK's innovation system.

24. Given that uncertainty can have a negative influence on businesses' activities and R&D investment plans are often long-term, providing long-term and stable innovation support can give businesses the confidence to invest. In this regard, innovation support from the EU is considered superior to the UK in two main ways: it is perceived as less susceptible to

[7] Global Innovation Index 2018, Cornell University, INSEAD and WIPO, 2018
[8] 10 years shaping the future, Innovate UK, 2017.

short-term changes and political whim; and, it provides support across the innovation pipeline in a more continuous way than current UK support does. Similarly, a much wider breadth of sectors and disciplines are supported.

25. The UK's world-leading academic research base provides an excellent source of new ideas and discoveries. Through innovation and commercialisation, these can result in advances to our economy and wellbeing. In general, universities' technology transfer offices (TTOs) are responsible for protecting and commercialising IP developed at universities by licensing IP rights to existing companies and through spin-out companies.[9] However, there is a perception that a university's objective to maximise returns from research commercialisation can take precedence over maximising the exploitation of IP. For universities to 'consider their IP strategies as part of their research strategy rather than earned income strategy', as recommended by the UK's IPO, TTOs require long-term financial security. The previous Committee ran an inquiry on the management of intellectual property and technology transfer[10] but it remains a point of concern for many, including the Academy, as there are still significant challenges in creating the best possible conditions for the commercialisation of academic discoveries; from the long-term financial security of TTOs to the way equity is allocated during the formation of spin outs.[11]

Levers to encourage innovation and increase private R&D investment

26. Reaching the 2.4% target will require considerable uplift in investment from businesses, alongside increased public investment. Government has a pivotal role to play in stimulating businesses to invest more in innovation. A substantial body of evidence has shown that public investment in R&D 'crowds-in' private investment, with every £1 spent by the government on R&D leading to a further 20p in R&D output per year in perpetuity by the private sector.[12] While innovation offers many potential benefits at the level of an individual business, government support is often essential to encourage companies to engage in this. This is because R&D and innovation are inherently risky processes with uncertain outcomes, the benefits may only materialise over very long timescales and the innovator often accrues only a small proportion of the overall benefit generated. By creating a conducive policy environment, the public sector can be highly effective at encouraging the private sector to invest in R&D and innovation.

27. Most companies, including those established in the UK, have to make global decisions about where to situate their high value R&D activities. In a highly competitive and international environment, countries must offer a competitive research, innovation and business environment if they want to attract skilled people and companies. Critically, the policy environment for business R&D and innovation extends well beyond the remit of UKRI, cutting across the public sector – from government departments to devolved administrations and local government.

28. Making the UK the leading nation for engineering innovation is one of the Academy's key priorities and exploring factors impacting on engineering businesses R&D and innovation investments decisions is a focus of our research and innovation policy activities. Fiscal

[9] UK University Technology Transfer: behind the headlines, 2015
[10] Managing intellectual property and technology transfer, Science and Technology Committee, 13 March 2017, HC 755 2016-17.
[11] Engineering an economy that works for all, Royal Academy of Engineering, Industrial Strategy Green paper Response, April 2017.
[12] The economic significance of the UK science base, Haskel et al, 2014.

incentives, measures to support business-university collaboration and skills development were measures identified in a survey with almost 1,300 respondents, as part of the engineering profession's response to the Industrial Strategy Green Paper.[13]

29. Building on this work and in response to the 2.4% target, the Academy has set out to ensure that engineering businesses can play a key role in developing a plan to achieve the 2.4% target in a way that delivers social and economic benefits of innovation to the whole of the UK. Given that sectors tightly-linked to engineering are responsible for a significant amount of R&D expenditure[14], it essential that the engineering voice is heard.

30. As a first step, the Academy has conducted a series of interviews with the individuals responsible for making decisions on R&D activity (Chief Technology Officers, heads of R&D, etc) across a wide range of engineering companies, bringing in the perspective of the practitioner in different sectors and parts of UK, to understand the factors that influence decisions on R&D investment. This is a key area of focus in the Academy's policy work and the Academy would be keen to share more of our findings with the Committee as they emerge.

Key areas in attracting, supporting and maintaining R&D investment in the UK:

31. The excellent academic research base in the UK is a key factor in attracting engineering R&D to the UK, primarily early TRL and long-term strategic work. For some companies, collaboration with UK universities plays a crucial role in company growth, driving further R&D investment. However, research in many countries is improving rapidly, increasing competition for collaborative work. Much has been done to understand how to improve collaboration between businesses and universities in a review conducted by the Academy's President, Professor Dame Ann Dowling.[15] While companies value the various ways of collaborating with universities, there remains more to be done for the UK to stay competitive in this area.

32. The tax environment is a powerful lever for Government to encourage businesses from the UK or abroad to invest in R&D in the UK. R&D tax credits are highly valued by companies of all sizes, and the UK system is perceived as competitive in comparison to many other countries. Tax credits can support placement of R&D investment in the UK by large multinational companies by lowering the overall R&D cost. For small companies, tax credits increase their available finance. Unlike grants allocated to specific projects, this allows them to respond to emerging business opportunities and threats as they arise, including further R&D investment. Several other factors make R&D tax credits an effective lever for investment: claiming relief on R&D expenditure with suppliers and staff setting the direction, design and financing of projects (even if R&D work is conducted overseas), to HMRC's pragmatic approach in not requiring significant technical input for claims. The generous definition of what qualifies as an SME for tax purposes[16] is also considered very helpful However, bureaucratic burden remains a problem for some time- and resource-poor SMEs.

33. Innovate UK grants are highly effective at supporting small companies, playing a vital role in their survival, innovation, and growth. They allow companies to increase their R&D

[13] Engineering an economy that works for all, Royal Academy of Engineering and Engineering the Future, April 2017.
[14] Assessing the economic returns of engineering research and postgraduate training in the UK, 2015
[15] Dowling Review of Business-University Research Collaborations, 2015
[16] The definition of SME for tax credits purposes is broader than the conventional one: companies with up to 500 staff and turnover under £100m or balance sheet of £86m qualify as an SME (as opposed to the EU definition, for which limits are 250 staff, £50m turnover or £42m balance sheet).

activity and conduct novel and high-risk projects, driving collaboration and increasing access to a broader network. For many SMEs, grants act as a signal of quality that helps attract private investors. Large companies also use innovation grants (receiving around one-third of Innovate UK's funding in 2017/18), with the benefits of de-risking and driving collaboration as common benefits. However, important limitations need addressing: there are concerns innovation grants work less well for companies developing services rather than products; the scope and timing of funding calls are often perceived to be too restrictive – companies need to access the right support at the right time.

Areas where action could have a transformative effect for businesses to invest in R&D in the UK

34. There is broad consensus across the engineering community that it becomes harder to access finance as companies progress along the investment spectrum, with particular challenges encountered at the growth and later scale-up stages. Frequently, the requirement for relatively short-term returns of many investment funds does not align with the long-term goals of engineering companies wishing to grow. In this context, Enterprise Investment Scheme (EIS) and Seed Enterprise Investment Scheme (SEIS) are very effective for small companies, helping them to attract finance for high-risk R&D activities, and reducing pressure to seek public investment before their products or services are fully developed. In addition, the availability of patient capital has long been identified as a significant barrier in the ability of UK companies to innovate.[17] Whilst the measures outlined in the Patient Capital Review represent a positive step, more needs to be done to address and improve companies' access to long-term capital.

35. Public procurement is an area that has the potential to have a disproportionately transformative effect on UK companies: utilising only a small proportion of the procurement budget (which currently amounts to 14% of GDP at £268 billion a year)[18] to target innovative approaches and SMEs could have a huge impact. For many engineering companies, the public sector forms a major proportion of their market, with procurement processes a key determinant of their location and R&D investment. But procurement is a significant barrier to increased R&D investment for many companies due to the focus on achieving the lowest cost, failure to develop collaborative relationships, restrictive rules on IP and the absence of incentives for companies to take risk and propose novel approaches. Government has long recognised this is an unresolved challenge that provides opportunities to support and drive innovation in the private sector, but interventions to date have not delivered catalytic change. It is important not to reduce public procurement to SBRI: procurement can be used beyond research and beyond small businesses. Defence projects for the Ministry of Defence or Highways England Innovation Fund were highlighted as important examples outside SBRI.

36. After early stage R&D and prototyping, most new products need to be developed and demonstrated at scale before they can be put on the market – for example, autonomous vehicle technology need to be trialled in full-scale, city-like testing facilities between lab-based research and being sold to customers. Attracting investment in late stage R&D also has benefits for the broader economy as it often becomes a primary site for a company's market development and further R&D. Support for this work in the UK is very limited

[17] Industrial Strategy: building a Britain fit for the future, Department for Business, Energy and Industrial Strategy, November 2017.
[18] *Ibid.*

compared to competitor countries and it is a significant barrier to some companies' R&D investment in the UK. Of active Innovate UK projects in 2017, only 10% received funding over £1 million, suggesting that large scale, late stage projects like demonstrators are relatively rare. This lack of support means that small companies find it harder to cross the 'valley of death' to market and that large companies often decide to invest outside the UK, leading to knock-on effects around market development and technology uptake. Waves 2 and 3 of ISCF present opportunities to help address this demonstrator gap through investments of scale.

37. At a strategic level, many companies find UK government support for R&D and innovation frustrating, fragmented, and not joined-up. This detracts significantly from the UK as a site for business R&D investment. The Industrial Strategy sends a positive message, providing a long-term backdrop for private investment in innovation. However, it is vital that this receives sufficient support for delivery in practice, and that delivery is understood as a cross-government responsibility. It should also continue to be informed by industry themselves. Effective support for innovation and the commercialisation of research needs to connect with relevant policy areas beyond those which BEIS is directly responsible for, with important interfaces to policies on trade, exports, infrastructure, education and skills, immigration, procurement, energy and tax etc. The ability of the UK to achieve longevity of innovation success depends on the support of, and coordination with all government departments.