# Building a stronger future

Research, innovation and growth

THE ROYAL SOCIETY

BRITISH ACADEMY
for the humanities and social sciences

ROYAL ACADEMY OF ENGINEERING

The Academy of Medical Sciences

# To make the UK the best place in which to do research and innovation, the National Academies urge the next Government to:

### Place research and innovation at the heart of plans for long-term economic growth.

- Build a long-term flexible framework to support research across Government, industry and charities.
- Create an environment that attracts more industrial and charitable investment in addition to that from Government.

### Secure prosperity by strengthening public investment in research and innovation.

- Increase investment in world-leading research and strengthen support for innovation.
- Commit to investment levels that keep pace with other leading knowledge economies.
- Create a stable long-term investment environment and secure the ring fence around the science budget.

### Meet demand for research skills through a flexible and diverse workforce.

- Provide enough teachers with specialist subject knowledge at all stages of education.
- Make the research workforce more diverse, giving equal opportunity to all available talent.
- Remove unnecessary barriers to the flow of talented people.
- Encourage and facilitate mobility between sectors and disciplines.

### Strengthen policy by embedding expert advice across Government.

- Promote the principles and practice of independent expert advice in UK, European and international policy making.
- Build reliable horizon scanning into long-term policy development.

# Building a stronger future

Outstanding research and innovation advance our economic, social and cultural well-being and our health. In modern economies they are a key source of competitive advantage and can help increase productivity. The UK has created a world-leading research base, which provides the foundation for new ideas and discoveries, and fuels economic growth and the creation of high-value jobs and skills in our knowledge-driven economy. Excellent research and innovation help us to live healthier, fuller and better lives.

Working together across the full spectrum of disciplines, UK researchers address major national and global challenges – from economic recovery to climate change, from security to ageing. The evident high quality and productivity of UK researchers and institutions make them attractive partners for the best and most ambitious in the rest of the world, which is crucial to keeping UK research at the cutting edge.

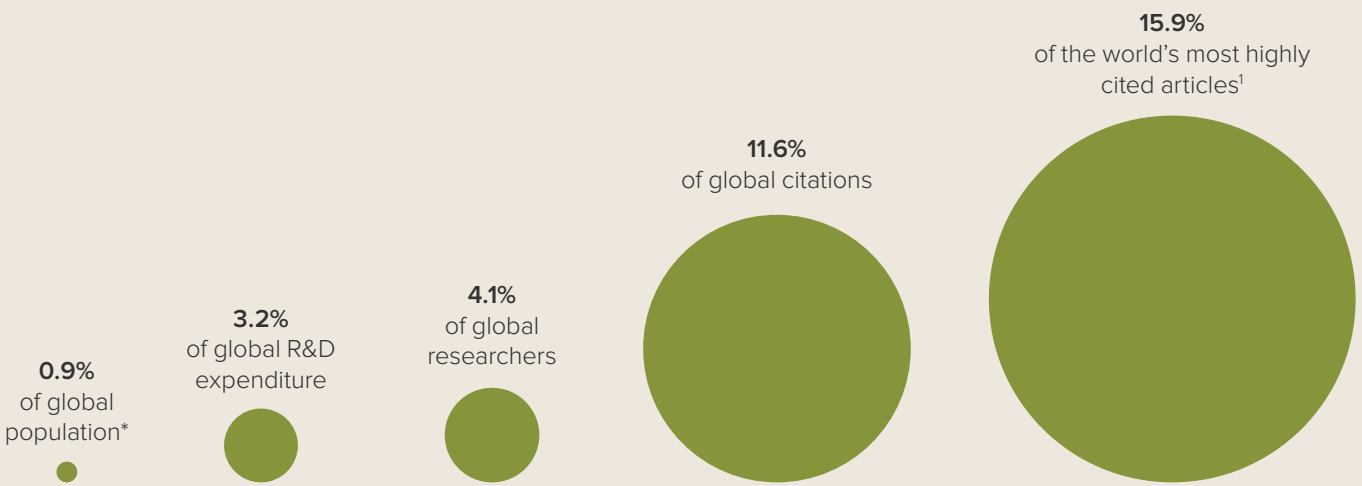
However, the UK's leadership in research cannot be taken for granted. UK investment in research is failing to keep pace with other leading nations and risks eroding the UK's capacity to attract and retain the very best researchers from the UK and overseas. In addition, the UK has skills shortages that damage the health of its research and innovation base, limiting its ability to pull through the output of the research base and compete in a global marketplace.

To ensure that the UK can exploit all that its excellent research and innovation base has to offer and remain an economic powerhouse, it must keep investing in and building an environment in which research will prosper and ideas will flourish. Research and innovation are major routes to the revival of sustainable growth in this country, and are essential if the UK is not to fall behind its international competitors. They also play a powerful role in ensuring that the UK is an open, vibrant and enquiring society with a deep cultural base. A society worth living in.

Building stronger bridges between researchers, innovators and policy makers is vital to ensure that expert advice is at the heart of policy making. Public engagement will help to ensure that research and innovation is open and inclusive, that citizens make informed choices about their lives and the lives of others and that the benefits arising from advances in research and innovation can be fully realised.

This statement from the four UK National Academies speaks for UK research and innovation across the full range of the natural, engineering, medical and social sciences, and the humanities. As Fellowships of many of the world's most distinguished scientists, researchers, and engineers we are dedicated to achieving extraordinary improvements in prosperity and well-being.

## BOX 1: The strength of UK research and innovation




*Circles are scaled by diameter for comparison

### HOW THE UK RANKS GLOBALLY

- **2nd** for the quality of its scientific research institutions.[2]
- **2nd** in the Global Innovation Index which compares 143 economies on 81 indicators.[3]
- **4th** for its university-industry collaboration in R&D.[4]

The UK has won 16% of research funding from the most recent European Framework Programme (FP7) with only 12.7% of the EU-28 population.[5]

**In 2013 medical research charities fund £1.3 billion of health research** – a third of all publicly funded medical research.[6]

UK research is cited in **10.9%** of all patent applications worldwide.[7]

PART ONE

# Place research and innovation at the heart of plans for long-term economic growth.

**Build a long-term flexible framework to support research across Government, industry and charities.**

In advanced economies like the UK, research and innovation make a major contribution to long-term growth.[8] To fully realise these benefits Government needs to provide leadership and coordination over decades. The 2014 Science and Innovation Strategy represents progress toward such a long-term approach. The Strategy highlights the importance of investment in research capital but complementary funding is also needed to breathe life into buildings, equipment and resources. The Academies urge the next Government to use the Strategy as a starting point to develop a flexible delivery plan in collaboration with the research community.

Firms that consistently invest in R&D are **13%** more productive than firms that don't invest in R&D.[9]

**Create an environment that attracts more industrial and charitable investment, in addition to that from Government.**

Business is the engine of the UK economy (see box 2) and industry is responsible for performing nearly two thirds of UK research and development (R&D) (see figure 1). However, industrial expenditure is relatively low by international standards (see figure 2), research is concentrated in only a few areas and there is insufficient innovation in small and medium-sized enterprises (SMEs).[10] Industrial strategies that help stimulate key sectors are important and need to be supported by effective policies in areas such as procurement, regulation, taxation, immigration and access to data and finance to help create the conditions that are conducive to investment. An environment that attracts additional investment would also provide incentives for globally mobile international companies to establish and retain their research bases in the UK.

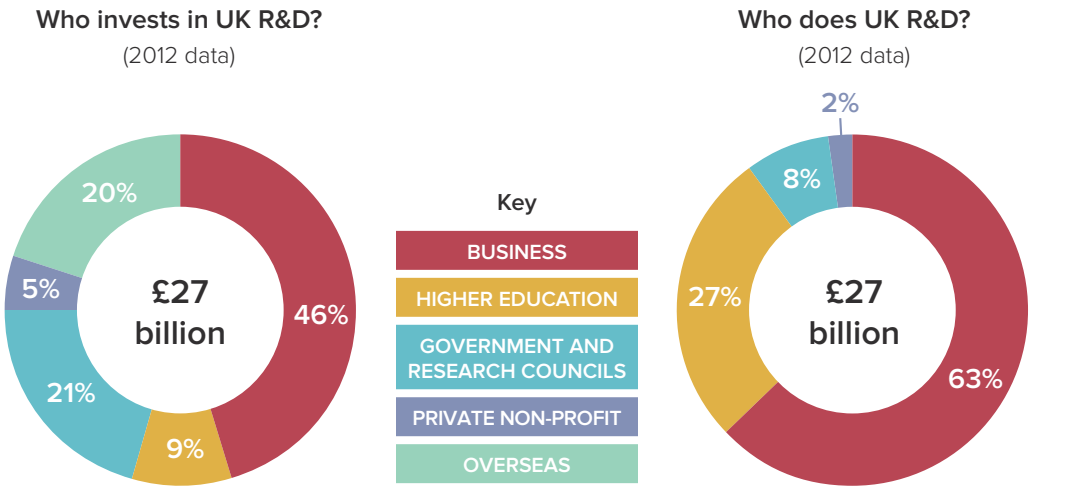
These issues are also important to secure support from charities that help fund and undertake life-saving research. Medical charities invest £1.3 billion annually, constituting a third of all publicly funded medical research.

"Unless we get smarter, we'll get poorer."

**Lord Rees of Ludlow OM FRS, Astronomer Royal**[11]

It is estimated that every £1 increase in public funding for medical research stimulates up to £5 of additional investment into research by the pharmaceutical industry.[12]

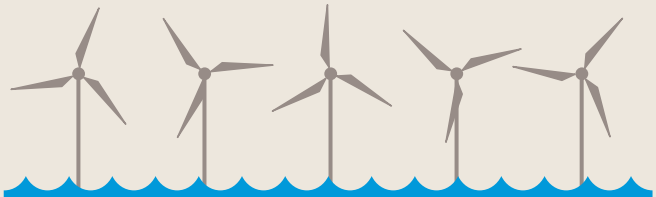
**FIGURE 1: UK R&D expenditure by funding and by performing sector[13]**




Note that figures are rounded.

The British Museum is the UK's largest visitor attraction. In 2013-14 it had **6.7 million visitors** and secured a record **£3.26 million** in research funding.[14]

## BOX 2: Examples of the value of research-based industry activity



The UK operates **more offshore wind turbines** than the rest of the world combined and the sector could deliver up to **£7 billion GVA*** by 2020/21 and support **30,000 jobs**[15]

A **1% increase** in the number of high-growth firms (scale-ups) should create an additional

**238,000 jobs**

and **£38 billion** to GVA within three years[16]

The digital sector employs **3%** of the UK workforce and contributes nearly

**£69 billion**

GVA to the UK economy[17]

The UK chemicals sector generated annual sales of nearly **£31 billion...**

...accounting for **11%** of all manufacturing exports by value

**2012**

Produced **£8.6 billion** in GVA

contributed a total of **£591 million** in R&D investment[18]

There are **177,000** design jobs in the UK creative economy and the design sector was responsible for an estimated

**£3.1 billion**

GVA in 2013 – a 23.8% rise from 2008[19]

*Gross Value Added

PART TWO

# Secure prosperity by strengthening public investment in research and innovation.

**Increase investment in world-leading research and strengthen support for innovation.**

To fully realise the economic and social benefits of research and innovation, the full spectrum of inquiry has to be supported.[20] Applied investigation needs a constant stream of ideas from discovery-oriented work, and many benefits of 'blue skies' research are unforeseen but of great practical use. However, linear models of research do not properly describe the multidirectional flow of ideas between different types of study or acknowledge the time lags that sometimes separate investment and substantial returns. Public funding for UK research flows through two complementary streams, one of which supports specific research projects while the other provides underpinning institutional funding. Both are governed by two key principles: funding decisions should be insulated from political pressure and resources should be allocated on the basis of excellence.

While recent Government support for innovation has been encouraging, it does not go far enough and is not on the same scale as many competitors.[21] The Finnish economy is one-tenth of the size of the UK's, but in 2013, TEKES (the Finnish innovation agency) invested €542.3 million*, compared to Innovate UK's £440.9 million.[22] Government must continue to support the channels through which investment in knowledge and skills create value but investment in innovation should not come at the expense of other parts of the research base. To position innovation and research in competition with one another risks doing damage to the system as a whole.

**51%** of productivity growth between 2000 and 2008 was due to innovation.[23]

"Genuinely revolutionary technology begins with research."

Sir James Dyson FREng[24]

*Equivalent to £460.3 million at pound sterling to euro exchange on 15 June 2013.

"There are two kinds of research: applied research and not yet applied research."

**Lord Porter FRS, Nobel Laureate[25]**

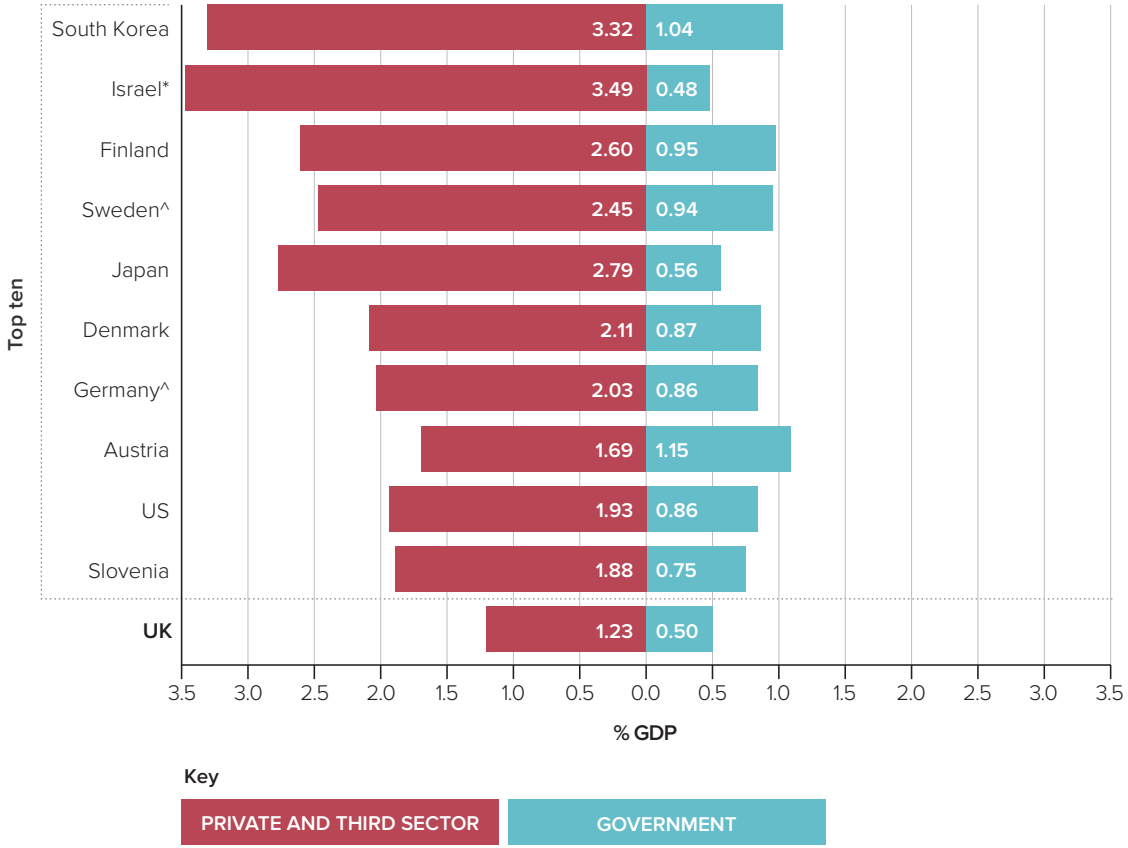
**Commit to investment levels that keep pace with other leading knowledge economies.**

The level of UK public investment in research and innovation needs to be closer to that of its international competitors and collaborators (see figure 2). Narrowing the gap with other knowledge economies will help the UK research base to tackle national and global challenges, attract research talent and investment from abroad, and allow participation in international research collaborations such as the 2014 Rosetta space mission by the European Space Agency. In 2014 the House of Commons Business, Innovation and Skills Select Committee recommended investment levels of 3% of GDP by 2020, and that same year a report for the Government called for investment to be closer to 2.9% of GDP.[26] However the disparity is framed, one thing is clear: increased investment is necessary for the UK to remain competitive.

While recent investment in research capital is welcome, 'flat cash' settlements means that the cumulative erosion of the ring fenced science budget from the 2010 spending review to 2015/16 will be over £1.1 billion.[27] The effect of continued flat cash settlements for resource funding is illustrated in figure 3. The research community has made large savings through efficiencies, such as equipment sharing and team science, but this cannot continue indefinitely.[28] Cuts to research and innovation in the 1980s drove many leading UK scientists to the USA.[29] Generous investments in research by governments across the world, coupled with austerity at home, risks creating a similar exodus today.

The technology that drives **95%** of the world's smart phones, **80%** of digital cameras, and **35%** of all electronic devices was developed in the UK.[30]

**FIGURE 2: Top ten OECD investors in research and innovation – How does the UK compare?[31]**

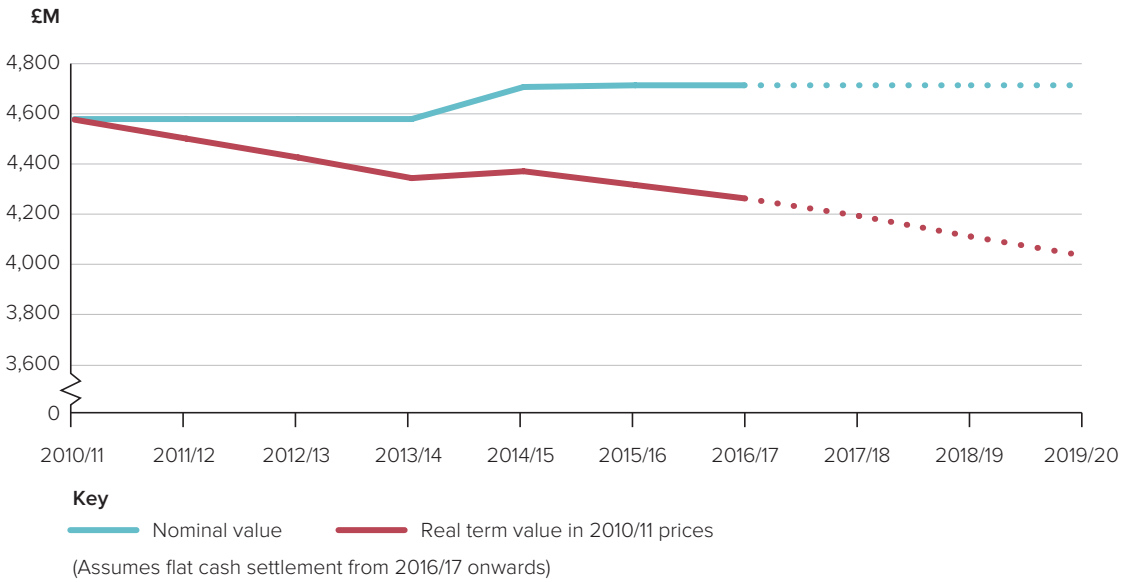



Latest available data – unless otherwise stated from 2012
* Data from 2010
^ Data from 2011

"The public and private sectors must invest more in R&D to prevent us falling further behind our international competitors."

**CBI, 2014[32]**

**FIGURE 3: Effect of flat cash on the ring fenced science budget[33]**

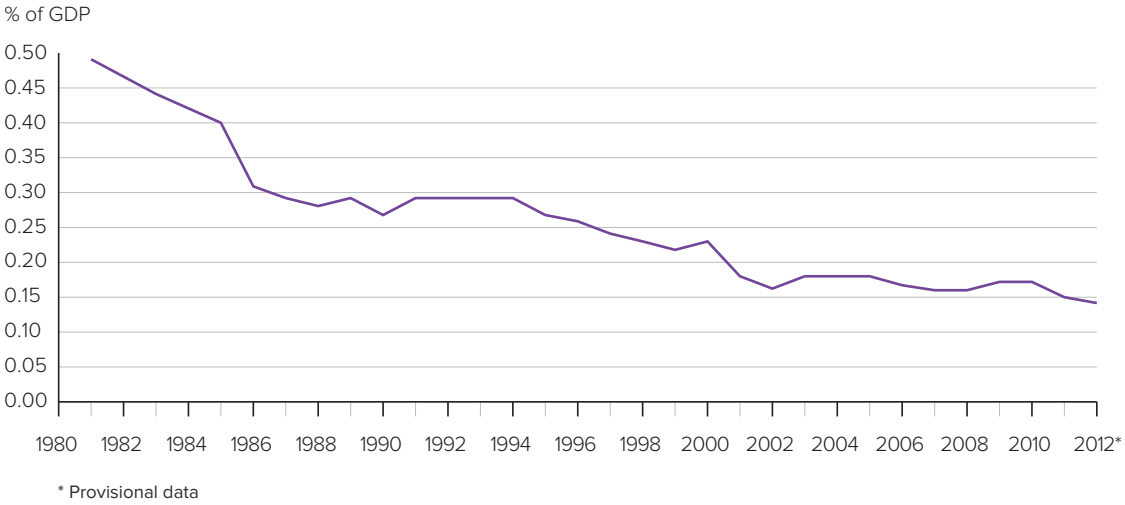



## Create a stable long-term investment environment and secure the ring fence around the science budget.

The 'science ring fence' offers stability and a degree of certainty in turbulent fiscal times. Such clear commitment is crucial for investigations that span decades or even lifetimes, like the five British birth cohort studies which have been in place for over half a century and have been an invaluable resource for both research and policy.[34] Much of the funding that is important to the research base, such as money for further education and higher education teaching, lies outside the ring fence but within BIS. While maintaining the ring fence, the Government should avoid creating a competition for resources between important and complementary aspects of the UK's knowledge and skills base.

Strategic research in other Government departments, such as health and international development, informs public policy and provides solid foundations for the research and innovation system, through instrumentation, monitoring, development of standards and regulation. However, overall

**FIGURE 4: Government departmental spending on R&D (GovERD)[35]**




* Provisional data

departmental R&D spending has undergone a sustained long-term decline (see figure 4). This is worrying because departments need access to high-quality strategic research and the science budget within BIS cannot replace research undertaken by Government departments, either internally or in collaboration with the academic research community. The Academies welcome the Government's forthcoming consideration of controls to protect departmental R&D spending from short-term pressure. If suitable measures are identified they should be implemented as soon as possible.

Pioneering surgery based on British research helped a paralysed man walk again, by using cells from his nose to regrow nerve fibres to close an 8mm gap in his spinal cord.[36]

PART THREE

# Meet demand for research skills through a flexible and diverse workforce.

## Provide enough teachers with specialist subject knowledge at all stages of education.

Urgent action is required so the UK can meet the demand for skilled people, otherwise both the UK research base and the wider economy will be weakened. By 2020, 1.28 million workers will be required[37] to fill science, engineering and technology roles, yet not enough UK-based students are coming through the education system to take up those roles.

The education of the future workforce needs to be underpinned by a highly valued and highly skilled teaching profession. There are currently too few teachers with specialist subject knowledge at all stages of education. More than 20% of mathematics and chemistry teachers, a third of physics teachers and more than half of computing teachers in state-funded schools in England have no relevant post-A-level qualification in the subject they are teaching.[38] Shortages are a particular problem in science, technology, engineering and mathematics (STEM) subjects and languages.[39,40] In higher education, teaching is often undervalued when compared with research performance.[41]

**39%**

**of firms have difficulty recruiting staff with skills in science, technology, engineering and mathematics and**

**65%**

**of firms value foreign language skills.[42]**

**Only 3%**

**of black and minority ethnic female academics are professors, compared to 14.6% of white male academics.[43]**

**80%**

**of vice-chancellors and principals are male.[44]**

## Make the research workforce more diverse, giving equal opportunity to all available talent.

Equality of opportunity is a fundamental part of civilised society and no individual should be unfairly prevented from engaging in research, education, training or careers. However, it is not enough to simply secure access. Structural impediments, such as short-term contracts and lack of flexible working arrangements, as well as research culture, need to be addressed. Government can play a key role in coordinating action, helping to measure impact and improving data collection to inform future policy.[45]

**40%** of all living British Nobel Prize winners were born overseas.[46]

## Remove unnecessary barriers to the flow of talented people.

The UK is a major hub for international research and education. Career researchers are likely to follow the best work and resources, and in an increasingly networked world discussion has moved from halting the 'brain drain' to making the most of 'brain circulation'.[47] This can be aided by initiatives such as the Newton Fund which supports early-career researchers to work in the UK, and helps develop and strengthen international partnerships.[48] Traditionally, the UK has attracted many international students,[49] and has been particularly competitive in attracting post-graduate level students, although the numbers choosing to study some types of research-based degrees have recently decreased.[50]

The UK needs to have the right policies in place to encourage valuable immigration, and minimise unnecessary barriers to the flow of talented researchers and students. Clear messages and policies are crucially needed to counter perceptions that recent changes to immigration policy mean the UK is closed for business.[51] Moreover, there is a need to collect better data on the migration of talented scientists and their diaspora networks, to enable policy makers to better understand and support relationships between researchers from different parts of the world.

### Encourage and facilitate mobility between sectors and disciplines.

High-level academic qualifications are a gateway to research careers but also to employment in other sectors, such as financial services, heritage and culture, creative industries and information technology. Multiple education and career pathways are needed, with more opportunities to move seamlessly between sectors and disciplines.

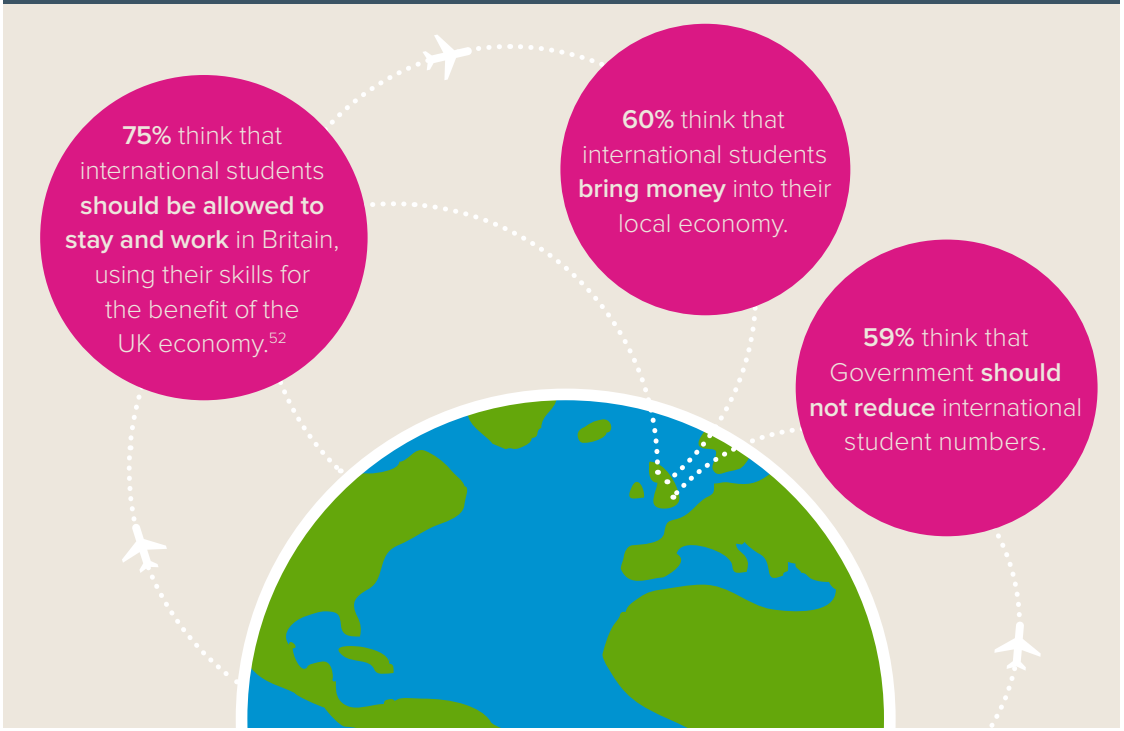
This will also encourage interdisciplinary working. High-quality career guidance is needed to help illuminate different roles and transferable skills programmes are required to ease mobility. Richer dialogue between academia and industry will ensure courses equip individuals with the skills needed for current and future research careers in any sector.

**The higher education sector generated**

**£73 billion**

**of output in 2011/12, through direct and indirect effects.[53]**

**BOX 3: Public perception of international students**



PART FOUR

# Strengthen policy by embedding expert advice across Government.

**Promote the principles and practice of independent expert advice in UK, European and international policy making.**

Policy making is increasingly dependent on complex evidence that could help unlock solutions of great economic and social value (see box 4). Input from experts is required for decision makers to tackle unexpected challenges (see box 5), like the disruption of air travel caused by the eruption of the Icelandic volcano Eyjafjallajökull in 2010, and more everyday challenges, like how to pay for the care of older people. Many risks in today's interconnected world also stem from global political or economic instability and research-based evidence can help provide long-term solutions.[55] The Kay review of UK equity markets[56] is an example of how economic research can be used to advise on economic stability and trust within a nation.

High-quality expert advice should be based on an assessment of the overall strength of the available evidence. If there is no strong consensus, or if knowledge is still tentative, these uncertainties should be reflected in the advice. Other factors, such as moral values, play a legitimate role in shaping policy. In all cases, the Government should be transparent about why decisions have been made.

By helping to prevent a bluetongue virus outbreak among livestock, **a potential loss of £485 million and 10,000 jobs was avoided,** through Biotechnology and Biological Sciences Research Council-led research.[54]

**1 in 10** workers' wages have increased due to the introduction of the national minimum wage which was influenced by research funded by the Economic and Social Research Council.[57]

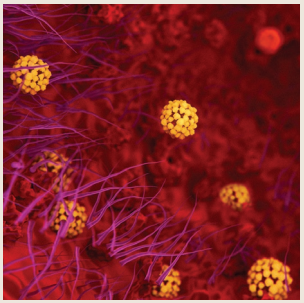
## BOX 4: Value of expert advice in infectious diseases



### BSE

In the 1990s the emergence of bovine spongiform encephalopathy (BSE) meant that policy makers had to take swift decisions with limited information. There were major failings in the way evidence was sought and used in tackling the BSE crisis and by 2000, it had cost the Government £3.7 billion and damaged public trust.[58]





### SARS

Expert advice helped identify the virus responsible for Severe Acute Respiratory Syndrome (SARS), trace those who had been exposed and provide a coordinated global response, halting the 2003 outbreak that had caused 774 deaths and cost tens of billions of dollars.[59,60]



### EBOLA

By 20 January 2015 more than 8,500 people had died from the Ebola virus, mainly in West Africa.[61] The full impact of the disease is as yet unknown but the World Bank estimates the regional financial cost could reach as much as US$32.6 billion by the end of 2015.[62] To reduce the toll of future health crises there have been widespread calls to strengthen global health governance,[63] of which expert advice is an important part.



### AMR

A 2014 report commissioned by the Prime Minister estimated that antimicrobial resistance (AMR) will lead to an additional 10 million deaths each year worldwide by 2050 and cost the global economy up to US$100 trillion. Expert advice and collaborative research, both internationally and between academia and industry, will be crucial to address this challenge.[64]

The UK's world-class research and innovation should be reflected in world-class policy making. The presence of Chief Scientific Advisers (CSAs) in most Government departments is the cornerstone of the UK's system of expert advice. This could be further strengthened by ensuring that all CSAs have sufficient support and status within their departments as well as access to Ministers. Growing enthusiasm for devolution means that expert advice may also need to be better embedded in local or regional decision making. The CSAs in the devolved nations and the first city CSA in Southampton might offer useful templates for independent expert advice outside Whitehall.

**79% of the public** agree that even if it brings no immediate benefits, research which advances knowledge should be funded by the Government.[65]

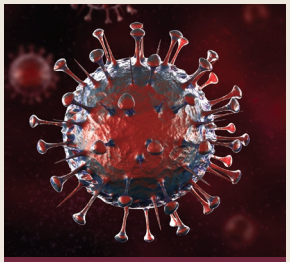
As Government wrestles with ever more intractable problems, civil servants face more demands on their time, calls for transparency become louder and decision makers are increasingly looking outward when developing policy. There are many initiatives to build bridges between researchers and policy makers, such as What Works Centres and the Parliamentary Office of Science and Technology. The UK's world-class research base offers a rich resource for policy makers, (see box 6) with bodies that are impartial, transparent and understand the methods and value of research. Alongside other organisations, national academies and their international networks are well placed to assist. The public can play an important role and should be involved from the earliest stages of policy development. Public engagement can help to ensure that research and innovation is open and inclusive and that citizens make informed choices about their lives and the lives of others. In this way, public engagement can help to ensure that the benefits arising in research and innovation can be fully realised.

**75%**

**of the public feel that the Government should act in line with public concerns about science.[66]**

## BOX 5: Challenges can benefit from expert advice

Recent challenges faced by the Scientific Advisory Group for Emergencies (SAGE)[67]




**2009** Pandemic flu


**2010** Volcanic ash


**2011** Fukushima


**2013** Flooding


**2014** Ebola

**2015 and beyond**

## BOX 6: Interdisciplinary advice in policy making


Research in psychology and economics was used to successfully promote the introduction of **cognitive behavioural therapies** that could run alongside and sometimes replace **drug treatment** for people with anxiety and depression.

These ideas have been heavily influential in the NHS, where the development and growth of the IAPT initiative (Improving Access to Psychological Therapies) now offers thousands of people more widely available and more cost-effective routes back to better health.[68]

The outcome of a Design Council challenge to identify effective means of reducing violence and aggression in A&E resulted in a 50% reduction in threatening body language and aggressive behaviour.[69]

Many global challenges and new technologies, such as antimicrobial resistance or geoengineering, require international collaboration involving multiple partners. Others involve bilateral arrangements such as when the UK worked with Japan following the Fukushima nuclear disaster in 2011.[70] The European Union has an increasing influence on policy making both within its member states and in international negotiations. The UK Government should draw on its expertise and promote the use of expert advice as central to the European policy making process.

**Build reliable horizon scanning into long-term policy development.**

Horizon scanning is a useful strategic tool for government decision making and the renewed interest of the UK Government following the Day Review is welcome.[71] There is much to be gained by embedding methodologically robust futures thinking (informed by independent expert advice) in strategic and policy development. For example, the UK Government's 2006 infectious disease Foresight exercise has had substantial impact in the UK and internationally, including greater funding for the detection and identification of infectious diseases, promoting links across Government departments and informing long-term strategies of major European and multi-national organisations.[72]

Sulphur pollution in the UK has been reduced by **80%** through international protocols that drew greatly on research by the Natural Environment Research Council.[73]

# Groundbreaking advances in research can be harnessed to transform society, revitalise the economy and improve our health and quality of life.

The UK's track record of research excellence took centuries to establish but could be quickly lost. Discovery and innovation helped to make the UK an economic powerhouse during the enlightenment and industrial revolution. To secure a prosperous future the UK needs an innovation revolution with research front and centre. Bold leadership and decisive action is required to make the UK the best place in which to do research and innovation.

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**For further information**


**The Royal Society**
Science Policy Centre
6 – 9 Carlton House Terrace
London SW1Y 5AG

**T** +44 20 7451 2500
**W** royalsociety.org

Registered Charity No. 207043

**Royal Academy of Engineering**
Prince Philip House
3 Carlton House Terrace
London SW1Y 5DG

**T** +44 20 7766 0600
**W** raeng.org.uk

Registered Charity No. 293074

**British Academy**
10 –11 Carlton House Terrace
London SW1Y 5AH

**T** +44 207 969 5200
**W** britac.ac.uk

Registered Charity No. 233176

**Academy of Medical Sciences**
41 Portland Place
London W1B 1QH

**T** +44 20 3176 2154
**W** acmedsci.ac.uk

Registered Charity No. 1070618



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“I believe in innovation and that the way you get innovation is you fund research and you learn the basic facts.”

**Bill Gates**