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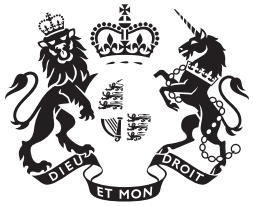
Scotland analysis: Science and research

November 2013



Scotland analysis: Science and research

Presented to Parliament
by the Secretary of State for
Business, Innovation and Skills
by Command of Her Majesty
November 2013

Cm 8728
£21.25

Any enquiries regarding this publication should be sent to us at
The Enquiry Unit, The Department for Business, Innovation and Skills, London SW1H 0ET

ISBN: 9780101872829

Printed in the UK by
The Stationery Office Limited on behalf of the Controller of Her Majesty's Stationery Office

ID 2599451 11/13

Printed on paper containing 75% recycled fibre content minimum.

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Executive summary

In September 2014 the people in Scotland will take one of the most important decisions in the history of Scotland and the whole of the United Kingdom (UK) – whether to stay in the UK, or leave it and become a new, separate and independent state.

This paper is the latest in the Scotland analysis series and explores how an integrated domestic environment for research in publicly funded institutions supports the UK's, including Scotland's, excellent and thriving research base which is vital for innovation and economic success.

The UK research sector

Together, Scotland and the rest of the UK have a large, heavily integrated, and thriving research base[1] which is highly respected across the world. The UK is ranked second only to the US in terms of world-class research, and the UK's share of the world's top 1 per cent most cited publications is on an upward trend.

Within this framework, universities and other higher education institutions in Scotland perform strongly. The UK has 31 institutions in the world's top 200 universities, with five (16 per cent of the UK's representation), located in Scotland.[2]

Funding

Governments have a central role in supporting the research sector by encouraging and facilitating research activity, including helping overcome the risks and uncertainties associated with research. In 2011 public funding accounted for 30 per cent of the £27.4 billion research and development (R&D) spend in the UK, with nearly £2 billion of grant support provided through the UK Research Councils.

Research Council funding is allocated on the basis of excellence through a competitive peer review process, regardless of where in the UK it takes place. As part of the UK, Scotland's well-developed and high performing research base means that Scottish research institutions have traditionally performed strongly. In 2012-13 Scottish Higher Education Institutions (HEIs) secured £257 million of UK Research Council grants (excluding Research Council institutes and infrastructure). This represents 13.1 per cent of the UK total, significantly more than its 8 per cent of UK Gross Domestic Product (GDP), or 8.4 per cent of the UK population. Including all

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1 This paper focuses on research carried out in or in collaboration with publicly funded institutions such as Higher Education Institutions and Research Council institutes.

2 Times Higher Education, *The World University Rankings 2013-14,* retrieved October 2013, <www.timeshighereducation.co.uk/world-unverisity-rankings/2013-14/world-ranking/range/001-200/order/country%7Casc>.

Research Council funding (including grants, studentships and fellowships and spending on infrastructure), Scotland secured £307 million (10.7 per cent of the UK total).

It is not only Research Councils that provide UK Government funding for research. For example, UK Government departments such as the Ministry of Defence (MoD) and Department of Health have significant R&D programmes. To maintain operational advantage and security of supply the MoD budget is typically only invested within the UK.

In addition to public funding, the UK's network of charitable organisations fund significant amounts of research. These organisations invested approximately £1.1 billion per annum, 13 per cent of which was spent on research in Scotland.[3] For example, in 2012-13 Cancer Research UK spent around £34 million in Scotland, including at the University of Stirling which is home to Cancer Research's UK Centre for Tobacco Control Research.

National governments fund national research. Although Research Councils do support international projects, they generally only provide funding to researchers in UK institutions. In the event of independence the government of an independent Scottish state would become responsible for deciding how much to spend on research activity and how to distribute research funding. In order to replace the 2012-13 level of Research Council expenditure in Scotland (£307 million), the government of an independent Scottish state would have to spend 0.23 per cent of 2012 GDP on research or seek additional funding from elsewhere such as overseas, businesses or charities. Businesses and research charities could, however, face additional administrative burdens created by divergences in regulatory regimes and tax jurisdictions, meaning funding projects in both the continuing UK and an independent Scottish state could become more complex for the private and third sectors.

Infrastructure

In addition to funding research projects, unlocking research potential requires both highly technical and often expensive research infrastructure. Researchers from across all of the UK benefit from access to world leading infrastructure both within the UK (such as advanced computing and special monitoring facilities) but also around the world through UK membership of international facilities (such as the European Centre for Nuclear Research (CERN) and the European Southern Observatory). The Big Science and Innovation report compiled a list of 221 Big Science facilities in the UK or to which the UK is signed up to.[4] Sharing the costs of this infrastructure across a broader research base and funded by a large and diverse tax base makes this infrastructure more affordable. In 2010 the UK Government allocated £1.9 billion for science and research capital for the period 2011-15 and since then has allocated an additional £1.5 billion funding for science and innovation capital.

In the event of independence, the government of an independent Scottish state would need to consider its research infrastructure requirements. As set out in *Scotland analysis: Devolution and the implications of independence*, UK national institutions would operate on behalf of the continuing UK as before but would have no power or obligation to act in, or on behalf of, an independent Scottish state. The terms of access to existing UK-operated research institutions by researchers in a newly independent Scottish state could not be guaranteed, and there is a risk those terms would not be on the same basis as researchers in the continuing UK.

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3 Association of Medical Research Charities grants database.

4 Technopolis Group, *Big Science and Innovation*, July 2013, retrieved October 2013, <www.gov.uk/government/uploads/system/uploads/attachment_data/file/249715/bis-13-861-big-science-and-innovation.pdf>.

A common framework for research coordination and collaboration

Researchers from across the UK currently benefit from a highly integrated and interdependent, well-aligned system. This facilitates collaborations between researchers across the UK, as well as projects with industry and overseas academics.

Working within the UK's integrated research environment, Research Councils provide a strategic overview of all research disciplines from shaping strategic priorities, and the balance of funding across these, to the particular focus of research programmes and mechanisms. Research Councils help ensure a coherent and strategic approach to research activity in the UK. This common approach ensures that research activity delivers value for money and that duplication and overlap is minimised.

This single framework, and the absence of barriers across the UK, helps support collaboration and networking between UK researchers, helping ideas and funding flow freely.

International collaborations are of course important and the UK's Science and Innovation Network in 29 different countries helps extend the reach of the UK research base, forming new partnerships with the best researchers from around the world. However, national research funding agencies typically only fund the element of research that is carried out in their own nation. While there are examples of international shared pots of research funding they tend to be on a relatively small scale, for example the Nordic countries share a pot of approximately £13 million. There is little precedent for sharing or replicating a system on the scale of the current UK funding streams across international borders.

In the event of independence this single strategic and highly integrated research framework would be likely to diverge as an independent Scottish state set and deliver its own research priorities. Research collaborations between the continuing UK and an independent Scottish state would be international collaborations associated with levels of risk not present in domestic collaborations.

Ensuring research excellence

As part of the UK, Scotland contributes to, and benefits from the UK's common framework for assessing research outputs and quality (the Research Excellence Framework, formerly the Research Assessment Exercise), and uses a panel peer review process. This allows institutions to benchmark their performance, and demonstrate their research strength across the 160 HEIs in the UK, 19 of which are in Scotland. Demonstrating research excellence attracts high quality students, academics and funding. This framework is internationally recognised and is often used as a quality benchmark for securing international collaboration and funding from businesses.

Research excellence is also supported by the ability of researchers and staff to move freely across the UK and elsewhere, thereby supporting the flow of knowledge. A common approach to supporting research careers as well as a unified labour market allows skilled researchers to move to where they can perform to their highest potential. In the event of independence, the current, shared framework would inevitably begin to diverge as research and economic priorities change over time.

Introduction

The September 2014 referendum on independence presents one of the most important decision points in Scotland's history. The UK Government is committed to ensuring the debate ahead of the referendum is informed by wider analysis, and that the facts that are crucial to considering Scotland's future are set out.

This paper focuses on research carried out in, or in collaboration with, publicly funded bodies such as Higher Education Institutions (HEIs) and Research Councils. It demonstrates the importance of an integrated and interdependent framework for scientific research for HEIs in both Scotland and the rest of the UK and the possible implications of Scottish independence. It also highlights the wider benefits for business and society as a whole from the UK's integrated research framework.

A strong research base

As part of the UK, Scotland has a strong and vibrant research base which brings both economic and societal benefits. The UK, including Scotland, is:

- Ranked second only to the US in terms of world-class research (according to independent research commissioned by Department for Business, Innovation & Skills (BIS) in 2011);[1]
- Ranked among top five (alongside the US) in terms of university-industry research and development (R&D) collaboration, according to the World Economic Forum in 2013;[2]
- An attractive location for scientists and researchers (ranked 7th out of 59 by the Institute for Management Development in 2013);[3] and
- Successful in attracting commercial investment in R&D from overseas. In 2010, 24 per cent of UK Business Enterprise Research and Development (BERD) was financed from abroad, compared with 9 per cent in France, 3.5 per cent for Germany and 0.5 per cent for Japan.[4]

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1 Department for Business, Innovation and Skills (BIS), *International Comparative Performance of the UK Research Base 2011*, 2011, p2, retrieved August 2013, <www.gov.uk/government/publications/uk-research-base-international-comparative-performance-2011>.

2 World Economic Forum, *The Global Competitiveness Report 2013-14*, 2013, retrieved September 2013, <www3.weforum.org/docs/WEF_GlobalCompetitivenessReport_2013-14.pdf>.

3 International Institute for Management Development, *World Competitiveness Yearbook 2012*, retrieved April 2013, <www.imd.org/research/publications/wcy/index.cfmIMD>.

4 OECD, Main Science and Technology Indicators.

Scottish universities are a key part of this success story. The UK has 31 universities in the world's top 200 of which Scotland has five (Universities of Edinburgh, St Andrews, Glasgow Aberdeen and Dundee).[5] The UK's share of the world's top 1 per cent most cited publications is on an upward trend. It increased from 11.9 per cent over 1996-2000 to 13.8 per cent over 2006-2010 and within the UK's total Scotland's citation performance rose from 1.4 per cent to 1.7 per cent over the same period.[6] Scotland produced over 11,000 research papers in 2010 (around 9 per cent of the 123,000 UK research papers), drawing ahead of most other nations in terms of published output per researcher.[7] There are more research professionals per capita in Scotland than in the rest of the UK, with around 32,000 in Scotland (1.3 per cent of all employment in Scotland) and 279,000 in the rest of the UK (1.1 per cent of all employment).[8]

Economic and social impact of research

Investment in research and innovation is a key driver of long-term economic success.[9] The application and commercialisation of research and technology has transformed many aspects of daily lives, such as driving improvements in health, ways of working, transport and communication.

Estimating the impact of research on innovation is complex.[10] It is widely acknowledged that advances in productivity often result from breakthroughs in knowledge, but this can be difficult to quantify.[11] Some studies have looked at the impact of research in particular sectors and demonstrated the positive impact on employment and Gross Value Added.[12] In addition, public sector investment in research typically leverages private sector investment.

There are also broader, societal and cultural benefits from a strong research base. A 2011 Ipsos MORI poll of public attitudes to science found that 80 per cent of people agree that 'on the whole, science will make our lives easier' and 88 per cent think 'scientists make a valuable contribution to society'. The same poll found that 76 per cent agree that, even if it brings no immediate benefits, research which advances knowledge should be funded by the Government.[13]

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5 Times Higher Education, *The World University Rankings 2013-14*, retrieved October 2013, <www.timeshighereducation.co.uk/world-university-rankings/2013-14/world-ranking/range/001-200/order/country%7Casc>.

6 BIS, *International Comparative Performance of the UK Research Base 2011, 2011*, retrieved August 2013, <www.gov.uk/government/publications/uk-research-base-international-comparative-performance-2011>.

7 BIS, *International Comparative Performance of the UK Research Base 2011*, 2011.

8 Labour Force Survey, Quarter 3 2012–Quarter 2 2013. Standard Occupational Code (SOC) Minor Group 211 ('Natural and Social Science Professionals') and SOC Unit Code 2311 ('Higher Education teaching professionals').

9 For example, see BIS Economics Paper No. 15, *Innovation & Research Strategy for Growth*, December 2011, retrieved March 2013, <www.bis.gov.uk/assets/BISCore/innovation/docs/I/11-1387-innovation-and-research-strategy-for-growth.pdf>.

10 BIS Economics Paper No. 15, *Innovation & Research Strategy for Growth*, December 2011.

11 For example, see Guellec and de la Potterie, From R&D to Productivity Growth: Do the Institutional Settings and the Source of Funds of R&D Matter? *Oxford Bulletin of Economics and Statistics*, July 2004, retrieved August 2013, <onlinelibrary.wiley.com/doi/10.1111/j.1468-0084.2004.00083.x/abstract>.

12 For example, see Deloitte (*Measuring the Economic Benefits of Mathematical Science Research in the UK*, Final Report, 2012).

13 Ipsos MORI, Public Attitudes to Science 2011, 2011, retrieved August 2013, <www.ipsos-mori.com/researchpublications/researcharchive/2764/Public-attitudes-to-science-2011.aspx>.

Universities

Universities and other HEIs are central to the UK's strong research base. Universities conduct much of the blue-skies or curiosity-driven research and also collaborate with businesses in order to facilitate the translation of research into new products or services. But universities are also a key economic sector in their own right. A 2010 report for Universities Scotland estimates that, in terms of its wider economic impact, the 19 HEIs in Scotland contributed £6.2 billion to the Scottish economy.[14]

Universities are also large recruiters. Scottish universities employ around 39,000 people,[15] making a significant contribution to Scotland's stock of highly skilled workers. This figure does not take into account indirect employment effects. The Institute for Public Policy Research (IPPR) estimates the employment effect of universities in the UK is almost double the number directly employed.[16] According to this research, for every university job there is a second job in the local economy generated through knock-on effects.

Government support and the devolution settlement

"Scottish Universities should continue to be active in UK Research Council funded activities, particularly to maintain the critical mass required to fund modern scientific research"

Royal Society of Edinburgh evidence to the Calman Commission

The benefits of both applied and curiosity-driven research may take some time, even decades, to materialise. Research and innovation also create knowledge which helps advance thinking elsewhere, but may not be captured by the company or university doing the research. Government therefore has a central role in encouraging research activity, including investing in scientific and data infrastructures and shaping the wider business environment to encourage investment by the private sector.

Devolution within the UK means the Scottish Parliament and Scottish Government are empowered to take decisions on many policy areas to develop the knowledge base and encourage research in Scotland. This includes, to a large extent, policy and financial responsibility for education including university teaching and business support. The Scottish Funding Council (SFC) has a key role, distributing funding for teaching and learning, research and other activities to Scotland's HEIs and Further Education colleges, and helping promote knowledge transfer. But devolution also means decisions can be taken at the UK level where all its citizens benefit from collective action. Allowing resources and risks to be shared effectively, such as through the Research Councils, can provide significant economic opportunity. Further information on the role of key organisations supporting the Scottish science and research base is at Annex A.

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[14] BiGGAR Economics, *The contribution of Scottish Universities. A report to Universities Scotland*, June 2010, retrieved August 2013, <www.universities-scotland.ac.uk/uploads/latest/Biggar%20summary%2015%20June10.pdf>.

[15] Scottish Enterprise, *The Economic Impacts of Scottish Universities*, 2012, retrieved August 2013, <www.scottish-enterprise.com/resources/reports/universities-and-economic-growth.aspx>.

[16] Institute for Public Policy Research, *Beyond bricks and mortar boards: universities' role in building regional economies*, retrieved August 2013, <www.ippr.org/publications/55/8659/beyond-bricks-and-mortar-boards-universities-role-in-building-regional-economies>.

Evidence to the Calman Commission in 2008-2009 supported the balance of devolved and reserved responsibilities for research funding, acknowledging the benefits of working at scale across the UK in providing the critical mass needed in modern science and research.[17] The Calman Commission did not recommend any changes to the existing system of Research Councils and indeed commented it had been "struck by the volume of evidence it has received claiming that Scotland 'punches above its weight' in terms of attracting research funding and that institutions themselves benefit from being part of a wider academic community offering competition and challenge".[18]

Scotland analysis: Devolution and the implications of Scottish independence demonstrated how devolution is a flexible, efficient and collaborative system of government. It enables the two governments to work together effectively to serve and further the interests of Scotland and its people. This paper demonstrates how devolution delivers for Scotland, as part of the UK's research system. It also shows how Scotland strengthens the UK's research capability and international reputation for excellence.

In the event of independence, as set out in previous papers in the Scotland analysis series, the UK's national institutions would operate on behalf of the continuing UK as before. National governments fund national research, and the government of an independent Scottish state would be responsible for deciding how much to spend on research activity and how to distribute funding. The Calman Commission was presented with a compelling case that further devolution for these research funding responsibilities would be detrimental to Scottish universities. Independence would remove Scottish universities from direct access to a significant source of funding and a community of academic excellence.

Structure of the paper

The benefits of the UK's strong research base are significant and far reaching, particularly for the UK's integrated and interdependent scientific and research community. There are also wider benefits: from supporting businesses, to developing new products and helping to improve public services, health, culture, environment and security. This paper demonstrates the depth of integration and level of interdependence between institutions in Scotland and the rest of the UK, how this framework helps raise standards and results in benefits across the UK.

Chapter 1 discusses the UK-wide support for research, including funding from UK Research Councils, wider UK Government funding and research charities. This includes access to major research facilities and infrastructure across the UK and internationally.

Chapter 2 sets out how the UK ensures strategic coordination of research to reflect key priorities and the costs and benefits of intra-UK projects and international collaborative research. It also demonstrates the integrated nature of the UK's policy and operational frameworks that encourage research excellence and support research careers across the UK.

The annexes provide a summary of the devolution settlement for supporting research and information on UK research facilities.

[17] For example, see evidence submitted by Universities Scotland.

[18] Commission on Scottish Devolution, *Serving Scotland Better: Scotland and the United Kingdom in the 21st Century*, Final Report – June 2009, p. 199.

Chapter 1:
Funding and infrastructure

Scottish research institutions receive funding from a number of UK-wide and external sources, including UK Research Councils, government departments, EU funding programmes, business (including foreign direct investment) and charities. Such funding can be significant – for example in areas such as healthcare and medical research.

The UK Research Councils play a central role in the UK's – including Scotland's – world-class reputation for research and established research infrastructure. Within a competitive UK research environment, Scotland has been very successful in securing UK Research Council funding; Scottish Higher Education Institutions (HEIs) secured £257 million of Research Council grants (excluding Research Council institutes and infrastructure) in 2012-13. This represents 13.1 per cent of the UK total, significantly more than its 8 per cent of UK GDP, or 8.4 per cent of the UK population. Including all Research Council funding (including grants, studentships and fellowships and spending on infrastructure), Scotland secured £307 million (10.7 per cent of the UK total).

In the event of a vote in favour of independence, the UK's current research and innovation system would operate in the continuing UK. Although Research Councils do support international projects, they generally only provide funding to researchers in UK institutions taking part in collaborations with international partners. It would be up to an independent Scotland to fund any partners from Scottish institutions.

Business and research charities could face additional administrative burdens created by divergences in regulatory regimes and tax jurisdictions. This could mean funding cross-border projects in the continuing UK and an independent Scottish state becomes more complex for the private and third sectors.

Access to existing UK research facilities and infrastructure could become more restricted. The terms of access by researchers in an independent Scottish state would need to be agreed with the continuing UK. The government of an independent Scottish state would also need to seek to negotiate access for academics in Scotland to international facilities such as CERN; existing arrangements would only provide continued access to researchers in the continuing UK.

Such changes would be to the detriment of researchers in both Scotland and the rest of the UK, risking the ability to work together through the Research Councils and other UK-wide funding mechanisms.

Introduction

1.1 Public funding for research in Higher Education Institutions (HEIs) is administered under a 'dual support' system. National funding councils (such as the Higher Education Funding Council for England (HEFCE) and the Scottish Funding Council (SFC)) provide block grant funding for teaching and quality-related research, while Research Councils (and government departments, the European Union, and charities) provide grants for specific research projects and programmes.

1.2 Being part of a UK-wide system of funding enables support on a greater scale, across a wide breadth of research, with the risks and rewards from investment in research and technological innovation shared across the UK. The sharing of infrastructure also provides benefits and services, reduces duplication and can also be delivered at reduced costs per capita given the large domestic single market. The UK Research Councils are the main source of UK Government funding for research, providing £1.95 billion of grant support across the UK in 2012-13.

1.3 Complementing this UK-wide framework, devolution within the UK means the Scottish Parliament and Scottish Government are empowered to take decisions on, and fund, a wide range of issues that serve to develop the knowledge base and encourage research in Scotland. Annex A sets out the main organisations which play a role at the devolved level in supporting the Scottish science and research base. As with other national funding councils, the SFC has a central position in funding research within Scotland, with general fund research grants totalling £257.5 million in 2012-13.

1.4 This chapter provides detail on the levels of research funding, and the access to UK-wide infrastructure, available to Scottish HEIs from a variety of sources. It also considers their importance to the Scottish research community and some of the impacts that would need to be considered in the event of a vote in favour of independence.[1]

Total research income

1.5 Funding for research undertaken within the UK comes from a variety of sources. UK total spend on research and development (R&D) in 2011 was £27.4 billion, of which public funding accounts for 30 per cent, industry 46 per cent, overseas 18 per cent and charity 5 per cent.[2]

1.6 Scotland has a strong record of research performance. Estimates of expenditure on R&D compiled by the Office for National Statistics indicate Scottish HEIs have a higher proportion of R&D spend compared to Gross Domestic Product (GDP) and population size than the percentage for the UK as a whole. Higher Education Research and Development (HERD) expenditure figures for 2011 show that Scottish HEIs spent £953 million, 13.5 per cent of the £7.1 billion spent across the UK.[3] This is equivalent

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[1] A number of different data sets have been used in this chapter but it should be noted they cover different reporting periods (for example the financial reporting years are April–March for Research Councils, September–August for the Higher Education Statistics Agency (HESA) and January–December for European research programmes). Where comparisons are made between sources of research income, HESA data is used since this information is provided by HEIs themselves on their income from a variety of funding streams for a particular period.

[2] Office for National Statistics, GERD figures 2011, retrieved August 2013, <www.ons.gov.uk/ons/publications/re-reference-tables.html?edition=tcm%3A77-300392>.

[3] Office for National Statistics, Higher Education Expenditure on Research and Development figures, estimated breakdowns by region for 2011, retrieved August 2013, <www.ons.gov.uk/ons/publications/re-reference-tables.html?edition=tcm%3A77-300392>.

to approximately £180 per head of population in Scotland spent on research activities, compared with £112 across the UK as a whole.[4]

1.7 Table 1.1 shows the breakdown of research income streams for UK HEIs in 2011-12, and Figure 1.1 illustrates the breakdown for Scottish HEIs. UK Research Council funding currently accounts for over a quarter of research income to HEIs in Scotland. This is nearly as high as funding from the SFC, which accounts for 29 per cent of funding over the same period. As with HEFCE, the Research Councils provide an important, dual role of public research funding alongside the UK funding councils.

1.8 Of the other income streams highlighted in Figure 1.1, charities play a significant role in both Scotland and the UK (16 and 15 per cent of funding respectively), followed by business and funding from Europe and other public sources.[5] Of these sources, only the funding from the SFC can be said to be fully devolved. European funding comes primarily from the EU's Seventh Framework Programme for Research and Development (FP7), and the other income streams are a mixture of devolved and UK-wide sources. Indeed, evidence suggests that the majority of funding from business and charities come from UK-wide sources, as discussed in more detail later in this chapter.

1.9 The annual Higher Education-Business and Community Interaction Survey (HE-BCI) also suggests Scottish HEIs rely heavily on income from institutions outside Scotland. The survey indicates that work for Scottish partners made up only:

- 8 per cent of income for consultancy work;
- 15 per cent of contract research;
- 22 per cent for Continuous Professional Development; and
- 30 per cent for facilities and equipment related services.[6]

Table 1.1: UK and Scottish Higher Education Institutions: Source of research income 2011-12

Source of Funding	UK		Scotland only	
	Amount (£ million)	Percentage of total (%)	Amount (£ million)	Percentage of total (%)
Funding Council Research Grant (including HEFCE and SFC devolved funding)	1,930	30%	251	30%
Research Councils Research Grant	1,434	22%	219	26%
Research Income: Charities	1,046	16%	131	15%
Research Income: Public	805	13%	96	11%
Research Income : Business	461	7%	64	7%
Research Income : Europe	507	8%	63	7%
Research Income : Other	256	4%	36	4%
Total[7]	**6,440**	**100%**	**861**	**100%**

Source: Higher Education Statistics Agency (HESA). HESA figures are for the academic year 2011-2012, the most recent period for which comparable data is available.

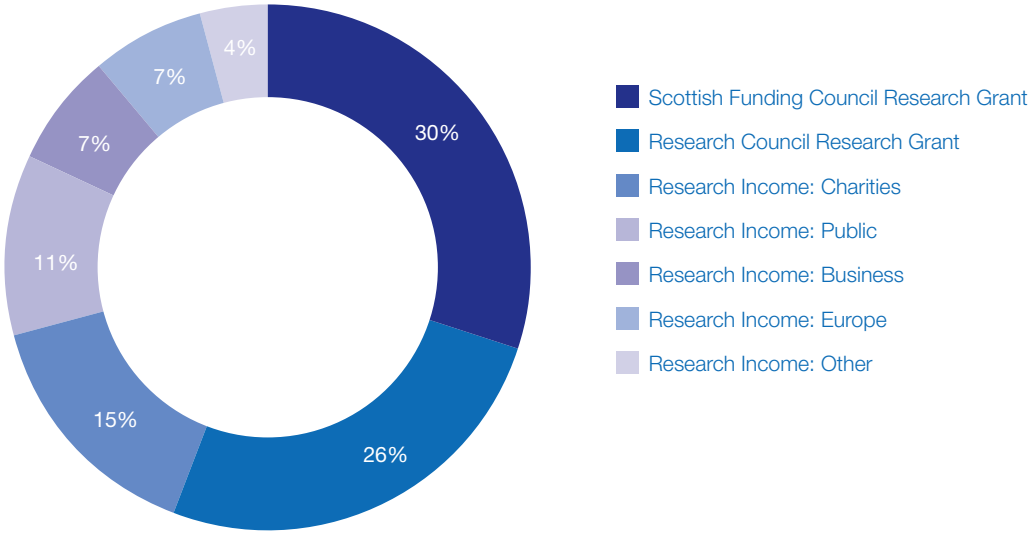
4 BIS calculations based on population data from the 2011 UK Census.

5 Other public sources of income include items such as one-off grants by local authorities, non-department public bodies and other public organisations.

6 Higher Education Statistics Agency, HE Business and Community Interaction Survey, May 2013, retrieved August 2013, <www.hesa.ac.uk/index.php?option=com_pubs&task=show_pub_detail&pubid=1718&Itemid=286>.

7 The totals are higher than the sum of the figures due to rounding.

Figure 1.1: Breakdown of Scottish HEI sources of research income academic year 2011-12



Source: Higher Education Statistics Agency (HESA). HESA figures are for the academic year 2011-12, the most recent period for which comparable data is available at the time of writing.

UK Research Councils

1.10 The seven UK Research Councils work and provide funding across the entire field of UK research subjects: from the sciences, to economic and social research, health and the arts (see Annex A for more detail on the Research Councils). Indeed, the Economic and Social Research Council (ESRC) is undertaking its own work independently examining the issues around the referendum debate (see Box 1A for details). The UK Research Councils are public institutions funded by the UK Government, but which operate independently to ensure the funding is based on excellence. Funding is allocated in line with the Haldane Principle (that decisions on individual research proposals are best taken by researchers themselves through peer review) allowing Research Councils to operate independently from Government in pursuit of research excellence.

1.11 The UK Research Councils support over 50,000 researchers, including 19,000 doctoral students, around 14,000 research staff and 2,000 research fellows in UK universities and in their own research institutes. Scotland is home to a number of UK Research Council-funded institutes, such as the Roslin Institute,[8] the Sea Mammal Research Centre and the British Geological Survey's research centre in Edinburgh. Research Councils UK (RCUK) is the administrative group that supports and co-ordinates the individual Research Councils (see Annexes B and C for a list of Research Council facilities and other physical assets located in Scotland).

[8] This is now a part of the University of Edinburgh, but receives strategic funding from the Biotechnology and Biological Sciences Research Council.

Box 1A: ESRC's The Future of the UK and Scotland programme

The ESRC has allocated £6 million to undertake a number of independent research projects looking at the referendum debate and beyond (£4 million on activities in the lead up to the referendum, and up to £2 million for post referendum research). The programme of activities will aim both to inform the debate in the run-up to the referendum and assist in planning across a wide range of areas which will be affected by the outcome of the vote – whether for Scottish independence or the Union.[1]

This project is being co-ordinated by Professor Charlie Jeffery (University of Edinburgh), and has awarded nine fellowship grants, and invested in seven more projects run through ESRC research centres throughout the UK. Projects range from studies into health and migration policy, to the impacts of social media on the debate.

[1] See the programme's website for more details <www.futureukandscotland.ac.uk>.

1.12 Scotland's well developed and high performing research base means that Scottish research institutions have traditionally performed strongly within the UK system of funding on the basis of excellence and peer review. In 2012-13, Scotland secured 10.7 per cent of all research grant funding (including studentships and fellowships and spending on infrastructure) from UK Research Councils – amounting to £307 million – which compares favourably with the fact that Scotland represents 8 per cent of UK GDP, or 8.4 per cent of the UK population.[9] This rises to 13.1 per cent (£257 million of grants) when expenditure on Research Council institutes and infrastructure is excluded. This has been a consistent trend in the proportion of Research Council funding in Scotland, demonstrating the excellence of its research base (see Table 1.2).

Table 1.2: Research Council UK funding to HEIs (including capital and running costs) 2005-2006 to 2012-2013 (£ million)

Research funding to HEIs including grants, studentships, fellowships, funding to Research Council Institutes, independent research organisations (IROs), infrastructure funding (Research Council expenditure)

	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Total UK Spend (grants, studentships, fellowships only)	1,200	1.370	1,550	1,790	1,880	1,870	1,980	1,950
Total Scotland spend (grants, studentship, fellowships only)	142	149	186	237	233	239	243	257
% against UK total	**11.5%**	**10.8%**	**12.1%**	**13.2%**	**12.4%**	**12.8%**	**12.3%**	**13.1%**
Total UK spend (including funding to Research Council Institutes, IROs, infrastructure funding)	2,096	2,255	2,472	2,739	2,897	2,881	2,977	2,880
Total Scotland spend (including funding to Research Council Institutes, IROs, infrastructure funding)	215	217	256	305	339	325	298	307
% against UK total	**10.2%**	**9.6%**	**10.4%**	**11.1%**	**11.7%**	**11.3%**	**10.0%**	**10.7%**

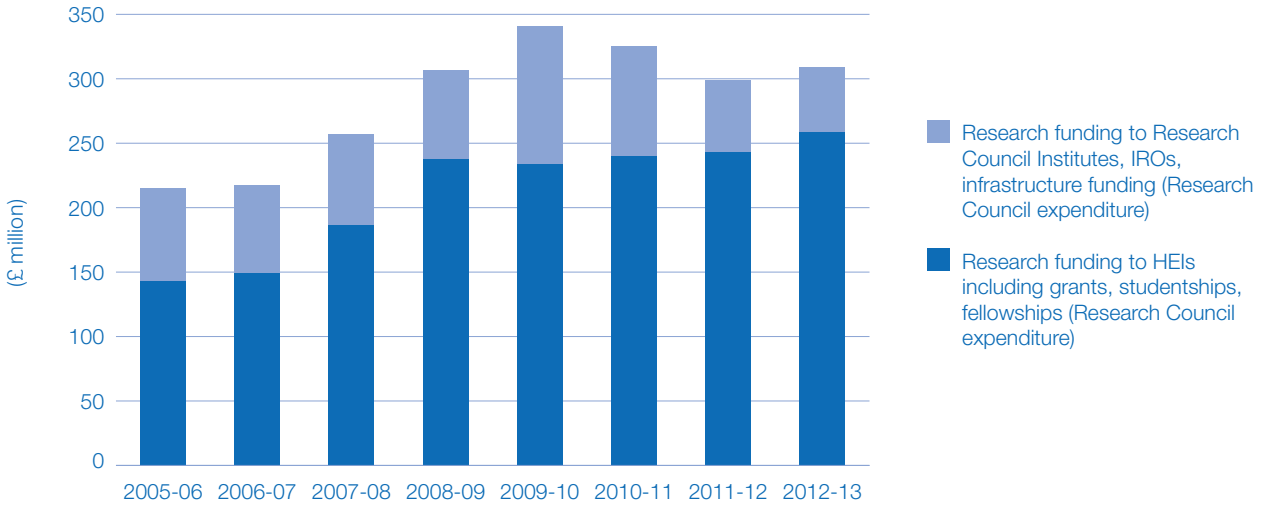
Source: Research Councils UK.

[9] Research Councils UK.

1.13 In addition to the Research Council funding detailed in Table 1.2, the Department for Business, Innovation & Skills (BIS) provides science and research funding as a contribution to HEI research capital for each of the four parts of the UK. This is allocated by BIS to each of the Higher Education (HE) funding bodies in proportion to the funding from Research Councils secured by HEIs in the respective countries. In 2013-14 BIS will provide £10.34 million to the SFC to allocate to HEIs in Scotland by reference to the research income these HEIs received from Research Councils.

1.14 Figure 1.2 demonstrates the amount of funding received by Scottish organisations from Research Councils UK has increased by around 50 per cent since 2005-06. Research Council funding is particularly valuable for research intensive universities. This is illustrated in Figure 1.3 and it can be seen that the University of Edinburgh received over £80 million in 2012-13, including a share of £32 million from the Engineering and Physical Sciences Research Council (EPSRC) for innovative projects such as smart-phone test and tracking systems for infectious diseases; fibre-optic probes to monitor people's condition in intensive care; and in-home sensors to immediately relay patient information to doctors.

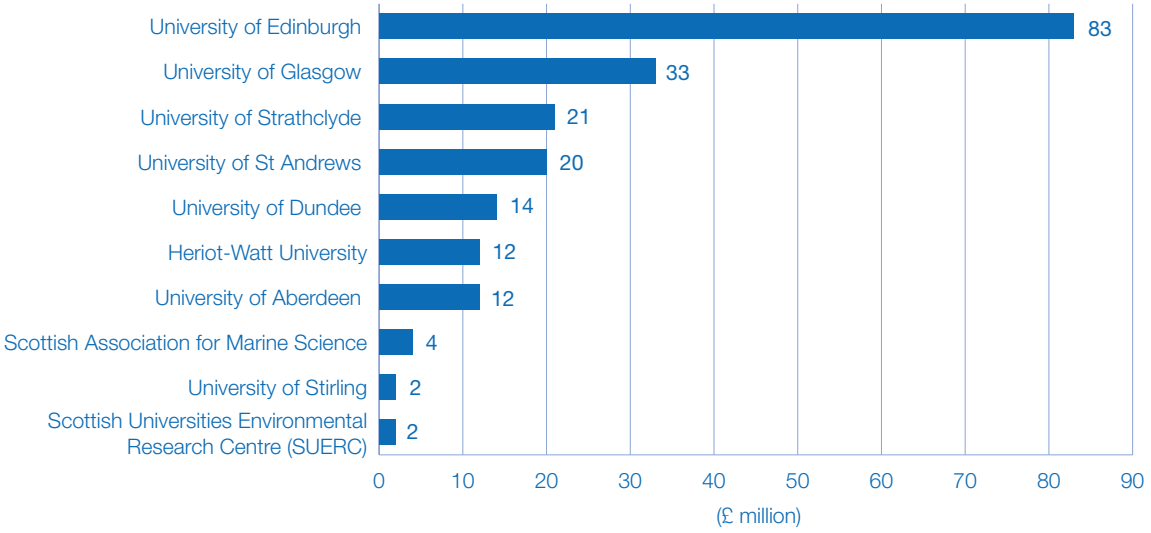
Figure 1.2: Total UK Research Councils funding to Scottish organisations, 2005-13 (£ million)



Source: Research Councils UK.[10]

[10] Data taken from RCUK devolved administration spend 4 September 2012. Associated caveats are still applicable. [Spending was brought forward in 2009-10 from 2010-11 and the Science and Research Budget has been maintained at flat cash since 2011-12.]

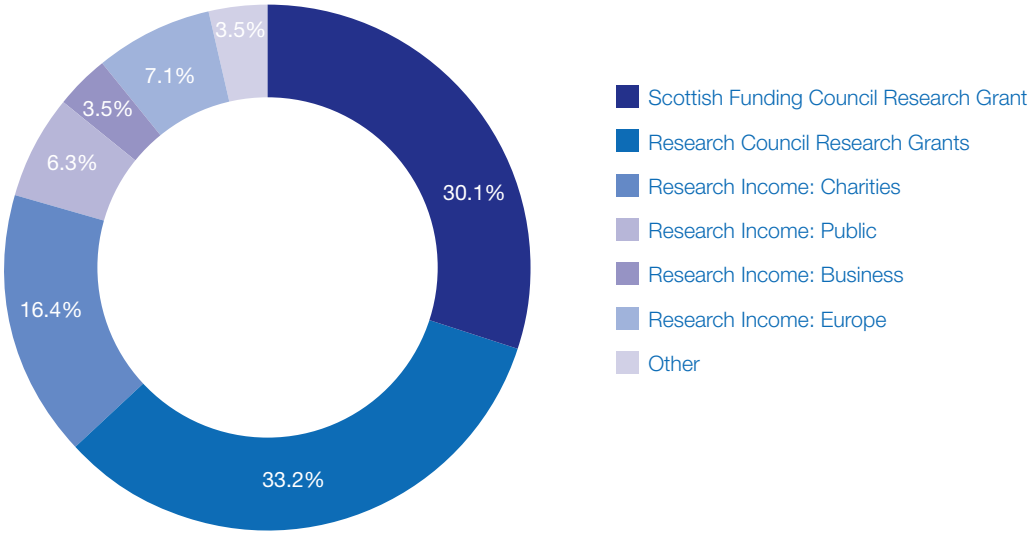
Figure 1.3: Top ten Scottish institutions for receipt of UK Research Council grants spend in 2012-13 (£ million)



Source: Research Councils UK.[11]

1.15 Figure 1.4 demonstrates that funding from Research Councils contributed a third of the University of Edinburgh's total research income (£270 million in 2011-12), a higher proportion than received from the SFC. Research Council income is also significant for other institutions, for example Figure 1.5 demonstrates the breakdown of the University of Highlands and Islands research income (£21 million total research income in 2011-12).[12]

Figure 1.4: University of Edinburgh sources of research income 2011-12

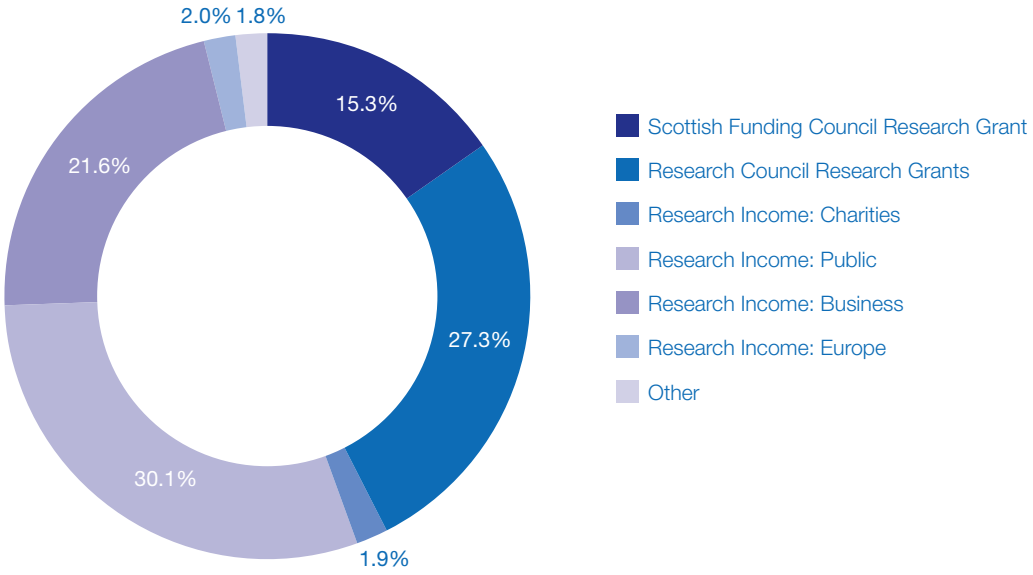


Source: HESA.

[11] Research Councils UK, grant figures 2012-13, *data includes* standard grant expenditure only. Excludes capital and other expenditure, retrieved July 2013.

[12] Higher Education Statistics Agency data for 2011-12.

Figure 1.5: University of the Highlands and Islands sources of research income 2011-12



Source: HESA.[13]

Box 1B: Research Council funding case studies

The following are examples of projects in Scotland which have been funded or part-funded by UK Research Councils. They illustrate the range and variety of research supported within the UK.

Detecting counterfeit goods

In an industry with an export value to the UK of £4.2 billion in 2011, counterfeit whisky bootlegging is a serious and expensive problem. The Engineering and Physical Sciences Research Council (EPSRC) supported physicists at the University of St Andrews to develop a new method for testing whether a whisky is genuine or not. Using a ray of light the width of human hair focused on a small whisky sample, the team are able to analyse the light scattered from the whisky, and so work out the brand, age and even which cask was used to create a single malt, from a sample no bigger than a teardrop.[1]

Copyright and innovation in the UK

CREATe: Creativity, Regulation, Enterprise and Technology is the UK Research Council's (funded by the Arts and Humanities Research Council (AHRC), EPSRC and ESRC) centre for copyright and new business models in the UK's creative economy. As a consortium comprising expertise from across the UK, it was set up with an award of £4 million for the period 2012 to 2016. The University of Glasgow is the lead institution, together with the universities of East Anglia, Edinburgh, Nottingham, St Andrews and Strathclyde, and Goldsmiths, University of London. Interdisciplinary teams of researchers from the seven universities are assisting UK cultural and creative industries in becoming innovation leaders within the global digital economy.[2]

1 See EPSRC, <www.epsrc,tac.uk/newsevents/2013/Pages/whiskyanono.wpx>.

2 See <www.ahrc.ac.uk/news-and-events/News/Pages/New-Centre-for copyright.wpx>.

13 Note on discrepancies between Figures 1.3 and Figures 1.4 and 1.5: HEIs report where their income is ultimately coming from via the UK-wide Higher Education Statistics Agency. This differs from RCUK reporting, which sets out how Research Councils have paid out funding. As some grants are collaborative or there may be subcontracting between HEIs, the funding is then passed onto other institutions, which RCUK data does not capture. Reporting by Research Councils is for the period April to March, while HESA data is for the period September to August.

Rural Digital Economy Hub

dot.rural is the UK Research Councils' Digital Economy Hub focusing on the rural digital economy. The University of Aberdeen leads this project, with £11 million from the EPSRC. Rural areas have specific characteristics that create challenges around issues such as quality of life and wealth creation. These include: small, often dispersed populations; narrow and uneven channels of information flow; rapid change in population structures and economic activity bases; and restricted access to digital infrastructure.

The project aims to show that rural areas of the UK can, through the user-led application of digital technology, be more economically, socially and environmentally sustainable. The aim is to harness the Hub's expertise with a range of partners to realise this ambition. Its activities are organised around four rural challenges: healthcare, accessibility and mobilities, conservation of natural resources, and enterprise and culture.

More widely, since its inception in 2008 the RCUK Digital Economy Theme, which runs across all UK Research Councils, has invested over £130 million in building the capacity and expertise needed to realise the Digital Economy and training a new generation of digital economy researchers.

Potential impacts of an independent Scottish state

1.16 The UK Research Councils are a significant funder of science and research activity. Decisions on research funding are currently made on the basis of research excellence and, due to the absence of barriers, funding is able to flow freely across the UK.

1.17 National governments fund national research. In the event of independence the government of an independent Scottish state would be responsible for deciding how much to spend on research activity and how to distribute funding. *Scotland analysis: Devolution and the implications of independence* makes clear that the UK's national institutions would operate on behalf of the continuing UK as before. As a result, UK Research Councils would have no power or obligation to act in, or on behalf of, an independent Scottish state.[14]

1.18 If Scotland were to become an independent state its government would need to consider how much to spend on research activity and how to deliver this funding. Other papers in the Scotland analysis series consider the benefits of the UK's broad fiscal base and the implications of independence on Scotland's spending power.

1.19 Although Research Councils do support international projects, they generally only provide funding to researchers in UK institutions taking part in collaborations with international partners. It would be up to an independent Scottish state to fund the partners from Scottish institutions. At present many Research Council projects benefit from involving researchers in different parts of the UK. If Scotland were to leave the UK it would create a significant risk for the creation and exploration of ideas and high quality projects.

Other key sources of research funding

Wider UK Government support

1.20 Scottish HEIs also benefit from other UK Government funding, such as the new UK Research Partnership Investment Fund (UK RPIF). This will deliver over £1 billion (including £300 million of public funding between 2012 and 2015) to support the development of

[14] HM Government, *Scotland Analysis: Devolution and the implications of independence*, February 2013.

new research facilities and projects in areas such as life sciences, energy and advanced manufacturing. UK RPIF has so far awarded £12 million (towards a £38 million partnership) to develop the *Centre for Translational and Interdisciplinary Research* at the University of Dundee, £11 million (towards a £34 million partnership) for the University of Strathclyde to contribute towards building the EPSRC *Centre for Continuous Manufacturing and Crystallisation* and £10 million (towards a £50 million partnership with £20.6 million private co-investment) to the University of Glasgow for a new clinical research facility and imaging suite at South Glasgow Hospital Campus.

1.21 Universities in Scotland have also received funding from the Technology Strategy Board. Since it was established in July 2007 the Technology Strategy Board has funded over 100 projects involving Scottish HEIs and together they have received over £25 million of funding (see paragraph 1.33).

1.22 Even where policy responsibility is clearly devolved to Scotland, there are still examples of funding flowing between the rest of the UK and Scotland, bringing benefits to the whole UK. Much of this flow emanates from UK Government Departments, including projects co-ordinated through the Chief Scientific Advisers' offices with individual departments, and the Government Office for Science. For example, some research funding from the UK Government Department of Health goes to Scottish research institutions, with £9.8 million of research funding going to Scottish based projects in 2012-13.[15] While the Scottish Government contributes to this funding (£7.2 million in 2012-13), there is a net benefit to Scotland. Similar arrangements are in place with the other devolved administrations, but not with countries outside the UK.

1.23 Box 1C provides examples of UK Government departmental funding awarded to Scottish research institutions. Many of these projects are created and co-funded through the UK Research Councils, demonstrating the joined up nature of the UK's policy and operational framework for research, as described in the next chapter. These projects also demonstrate joint working across different universities in Scotland and other parts of the UK.

Box 1C: Examples of UK Government funded research projects

The Department for International Development (DfID)

DfID who under the Combating Infectious Diseases in Livestock for International Development (CIDLID) Programme, (jointly funded by the Biotechnology and Biological Sciences Research Council (BBSRC) and the Scottish Government) have awarded a number of research grants to Scottish universities and researchers, totalling over £5 million since 2010. Projects include funding Scotland's Rural College for the identification, investigation and implementation of plant-based parasite control strategies; and the University of Glasgow for investigating strategic control of endemic foot-and-mouth disease in Africa using new techniques for a neglected problem.

Department for Energy and Climate Change (DECC)

The UK Carbon Capture and Storage (CCS) Research Centre, launched in April 2012, brings together over 100 of the UK's top CCS academics. It was set up and funded by the EPSRC (£10 million) and DECC (£3 million) to promote and coordinate UK CCS research capability and increase academic collaboration with industry.

The virtual centre is being led and coordinated by the University of Edinburgh. It also includes new capture testing facilities: run by Sheffield and Leeds Universities and based near Sheffield; facilities at Cranfield University; and a mobile testing unit based at Edinburgh.

[15] Figures provided by the UK Government Department of Health.

Forestry Commission

The Forestry Commission is the government department responsible for the protection and expansion of forests and woodlands in England and Scotland, working with devolved nations to deliver cross-border functions such as research, standards, and tree health. Shared UK Government funding for forestry research, which is delivered at a UK level supports England, Scotland and Wales and amounts to just under £11 million in 2013-14. The Forestry Commission Northern Research Station near Edinburgh supports some 65 research jobs.

Ministry of Defence (MoD)

The MoD has a significant Science and Technology Programme investing over £400 million per year across the UK. The MoD currently makes use of the expertise and capabilities offered by HEIs across Scotland, including research ranging from fuel cell technology to international relations and terrorism at the University of St Andrews; underwater autonomous systems and signal and image processing target recognition at Heriot-Watt University; and, certain capabilities in microwave technology, developed at Strathclyde University (unique in the UK).

1.24 In the event of a vote in favour of independence, HEIs in an independent Scottish state would no longer benefit from schemes such as UK Research Partnership Investment Fund (UK RPIF) which specifically seek to support UK research capability.[16] In addition, they may lose access to wider UK Government support for research, such as the £400 million per year the MoD invests in its Science and Technology Programme, which is typically invested in the UK to achieve operational advantage and maintain security of supply.[17] In addition to the impact on Scottish HEIs, there could also be an adverse impact on the quality of UK Government funded research projects if academics in Scotland could no longer offer their expertise.

European Union funding

1.25 Income from the EU is another important source of funding. However, income from UK Research Councils far exceeds the amount Scotland gains from the EU's Seventh European Framework Programme for R&D (FP7).

1.26 From the launch of FP7 on 1 January 2007 up to 21 June 2013 Scotland was awarded approximately €505 million (about £434 million), an average of around €84 million (£71.5 million) per year.[18] Of this total, around €415 million (£353 million) was awarded to HEIs, the rest going to other forms of research organisations, private commercial ventures and public bodies. The European Research Council (ERC), which funds curiosity-driven research, forms a significant part of the FP7 total with Scotland receiving €131 million out of the UK's total €1.3 billion for this scheme. As with RCUK funding, Scotland's research base performs well compared with the UK overall, securing 11.2 per cent of the €4.5 billion total awarded to the UK over this period.

1.27 As set out in *Scotland analysis: Devolution and the implications of Scottish independence*, in the event of a vote in favour of independence, Scotland would have to apply, and negotiate terms, for entry to the European Union. If successful, an independent Scottish state could

[16] HEFCE website, retrieved October 2013, <www.hefce.ac.uk/whatwedo/rsrch/howfundr/ukresearchpartnershipinvestmentfund20122015/>.

[17] HM Government, *Scotland analysis: Defence*, p69, October 2013, retrieved October 2013, <www.gov.uk/government/publications/scotland-analysis-defence>.

[18] European Commission, FP7 grant agreements and participants database, version 14.0, released 1 July 2013. retrieved August 2013.

choose to focus more on building links internationally, for example through EU funds such as Horizon 2020 which is the EU's Framework Programme for Research and Innovation in 2014-20. However, this might not be enough in itself to deliver the levels of funding lost from participation in UK-wide research networks, even though EU funding for research has been steadily increasing over recent years. At the time of writing the latest negotiations on the EU budget for 2014-20 suggest the budget for Horizon 2020 will be around €70 billion, compared with around €55 billion for equivalent programmes in 2007-13. As shown earlier in Figure 1.1, funding for Scottish HEIs from Research Councils is more than treble the levels received from EU funding and there is strong competition for EU funds. It is also easier for researchers to work within a common system than across different systems of funding and regulation – a point that will be covered in detail in Chapter 2.

Charities

1.28 In the UK research environment, charities contribute significantly to science and research. In 2010, charities contributed £1.3 billion to UK science and research, 85 per cent of which was spent on medical research. Scotland attracts a considerable amount of this investment. The Association of Medical Research Charities (AMRC) comprises 101 members, including 24 UK-wide organisations, five of which are based in Scotland.[19] These organisations invested approximately £1.1 billion per annum, 13 per cent of which was spent on research in Scotland. Figure 1.6 (below) shows how this funding compares to population share across the UK.[20] This demonstrates that Scotland attracts a greater spend compared to population than other parts of the UK. This reflects the success of Scottish research within the UK, as demonstrated through the relatively high concentration of HEIs located in Scotland, including five medical schools.

1.29 In 2011, members of the AMRC funded 86 post-doctoral fellows, 192 PhD studentships and 272 projects in Scotland.[21] The Wellcome Trust, a member of the AMRC, alone accounted for more than £600 million of funding to Scotland over the previous decade.[22] Box 1D gives an illustration of the work of another large UK-wide research charity, Cancer Research UK, including the importance of Scottish facilities and scientific expertise.

1.30 Starting up, funding and administrating cross-border projects involving different administrative bodies could become more complex, particularly for charities who currently operate in only one part of the UK. Previous Scotland analysis papers discuss the impacts of divergences in regulatory and tax regimes. Similar impacts may be felt by UK research charities, who could face additional burdens for fundraising activities and administration, as they would have to navigate two separate regimes. For example, the UK Government currently matches charity funding through AcoRD (attributing the costs of health and social care research and development). The Scottish Funding Council (along with similar approaches by other HE funding bodies across the UK) allocates a proportion of the Research Excellence Grant to support research funded by charities in Scottish HEIs (commonly referred to by the sector as the Charity Research Support Fund). In addition charities currently benefit from the UK Government's Gift Aid scheme. Independence could mean separate schemes in the continuing UK and an independent Scottish state, should it choose to create its own.

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[19] Association of Medical Research Charities website, retrieved July 2013, <www.amrc.org.uk/our-members_member-profiles>.

[20] 2011 figure based on the Association of Medical Research Charities grants database analysis.

[21] Association of Medical Research Charities, retrieved July 2013, <www.amrc.org.uk/news-policy--debate_pawg-scotland>.

[22] Wellcome Trust, submission to the House of Commons Business, Innovation and Skills Committee enquiry into the implications of Scottish independence for higher education and research, June 2013.

Box 1D: Cancer Research UK

Cancer Research UK fundraising income for 2012-13 was £460 million, and annual research activity in the UK for the same period amounted to £351 million.

In Scotland, Cancer Research UK spent around £34 million in 2012-13 on some of the UK's leading scientific and clinical research, including projects in Edinburgh, Glasgow, Dundee and the University of Stirling which is home to Cancer Research's UK Centre for Tobacco Control Research.

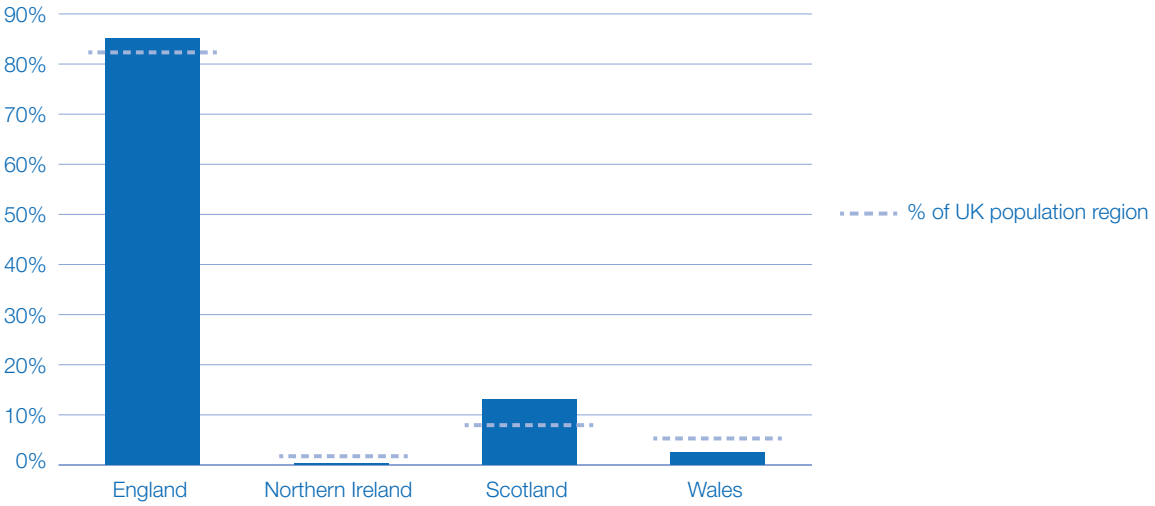
All basic and clinical cancer research at the Beatson Institute and the University of Glasgow is encompassed at the Glasgow Centre for Cancer Research. A programme of work has been established to seek out potential drug targets and develop cancer drug treatments of the future, including £24 million of funding from Cancer Research.

Glasgow, and Scotland more widely, has a successful history in this field: Cancer Research scientists first manufactured the brain cancer drug, Temozolomide, and thousands of people now benefit from treatment with this drug worldwide. In the 1970s, Cancer Research scientists in Dundee made a pioneering discovery – a molecule called p53 which is faulty in many cancers. This major breakthrough opened new avenues of research and led to treatments targeting p53, which are now being tested in clinical trials.

Today Dundee based scientists are investigating what causes non-melanoma skin cancer, one of the most common types of cancer in the UK. They have made great headway in revealing the inner workings of the disease which could lead to new treatments to help beat it. Edinburgh is also one of the sites for Cancer Research UK Centres. The Edinburgh Centre brings together scientists, doctors and nurses from across the city and Cancer Research committed £4 million in 2012 for Edinburgh based projects, including research into genes that can cause bowel cancer.

Source: Cancer Research UK

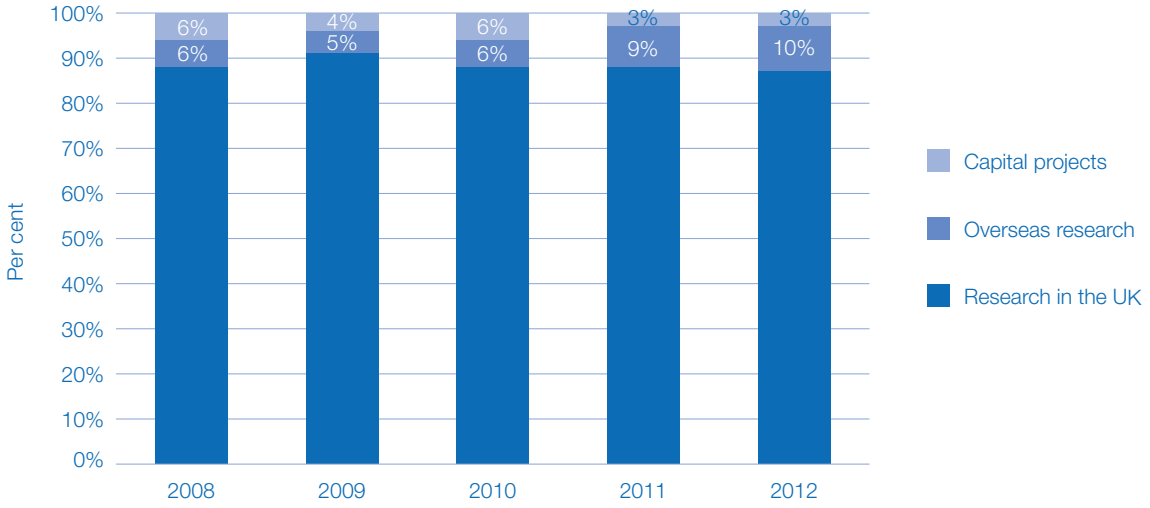
Figure 1.6: Research charity investment in the UK compared to population share in England, Northern Ireland, Scotland and Wales, 2011



Source: AMRC research portfolio database.

1.31 As discussed in the next chapter, there are restrictions and additional burdens when UK Research Councils embark on projects with countries and organisations outside of the UK. The same would be true of some research charities. AMRC estimates for 2012 indicate that only 10 per cent of research expenditure went to overseas projects. Although this figure has been growing in recent years (see Figure 1.7), it is still relatively small. The governance structure and policies of individual charities could play a role in this respect. For example the Wellcome Trust has a 50-50 funding partnership with the Republic of Ireland to ensure sustainable funding in the absence of an equivalent scheme to the HE funding bodies support for charitable research.[23] However, in other cases, such as with low to middle income overseas projects to support economic development, the Wellcome Trust can commit up to 100 per cent funding for a project, including capital and running costs.[24]

Figure 1.7: Breakdown of UK charities spending on research 2008-12



Source: Association of Medical Research Charities, *AMRC member research expenditure for 2012*, 14 June 2013, retrieved September 2013, <www.amrc.org.uk/publications/charity-funded-research-amrc-member-research-expenditure-2012>.

Industry bodies and incentivising R&D financing

1.32 *Scotland analysis: Business and microeconomic framework,* discussed some of the ways in which the UK Government encourages business led R&D projects. This includes direct support and funding through the UK Technology Strategy Board, and incentives to business such as the UK's R&D tax credit system, which provided more than £1.1 billion of tax relief to over 10,200 claimants across the UK in 2010-11.[25]

1.33 The Technology Strategy Board funds projects between innovative businesses and UK HEIs. For example, the Technology Strategy Board committed approximately £1.7 million co-funding to the Smart and Aware Pervasive Healthcare Environments (SAPHE) project, which has developed an unobtrusive sensor that can continuously monitor patients as they go about their daily lives. This type of monitoring can help preventative care and chronic disease management – giving early warning of emergencies and help manage long-term health problems discreetly. Imperial College London leads the project, in partnership with BT, Philips UK, Cardionetics, Docobo and Dundee University (who received £205,000 in

[23] Wellcome Trust, Wellcome Trust Biomedical Research Partnership, retrieved August 2013, <www.wellcome.ac.uk/Funding/Biomedical-science/Application-information/WTX062869.htm>.

[24] Wellcome Trust, <www.wellcome.ac.uk/Funding/International/index.htm>.

[25] HM Government, *Scotland Analysis: Business and microeconomic framework*, p82, July 2013, retrieved August 2013, <www.gov.uk/government/publications/scotland-analysis-business-and-microeconomic-framework>.

funding).[26] Other projects range from research into new methods of sea farming at the University of Stirling to business research specific to North East Scotland conducted by The Robert Gordon University and Aberdeen and Grampian Chamber of Commerce.[27]

1.34 The earlier paper also demonstrated how public funding for research helps leverage additional private investment in the UK, including foreign direct investment (FDI). The integrated nature of the UK's research and innovation framework is also a key factor in attracting FDI. The UK is the second biggest destination for FDI in the world, behind only the US. Scotland, as part of the UK, is also very successful in attracting foreign investors and these companies are also an important source of research funding. In 2010, 24 per cent of UK Business Enterprise Research and Development (BERD) was financed from abroad, compared with 9 per cent in France, 3.5 per cent for Germany and 0.5 per cent for Japan. An Ernst & Young survey found that research and innovation quality is the top feature the UK should display to remain a major destination for FDI.[28]

1.35 As well as supporting research in HEIs and their own research institutes, individual Research Councils also support knowledge translation to business and others by developing strategic relationships with companies and industry sectors. This enables the development of aligned and complementary R&D programmes. For example, the Medical Research Council is collaborating with the University of Dundee and six of the world's leading pharmaceutical companies to accelerate the development of new drug treatments for major global diseases including cancer, arthritis, lupus, hypertension and Parkinson's disease. The international market for these treatments is estimated to be worth £15 billion per annum and is projected to reach £30 billion per annum by 2025.

1.36 In the event of a vote in favour of independence, businesses in Scotland would no longer be able to benefit from the UK Government's tax credits or incentives. An independent Scottish state could set up and fund its own R&D tax credit system and seek alternative methods to identify its research priorities and align programmes with industry. This could include deciding whether to try to replicate UK research funding streams and expand Scotland's existing schemes to encourage business-HEI collaboration. It would also need to decide how such schemes should be administered. R&D based businesses operating across the UK could face the added complexities of adhering to two separate schemes.[29]

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[26] Technology Strategy Board, retrieved August 2013, <www.innovateuk.org/successes.ashx>.

[27] Technology Strategy Board projects database, retrieved September 2013, <www.innovateuk.org/projects>.

[28] Ernst & Young, *Staying ahead of the game: 2012 UK Attractiveness Survey*, 2012.

[29] HM Government, *Scotland Analysis: Business and microeconomic framework*, chapter 4, July 2013, <www.gov.uk/government/publications/scotland-analysis-business-and-microeconomic-framework>.

Box 1E: University spin-out companies

The knowledge universities generate from Research Council funding can also lead to the direct creation of new businesses and have an important economic impact. University spin-off companies take technological advancements from academic research and turn these into a commercial venture.

For example, Roslin Cells was founded by the Roslin Institute (which receives strategic funding from the Biotechnology and Biological Sciences Research Council) with the support of the University of Edinburgh, the Scottish National Blood Transfusion Service and Scottish Enterprise in 2006. It has grown rapidly to become a world leader in the isolation of new clinical grade undifferentiated stem cells for use in research and therapy. The company now employs 19 people, has an annual turnover of £1.3 million and reinvests any surplus revenues into stem cell research.[1]

The table below shows that in 2011-12, university spin-off businesses based on leading edge research from UK universities turned over nearly £2.5 billion and employed around 32,000 people. During the same period university spin-off companies in Scotland turned over approximately £360 million and employed around 4,700 people.[2] A recent report by Praxis Unico found Scotland to be the most successful region of the UK in the creation of university spin-outs[3] and the universities of Edinburgh and Strathclyde featured fourth and fifth in UK universities listings as measured by the number of spin-outs since 2000 (with 69 and 60 spin-outs respectively).[4] As these companies mature they can have a significant positive impact on the local and national economy.

Spin-off and start up activity in 2011-12

	Scotland	UK	Proportion of Scotland total in UK (%)
Number of active firms	656	8,688	7.6
Estimated current employment (full-time equivalents)	4,729	32,960	14.3
Estimated current turnover (£000s)	360,535	2,471,231	14.6
Estimated external investment received (£000s)	189,329	879,801	21.5

1 *BiGGAR Economics, Economic Impact of the Roslin Institute, 2013.*

2 Higher Education Funding Council for England, *Higher Education Business and Community Interaction Survey 2011-12*, retrieved August 2013, <www.hefce.ac.uk/pubs/year/2013/201311/>.

3 PraxisUnico, *Spin Out Survey Annual Report 2013*.

4 PraxisUnico *Spinouts UK Survey*, retrieved August 2013, <www.spinoutsuk.co.uk/listings/university-listings/>.

Shared infrastructure

1.37 In addition to directly funding research projects, researchers require both highly technical and often expensive infrastructure. Researchers across all of the UK, including Scotland, benefit from access to world leading shared infrastructure (e.g. advanced computing and special monitoring), as well as access to international facilities such as the European Centre for Nuclear Research (CERN)[30] and the European Southern Observatory (ESO).[31]

30 CERN convention was ratified in 1954 by 12 founding members including UK, France, Germany and Switzerland. It now has 20 members, with others in process of joining, such as Serbia and Israel. More details are available at <home.web.cern.ch/about>.

31 ESO is an inter-governmental organisation of 15 members, including Brazil which is in the process of joining (see <www.eso.org/public/about-eso/organisation.html>).

(These international facilities are each established under their own dedicated legal "convention" to which members are signatories.)

"Currently research groups in Scotland have excellent access to international science facilities such as the accelerators at CERN, the telescopes of the European Southern Observatory (ESO) and the space missions of the European Space Agency (ESA), for example, through subscription funding from the UK research councils. The Government of an independent Scotland would have to renegotiate access to these facilities with various bodies, such as CERN, ESO and ESA, and provide sufficient funds to secure that access. Currently RCUK facilitates research with international partners."

Institute of Physics in Scotland, Written evidence to House of Commons Business, Innovation and Skills Committee

1.38 Shared infrastructure allows for sharing of costs (improving efficiencies), expertise and larger scale investments than are possible through single funding streams. In addition the interaction between experts at shared facilities, frequently across a range of disciplines, leads to greater research quality beyond any cost savings generated.

1.39 In the 2010 Spending Review, UK Government allocated £1.9 billion for science and research capital for the period 2011-15 including capital for Research Councils and for large facilities. Since then the UK Government has allocated nearly £1.5 billion additional capital for science and innovation (including £145 million for e-infrastructure, £50 million to develop a Graphene Global Research and Technology Hub; £275 million for science capital projects, and £600 million in Autumn 2012 for science and innovation projects supporting the Eight Great Technologies).[32]

1.40 The UK's domestic research infrastructure is spread across the UK, with researchers able to access it regardless of where it is located. In some cases Scotland hosts such infrastructure on behalf of the UK, such as the UK National High Performance Computing service at Edinburgh University. In other cases Scottish researchers are users of infrastructure hosted elsewhere in the UK (e.g the Diamond Light Source synchrotron and the ISIS neutron in Harwell, Oxfordshire). Annex B contains a list of all UK Research Council owned and operated facilities in Scotland.

1.41 The UK also subscribes to international facilities, in Europe (e.g. CERN in Switzerland) or through global collaborations (e.g. the Jefferson Lab nuclear physics facility in the US which allows advanced study of atoms and matter through the use of continuous beams of high-energy electrons). In all cases, researchers contribute expertise to joint research programmes at international facilities and, with funding from Research Councils, have access to state of the art facilities and infrastructure that would not be affordable to any one country, but which is essential to maintain scientific leadership and a position at the forefront of research.

1.42 International subscriptions by the Science and Technology Facilities Council (STFC) amounted to £155 million in 2012. Over the last decade UK Government has invested some £932 million in infrastructure at the Harwell Science and Innovation Campus, including £453 million in the Diamond Light Source synchrotron and £261 million in the ISIS neutron source.

1.43 As the Big Science and Innovation report notes, there is no definitive list of research facilities available to UK researchers. Research Council operated facilities only make up

[32] Department for Business, Innovation & Skills, Eight Great Technologies, January 2013, retrieved September 2013, <www.gov.uk/government/speeches/eight-great-technologies>.

part of the reseach infrastructure (49 facilities as of September 2013, 7 of which are based in Scotland).[33] Many are controlled outright by their parent universities or research centres, or in partnership with other institutions, including business and charities. However, the Department for Business, Innovation & Skills was able to take advantage of the MERIL project, an EU-funded initiative to map research infrastructure across the EU, which reported at the end of 2012.[34] The report compiled a list of 221 Big Science facilities. This covers the EU's – including the UK's – main stock of large-scale research facilities of national or European scientific significance, of which 48 per cent only were single-sited, which means about half of such facilities are distributed, mobile or virtual. Annex C lists the UK's stock of large scale research facilities, based on the Technopolis report.

Box 1F: Examples of Scotland based research infrastructure

The UK Astronomy Technology Centre

STFC directly manages the UK Astronomy Technology Centre (ATC) in Edinburgh, providing funding of £1.78 million in 2012-13. The ATC is the UK's national facility for the design and production of world class astronomical technology. Scientists from ATC carry out observational and theoretical research into fundamental questions such as the origins of planets and of galaxies. STFC scientists and technicians have designed and built instruments for many of the world's major telescopes and have a track record of working with organisations such as the European Space Agency, NASA and the European Southern Observatory. In order to derive the maximum impact from publicly funded research, ATC Innovations (see <www.atcinnovations.com>) commercialises the technology and expertise located in Edinburgh.

Scottish Association for Marine Science

The Scottish Association for Marine Science has received £7 million in funding from the Natural Environment Research Council (NERC). It is one of the oldest oceanographic organisations in the world, and one of NERC's National Oceanography Centre delivery partners. It operates the Dunstaffnage Marine Laboratory – three miles north of Oban in Scotland – and hosts the National Facility for Scientific Diving and the Culture Collection of Algae and Protozoa.

It is an internationally renowned marine centre that focuses much of its activities on multidisciplinary research questions from Scottish coastal waters to the Arctic Ocean. Its core science programme investigates past and present changes in northern seas.

Potential impacts of an independent Scottish state

1.44 As set out in *Scotland analysis: Devolution and the implications of independence*, as the continuing state in the event of a vote for independence, UK national institutions would operate on behalf of the remainder of the UK as before but would have no power or obligation to act in or on behalf of an independent Scottish state. Access to existing assets located in the remainder of the UK, and mobile assets, would be subject to negotiation.

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[33] Number of facilities provided by Research Councils UK, September 2013.

[34] Technopolis, *Big Science and Innovation, 2013, commissioned by BIS, p15, notes,* "The basic criterion for inclusion in the database was a research facility judged by proposers and the MERIL team to be of national or European scientific significance, which is a reasonable proxy for large research facilities (our focus here). The MERIL database is available online and, while it remains a work in progress, it provided an excellent starting point for our ambition to quickly compile a reasonably complete list of current facilities. Definitional questions remain of course and our final list can only be seen as a partial inventory; it is not definitive. However, with 221 entries it is a useful platform from which to form a preliminary view of the current stock."

1.45 Currently access by international researchers to facilities and infrastructure which are under the direct control of RCUK reflects the nature of the facility and the demand on that facility. Box 1G provides examples of access criteria for selected STFC facilities, and it can be seen that greater access is provided for researchers based in the UK. The primary criteria is scientific excellence and all applications for access are subject to peer review. Similar access arrangements are available at many of those UK facilities and infrastructures which are outside of RCUK control. Access to EU based researchers is also available, but generally on a more limited basis, and all of STFC's major facilities recognise the European Commission's Research Infrastructures "I3" Programme. This programme was devised for larger projects to consolidate and integrate schemes into a single contract.[35]

1.46 Facilities owned by NERC, such as scientific research ships, follow the same policy as the responsive mode grants (i.e a funding stream that is responsive to excellent researcher inspired ideas in any area relevant to NERC's remit). This means an overseas researcher wanting access to a NERC facility would have to collaborate with an eligible UK academic. For some of the facilities not wholly funded by NERC an overseas researcher could access the facility on a commercial basis direct with the university.

1.47 In the event of a vote for independence, the terms of access to existing UK-operated research institutions by researchers in a newly independent Scottish state could not be guaranteed, and it is unlikely they would be on the same basis as researchers in the continuing UK. In some cases future access to infrastructures located in the continuing UK by academics in Scotland would be likely to depend on collaborative relationships with academic partners in the continuing UK.

1.48 Similar issues would also arise in relation to access to international facilities, where an independent Scottish state would need to negotiate its own membership of international collaborations and bodies in the same way as any other state. The same level of access as exists within the UK at present could not be guaranteed. For example, the UK has very recently signed an official agreement for the UK to become an associate partner of the Facility for Antiproton and Ion Research in Europe (FAIR). FAIR is a new and unique international accelerator facility based in Germany for research with antiprotons and ions. The facility, where various physics programmes can be operated in parallel, will offer outstanding research opportunities and discovery potential and around 3,000 scientists from about 50 countries are working on the planning of the experiment and accelerator facilities. The UK has been one of the first countries to negotiate access to this facility and is currently one of only 10 partner states. As part of this project, the University of Edinburgh has provided its expertise in nuclear astrophysics, nuclear physics and hadron physics. They have world-leading expertise in the development of Advanced Silicon Strip Detector Systems, which is being applied through the construction and installation of the AIDA (Advanced Implantation Detector Array) detector at FAIR.

[35] European Commission website, retrieved October 2013, <www.ec.europa.eu/research/infrastructures/index_en.cfm?pg=existing_infra>.

Box 1G: Examples of access criteria to UK research facilities

The STFC runs a number of UK based facilities, details of which can be found on their website, along with information on access criteria for certain facilities.[1] Below is brief information on access to two UK facilities.

ISIS

ISIS is a world-class neutron and muon source at STFC's Rutherford Appleton Laboratory, in Oxford. ISIS produces beams of neutrons and muons that allow scientists to study materials at the atomic level using a suite of instruments, often described as 'super-microscopes'.[2]

UK researchers have a number of methods to gain access or 'beamtime', including a twice yearly application process for direct access, a rapid access process where it can be demonstrated that beamtime is required at shorter notice, and express access for short or test measurements. There is also commercial access for "industries with a UK manufacturing or research base".[3]

ISIS is also a member of the 'NMI3' network of European neutron and muon facilities. It has some limited funding for EU research groups to access the facility, provided the majority of the group is affiliated with an EU member state.[4]

HECToR

HECToR is a supercomputer located at the University of Edinburgh. It has a wide range of uses from measuring the reactivities of functional materials such as minerals and ceramics, to modelling tropical climate systems.

The procedure for applying for access to the HECToR facility differs depending on whether you are a UK, European or other academic researcher; or work for a commercial organisation.[5] As a UK researcher there are a number of direct access routes, from a peer reviewed project to more limited access from review of professional grants and completion of a technical assessment form. European based researchers have more restricted access, either through collaboration with a UK researcher or through the existing pan-EU supercomputing initiatives. Researchers outside of the EU are largely restricted to collaboration with a UK researcher if they wish to have access.

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1 Science and Technology Facilities Council, <www.stfc.ac.uk/2466.aspx>.

2 ISIS website, <www.isis.stfc.ac.uk/about-isis/aboutisis.html>.

3 ibid, <www.isis.stfc.ac.uk/apply-for-beamtime/types-of-beamtime4407.html>.

4 ibid, <www.isis.stfc.ac.uk/apply-for-beamtime/eu-funding-for-experiments-at-isis9834.html>.

5 HECToR website, <www.hector.ac.uk/howcan/admin/#ukaca>.

Conclusion

1.49 Scotland benefits from a range of funding sources, both reserved and devolved, existing research facilities and infrastructure, and financial collaborations between institutions in Scotland and the rest of the UK. Scotland has prospered from the UK's strong commitment to research funding and has historically and consistently attracted a higher proportion of research funding from the UK-wide Research Councils compared to either its population or GDP share. This is testament to the strength of the Scottish research base as part of the UK.

1.50 National governments are responsible for funding national research. In the event of independence the government of an independent Scottish state would become responsible for deciding how much to spend on research activity and how to distribute funding. External sources of funding, such as the EU's Horizon 2020 research programme and FDI, would not fully replace lost income from Research Councils and other UK-wide schemes.

1.51 Research Councils are an important source of funding, but by no means the only consideration. There may be knock on effects on business and charities research activities in both an independent Scottish state and the continuing UK, as tax and regulatory regimes diverge. Business currently benefits from UK R&D tax incentives, and an independent Scottish state would need to consider if it wanted to set up and fund its own schemes. UK-wide research charities also play an important role in the UK research system, particularly in life sciences, and have a large presence in Scotland. Independence could effect the operation of these organisations, particularly those charities that currently operate within the UK only.

1.52 Accessing existing infrastructure, both mobile and non-mobile, in a continuing UK could become more complex for academics in an independent Scottish state. Where facilities are owned by UK Research Councils, this could mean access granted on the basis of peer-reviewed applications or collaboration with UK academics. Access to international facilities would need to be renegotiated between an independent Scottish state and the host of that facility.

1.53 The next chapter considers the role that the UK-wide research framework plays in fostering cooperation and collaboration both within the UK and internationally. This includes projects involving multiple HEIs, and coordinated by RCUK, to the role played by UK Government organisations to promote UK research internationally, such as the work of the UK Science and Innovation Network.

Chapter 2:
A common framework for excellence: coordination and collaboration

As part of the UK, Scotland contributes to, and benefits from, a common, strategic research framework ensuring that science and research activity aligns behind a common set of research priorities. Key elements which enable funding, research collaborations and knowledge to flow freely across the UK include:

- **Frameworks to develop strategic research priorities** for the UK and promote efficient funding arrangements to reflect research challenges and opportunities.
- **International representation.** The UK Science and Innovation Network and Research Council UK international offices provide support to UK, including Scottish, institutions seeking international collaboration and investments.
- **Support for collaborations with business.** Universities and research institutions act as hubs of expertise, knowledge, and facilities to help businesses access key skills, improve products and processes and bring new products to markets.
- **Shared frameworks, concordats and policy guidance through which research excellence is supported and coordinated.** The standards and frameworks put in place across UK higher education institutions and by UK-wide Research Councils provide the order and stability needed to promote excellent science and research.
- **Internationally recognised assessment criteria.** The UK Research Excellence Framework will benchmark UK institutions, including those in Scotland, against internationally recognised standards and internationally competitive institutions across the UK. This enhances their international reputations and assists the winning of funding (including from overseas) and enables collaborative arrangements.
- **Supporting a large pool of highly trained researchers.** Many researchers benefit from the opportunity to develop their careers across the UK and internationally. This provides a mobile highly skilled and larger pool of researchers for Scottish institutions with rewarding career opportunities.

In the event of a vote in favour of independence it cannot be guaranteed that this close coordination and collaboration would continue unhindered. It would be up to the government of an independent Scottish state to design and implement a policy framework to support research or negotiate with the continuing UK to remain part of the current system. There is limited international precedent for sharing such arrangements and it would only be possible if both an independent Scottish state and the continuing UK could reach an agreement that satisfied both countries' economic and social interests.

Introduction

2.1 Researchers from across the UK currently benefit from an integrated, well-aligned system which allows the delivery of excellent research and which supports collaborations between researchers across the UK, as well as projects with industry and academics overseas. In the event of a vote in favour of independence all collaboration between researchers in the continuing UK and an independent Scottish state would be international in nature and could involve additional administrative effort, time and risk. Current national frameworks including the highly-regarded Research Excellence Framework would not automatically be available in the event of a vote for an independent Scottish state. Each aspect would need to be negotiated on a case-by-case basis and would in any case be determined by decisions taken outside Scotland.

2.2 This chapter covers: mechanisms to support the strategic coordination of research across the UK; methods to facilitate collaborations with businesses and others, including internationally; arrangements to develop researchers' careers; and the current UK-wide mechanism to assure the excellence of research – the Research Excellence Framework. Many of these areas have been considered by Universities Scotland in *Universities in a dynamic constitutional environment: policy issues for consideration*.[1]

Strategic coordination of research

2.3 The UK Research Councils play a central role in driving the UK's – including Scotland's – world-class reputation for research. They have strong and well established relationships with relevant research and user communities across the UK and overseas. This ensures confidence in their strategy and its delivery, and in their ability to draw on expertise (for example to provide peer review in order to identify the highest quality proposals). Research Councils have provided a sustained long-term capability in research and training. This produces a pipeline of ideas, people and innovations needed both by business and government, and also remains flexible enough to move into new areas (e.g. graphene, synthetic biology and others mentioned in *Eight Great Technologies to Boost Growth* report[2]) as these arise.

2.4 In addition to the role of the Research Councils, a number of bodies support the strategic coordination of research. For example, the Office for Strategic Coordination of Health Research (OSCHR) helps coordinate health research across the UK (see Box 2A for more details). Another illustration is the Marine Science Coordination Committee, which is a partnership of UK Government Departments, the Devolved Administrations of Scotland, Northern Ireland and Wales, the Environment Agencies and research bodies involved in funding and carrying out marine science in the UK. It is chaired jointly by Defra and Marine Scotland.

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1 Universities Scotland, *Universities in a dynamic constitutional environment: policy issues for consideration*, November 2012, retrieved September 2013, <www.universities-scotland.ac.uk/uploads/ConstitutionPaper2012final.pdf>.

2 See <www.gov.uk/government/speeches/eight-great-technologies>.

Box 2A: Strategic coordination of health research

The Office for Strategic Coordination of Health Research (OSCHR) facilitates coordination of health research in the UK. The OSCHR Board has been a pivotal mechanism for creating partnerships between the principal Government funders of health research in England, Scotland, Wales and Northern Ireland. The Board's collective view facilitates the identification of new opportunities to promote the UK life science sector by exploiting the world-class life science academic base. OSCHR does not allocate funds or grants and partners retain their individual strategic and financial independence.

Scotland, through the Chief Scientist Office, has been a member of the OSCHR Board since 2008. This enables Scotland to contribute to the discussions around the UK health research strategy and collaborate on a number of programmes across UK health research. Two of many examples are the UK-wide establishment of 18 experimental cancer medicine centres; and the creation of the E-Health Informatics Research Centres, established in London, Manchester, Swansea and Dundee now enhanced with additional capital from the Medical Research Council (MRC) to create the UK-wide Farr Institute.

2.5 These common approaches help ensure that research activity is coordinated, delivers value for money and that duplication and overlap is minimised. In the event of a vote in favour of independence continuation of this co-ordination could not be guaranteed. This strategic funding framework would diverge, and research in an independent Scottish state and the continuing UK would be likely to become more fragmented.

Collaboration and networking between UK researchers

2.6 Collaboration between researchers across institutions, either domestically or internationally, is an intrinsic part of all developed science and research sectors. Collaboration in research leads to greater quality and reduced costs as expertise and equipment are shared.

2.7 Collaboration between researchers across all parts of the UK is facilitated by the absence of barriers within the current single coherent funding and operational framework and a highly integrated science community. Box 2B illustrates a typical example of collaborations between researchers from institutions based across the UK in a Research Council funded project, and further examples are shown in Chapter 1.

Box 2B: Collaboration across the UK

Innovation and Knowledge Centre for Synthetic Biology

The £10 million Innovation and Knowledge Centre (IKC) announced in July 2013 is a new national resource that will boost the UK's ability to translate the emerging field of synthetic biology into applications and provide a bridge between academia and industry.

The IKC, to be called SynbiCITE, will be based at Imperial College London and will involve researchers from further UK universities including Edinburgh and Glasgow as well as 13 industrial partners, such as the research arms of Microsoft, Shell and GlaxoSmithKline. Its main aim will be to act as an Industrial Translation Engine that can integrate university and industry based research in synthetic biology into industrial process and products.

SynbiCITE is funded by the Engineering and Physical Sciences Research Council (EPSRC), the Biotechnology and Biological Sciences Research Council (BBSRC) and the Technology Strategy Board. It will receive initial grant funding of £5 million, with a further £5 million to be awarded over the next two years.

2.8 Collaboration across the UK is also facilitated by formal government committees and multi-agency networks such as the Living with Environmental Change Partnership. This brings together 22 UK public sector organisations that fund, carry out and use environmental research and observations – allowing the sharing of knowledge and delivery of joint programmes involving many universities and research centres. The Scottish Government and the Scottish Environmental Protection Agency are members.

International collaborations

2.9 International collaboration allows researchers to undertake research on a scale that cannot be achieved within individual countries. This enhances the quality of research performed and contributes to the international standing and prestige of the UK research base. The intrinsic strength, quality and reputation of the UK research base is well-understood internationally and makes UK researchers attractive partners in international research, which further enhances the strength of the UK. Nearly half (46 per cent) of UK publications are internationally co-authored (second only to France in a comparator group of large research systems), and 16 per cent are co-authored with academics from other institutions within the UK. Such collaborative behaviour is associated with higher research performance: internationally co-authored publications have a citation impact twice as high as publications which are single-authored or co-authored with an academic within the same institution; the citation impact is 1.4 times higher for publications co-authored with academics from different institutions within the same country.[3]

2.10 Participating in international collaborations, while important, can involve additional administrative effort, time and risk. These result from the need to align priorities, and agree complementary assessment, funding and evaluation processes. Indeed for this reason international projects such as those under the European FP7 programme typically allocate significant sums for administration and project management – more than the level expected for national collaborations. The additional risks for international projects generally could include needing approval from different funding bodies, differences in the treatment of intellectual property and working in multiple currencies and the associated exchange rate risk and transaction costs.[4]

2.11 UK Research Councils have instigated various international collaborative arrangements which aim to facilitate these engagements and additionally work closely with the European Commission on behalf of the whole research community. International awards are either funded as part of a one-off multilateral activity of which the Research Council is a partner, or as part of a formal international group to which the RCUK or the UK is a partner. Awards to UK partners on international calls are generally made through existing grant payment systems. All projects are awarded primarily on the basis of excellence and need to be competitive with national programmes of research.

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[3] BIS, *International Comparative Performance of the UK Research Base 2011*, <www.gov.uk/government/publications/uk-research-base-international-comparative-performance-2011>.

[4] HM Government, *Scotland Analysis: Currency and monetary policy*, April 2013 discusses the benefits of the UK's single currency framework and the possible implications of independence on currency and monetary policy.

2.12 Formal collaborations with a particular country may require either political agreements or a significant financial (or other) offer in order to make use of the other country's research infrastructure. An example of the latter is the UK-Dutch collaboration in Antarctic science.[5] The Netherlands Polar Programme has signed a Memorandum of Understanding (MoU) with the British Antarctic Survey (BAS). The MoU included: provision for the installation of a Dutch science facility at Rothera Station on the Antarctic Peninsula; an agreed service level of scientific boating; laboratory access; accommodation; and access to facilities and services. The Netherlands funded the €1 million cost of the laboratory and pays an annual fee (currently £320,000) to BAS.

2.13 The Netherlands funds the science projects by grant rounds. UK researchers are involved with each grant and the programme is very closely integrated with UK science activity at Rothera. BAS advises on the logistical feasibility of each grant bid and has the right to refuse to host a project.

2.14 An independent Scottish state could look to co-invest some of its own funds in projects with other countries for example under a 'lead agency' agreement (see Box 2C). Under these agreements funding agencies agree to support research that has been supported by a peer review panel in another international country. This can be difficult if the two countries have different priority areas, or where the size of the relative research funds available to each country are very different – decisions made by the larger state can have greater implications for the smaller nation. For this reason such initiatives tend to be significantly smaller than nationally-driven programmes and are not a replacement for national schemes.

2.15 There is very limited evidence internationally of the effects on a shared knowledge base when countries seperate from a union. One of the closest and most recent examples is probably the break up of Czechoslovakia in 1992, creating the states of Slovakia and the Czech Republic.[6]

2.16 Evidence suggests that the Czech and Slovak national research resources separated during the first year after separation and there is no cross-border pooling scheme currently in existence. Czech and Slovak research councils discuss best practice, but without joint funding. Since the break-up, budgets have been passed through separate approval processes and spending allocations, and resources are not shared between the two countries.

2.17 The basic principle for the property division between the Czech Republic and Slovakia including the division of all science facilities was the location of a property – those in the Czech territory became the property of the Czech Republic, and those in Slovakia territory became Slovak. All corporeal assets including cash were divided according to the number of inhabitants (two thirds for the Czech Republic (10 million people) and one third for Slovakia (about 5 million people)). The Czech Government's science budget was agreed by the decision of the Czech parliament as one line in the budget proposal for 1993 and the same situation was true for Slovakia.

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5 <www.antarctica.ac.uk/about_bas/news/news_story.php?id=738>.

6 Sources: Czech Academy of Sciences, Act on establishment of the Czech Academy of Sciences from January 1 1993 (in Czech only), retrieved August 2013, <www.cas.cz/miranda2/export/sitesavcr/data.avcr.cz/o_avcr/zakladni_informace/dokumenty/zakon_283-1992.pdf?0.5695264439106177>. The Czech Official Journal of the Academy of Sciences discussion on division of Czechoslovakia and its effects on science (in Czech only), retrieved August 2013, <abicko.avcr.cz/archiv/2002/7/obsah/rozdeleni-ceskoslovenska.-deset-let-pote.html>.

Box 2C: Intergovernmental research cooperation

Germany operates a scheme which supports collaboration between Germany, Austria and Switzerland. It consists of mutual opening of certain respective funding programmes and enables cross-border funding. This is not a joint funding pot, but operates on a similar basis to the UK-Brazil agreement on research collaboration.[1]

The G8 Heads of Research Councils Multilateral Funding Initiative is aimed at supporting excellent research on topics of global relevance best tackled through a multinational approach. This recognises that global challenges need global solutions. Funding should support researchers to cooperate in consortia consisting of partners from at least three of the participating countries. The first call of the initiative was on Exascale Computing and was launched in 2010.

NordForsk is an organisation under the Nordic Council of Ministers that provides funding for Nordic research cooperation, as well as advice and input on Nordic research policy. It was established in 2005 and provides modest funding for cooperation within all fields of research (amounting to 117 million Krona – around £13 million in 2011 – small compared with the £307 million secured by Scottish institutions alone from UK-wide Research Councils in 2012-2013). Normally projects involve cooperation between at least three Nordic countries or autonomous areas. Grants are awarded on the basis of open calls for proposals and peer review procedures.

[1] The UK-Brazil Memorandum of Understanding provides for the relevant Research Council to act as the 'lead agency' (receiving and assessing collaborative proposals from eligible institutions), with the usual eligibility criteria for RCUK applicants and financial support from Brazil is given to eligible Brazilian organisations.

2.18 In recognition of the importance of international collaborations for all of the UK, the UK Government funds a Science and Innovation Network (SIN) of science and innovation officers based in British Embassies, High Commissions and Consulates around the world. The network is made up of more than 90 staff, based in 46 different locations in 29 countries and territories and costs £4.6 million a year to run. It is one of the largest networks of this kind in the world: smaller countries may not be able to replicate such a large dedicated force because of the significant cost and administrative effort required.

2.19 SIN officers engage with the local science and innovation community in support of UK policy overseas. Alongside the RCUK overseas teams, they provide support for UK research performers seeking international opportunities. In the event of independence Scotland would lose access to these networks. Box 2D highlights examples of the support offered by these bodies. In addition to the SIN network and RCUK overseas teams, Scottish universities currently use British Council services to support their international recruitment.[7] Scottish Development International (SDI) supports trade investment in Scotland with 26 offices in 16 countries worldwide (excluding the UK) but does not have the specialist focus on science and innovation.

[7] Source: European Science International Network representatives, July 2013.

Box 2D: The Science and Innovation Network (SIN) and RCUK international support for Scotland

Support for Scottish organisations is provided by the network of science and innovation officers based in British Embassies, High Commissions and Consulates around the world. For example the RCUK India team, along with SIN India, secured research funding of over £100 million for collaborative projects, including projects involving Scottish universities. Projects include:

- Bridging the Urban Rural Divide – involving University of Strathclyde, University of Aberdeen, and Heriot-Watt University.
- Changing Water Cycles – involving Heriot-Watt University, and University of Dundee.
- Fuel Cells – involving universities of St Andrews and Strathclyde.
- Solar – involving University of Strathclyde.
- Next Generation Networks – involving the University of St Andrews.

2.20 In the event of a vote in favour of independence, relationships between the continuing UK and an independent Scottish state would become international relationships. While there are examples of international research cooperation, these typically involve encouraging voluntary coordination of research programmes and limited joint funding initiatives as well as collaborations on specific projects and are not a replacement for national approaches. Normal practice for funding bilateral research programmes sees the researchers paid by their own respective national research organisation. The Research Councils would therefore continue to fund researchers in the continuing UK, and it would be for the government of an independent Scottish state to make arrangements for funding researchers in Scotland. The current ease of collaborations between researchers in Scotland and the rest of the UK may be put at risk.

Collaboration with business

2.21 Universities and research institutions act as hubs of expertise, knowledge, and facilities to help businesses access key skills, collaborate on research, improve products and processes and bring new products to markets. The World Economic Forum[8] ranks UK among the top five nations in the world for university-business R&D collaboration, which it considers a notable competitive advantage for the UK. In addition, the Global Innovation Index 2013 showed the UK moving up from 5th to 3rd in the world rankings (and now ahead of US) out of 142 economies.[9] Research Councils are currently working with nearly 2,500 businesses, in sectors ranging from broadcasting to biotechnology and engineering to insurance, and universities work with many more. EPSRC estimate that 40 per cent of their grant funding involves collaboration with business. An example of research collaborations with business is set out in Box 2E.

[8] World Economic Forum, *The Global Competitiveness Report 2012-13*, 2012, p515, retrieved April 2013, <reports.weforum.org/global-competitiveness-report-2012-2013/#=>.

[9] Johnson Cornell University, INSEAD and the World Intellectual Property Office, *The Global Innovation Index 2013*, retrieved October 2013, <www.globalinnovationindex.org/content.aspx?page=gii-full-report-2013>.

Box 2E: Collaborations with business

EPSRC Centre for Innovative Manufacturing for Continuous Manufacturing and Crystallisation

An initial £5 million from EPSRC along with £1.8 million from industry partners – plus a £34 million project extension (including £11.4 million of Research Partnership Investment Fund (UK RPIF) funding and co-funding from private partners).

This new Centre brings together an initial team of 13 leading academics from across seven UK institutions, including the Universities of Strathclyde, Glasgow, Edinburgh and Heriot-Watt. Working closely with industry partners it aims to accelerate the adoption of continuous manufacturing processes, systems and plants for the production of high-value chemical products to higher quality, at lower cost and more sustainably. By supporting a collaborative, multi-disciplinary programme the Centre aims to:

- Enable the change from batch to fully continuous manufacturing processes for high value chemical products.
- Produce better chemical and pharmaceutical products, at lower cost, more sustainably through transformational change in how particles are manufactured.
- Increase competitiveness of UK chemical manufacturers through reduced costs and higher value products.

2.22 In 2011-12, research income from business to HEIs in Scotland totalled over £64 million.[10] As noted in Chapter 1 UK-wide programmes encourage many businesses and universities to work together and generous tax credits encourage more business led research and development. In the event of a vote in favour of independence the UK national institutions would have no power to act in or on behalf of an independent Scottish state, and no obligation to create the powers to do so. While the government of an independent Scottish state could seek to increase collaborations between Scottish universities and businesses, partners would need to be found from a smaller pool of organisations (19 HEIs in Scotland compared with over 160 in the UK, and an estimated 320,000 businesses in Scotland compared with over 4.8 million businesses in the UK) reducing the opportunities to find organisations operating in the desired field and with appropriate expertise. If Scotland were to leave the UK it would pose a significant risk to these opportunities.

Research excellence

2.23 The UK research environment is underpinned by a set of shared operational and policy frameworks and guidelines establishing best practice across a range of issues. Indeed, the UK's Research Excellence Framework (REF), as discussed in Box 2F, will set, as with the Research Assessment Exercise which it replaces, a clear benchmark for research excellence which is widely recognised internationally and is used to attract funding (including from overseas and from businesses), researchers and students.

[10] Higher Education Statistics Agency Data 2011-12, <www.hesa.uc.uk>.

Box 2F: A single framework for assessing excellence

The UK Research Excellence Framework (REF) 2014, which replaces the Research Assessment Exercise, will assess (through a panel peer review process) HEIs in the UK on the quality of:

- Their research outputs;
- The institutional environment in which research is undertaken; and
- The impact that has arisen from their excellent science and research.

As a benchmarking exercise against many internationally competitive institutions across the UK, it allows institutions to demonstrate their strength and attract high quality students, academics and funding. This is a key element in demonstrating and enhancing the international research reputation of UK HEIs, including those in Scotland.

The REF has been developed collectively by the higher education (HE) funding bodies (led by the Higher Education Funding Council for England (HEFCE) and including the Scottish Funding Council (SFC)) through detailed consultation with the HE sector across the UK. For example, in order to develop the impact assessment methodology, a pilot assessment exercise involved researchers and institutions from across the UK (including the universities of Dundee, Glasgow, Stirling and St Andrews) and covered a selection of disciplines, to ensure that the diversity of UK institutions were properly reflected. The full REF exercise will involve the assessment of research within 36 units of assessment (disciplines) through peer review by panels of experts drawn from UK and overseas. UK HEIs plan to submit the research of over 50,000 academic staff for assessment in REF 2014.

The REF assessment will provide accountability for public investment in research and evidence of the benefits of this investment across the UK. The assessment outcomes will provide benchmarking information and establish reputational yardsticks for UK HEIs, and will be used by the HE funding bodies to inform future research funding allocations. It also will act as a benchmark for research excellence which is recognised internationally and is used to attract funding, researchers and students.

2.24 The peer review system is a crucial element in establishing and maintaining high standards. This process is easier to facilitate through a larger and integrated community of researchers. The UK has a population of 60 million, with over 160 HEIs to draw upon, including the strength of the Scottish research base. An independent Scottish state would have a population of around 5 million and 19 HEIs (Scottish HEIs account for just over 9 per cent of UK academic staff).

2.25 As Box 2F shows, the current REF process was developed across the UK with Scotland playing an active role. If Scotland became an independent state then participation in future REF exercises would need to be negotiated with the continuing UK. The implications of this would need to be considered carefully by the continuing UK and any arrangements would need to benefit the continuing UK as well as an independent Scottish state and would be subject to detailed negotiations. There is no international precedent for two nations collaborating on similar REF-style arrangements.

2.26 Research excellence is also facilitated across the UK through a range of other mechanisms. Research concordats, such as those discussed in Box 2G, are valuable in bringing together funders and sector representative organisations across a range of issues, enabling a coordinated approach to policy setting, evaluation and the development of best operational practice.

Box 2G: UK-wide research governance policies

- **The Concordat for Engaging the Public with Research** outlines the expectations and responsibilities of research funders with respect to public engagement, to help embed public engagement in universities and research institutes.[1]
- **Research Councils UK (RCUK) Research Integrity Policy** is governed by the UK Concordat to Support Research Integrity. This is a Universities UK policy document to which RCUK are signatories, in addition to all the HE funding bodies (including the SFC).[2] This helps researchers and research organisations to manage their research to the highest standards of rigour and integrity, and provides guidance on the reporting and investigation of unacceptable research conduct. It also makes a clear statement about the responsibilities of researchers, employers and funders of research in maintaining high standards in research.
- **The RCUK Policy on Open Access**[3] provides guidelines to institutions and researchers on how to comply with new open access requirements. This supports bodies in achieving the stated Research Council aim to achieve immediate, unrestricted, on-line access to peer-reviewed and published research papers, free of any access charge to researchers worldwide.
- **Transparent Approach to Costing** (TRAC) is a national framework for costing teaching and research in HEIs across the UK. TRAC enables institutions to acquire better cost information, which should help them make more informed decisions about their portfolios and the pricing of their activities. It provides a clear idea of the resources required to support a sustainable and excellent higher education sector.
- **Equality and diversity** across the UK research base is the responsibility of the UK Research Councils. This is currently overseen and assessed by a UK-wide framework.[4] In addition, in developing the arrangements for the REF[5] the UK funding bodies have taken forward their commitment to supporting and promoting equality and diversity in research careers, coherently and consistently across the UK.

1 <www.rcuk.ac.uk/per/Pages/Concordat.aspx>.

2 <www.universitiesuk.ac.uk/highereducation/Pages/TheconcordattosupportresearchintegrityAspx>.

3 <www.rcuk.ac.uk/research/Pages/outputs.aspx>.

4 <www.rcuk.ac.uk/research/Pages/Diversity.aspx>.

5 <www.ref.ac.uk/equality>.

2.27 *Scotland analysis: Business and microeconomic framework* set out how common rules and institutions reduce burdens for business. Researchers and research charities currently benefit from seamless regulation across the UK to facilitate biomedical research. Key areas include the use of tissues and embryos, ethical construction of research projects (especially those that are multi-site and within the NHS), clinical trials using humans or animals and the use of medical devices. For example the creation of a new Health Research Authority has streamlined regulatory processes and enables single permissions

and consents for medical research across the UK. In the event of a vote in favour of independence, new regulations and institutions would create uncertainties for researchers and investors. Organisations, including medical charities, would have to absorb the burden of regulatory divergence. Cross-border collaboration could also be impeded if partners needed to seek approval from different authorities and follow two different sets of regulation.

2.28 For example Directive 2010/63/EU on the protection of animals used for scientific purposes harmonises the regulation of research using animals across Europe. This assures investors looking to fund research in EU member states that the research they fund is conducted to a high standard of animal welfare. This also ensures no member state is placed at a competitive disadvantage by variances in regulation. Research using animals is currently a reserved matter and regulated by the UK Home Office. An independent Scotish state would need to put in place a new regulatory process to license and monitor research using animals and, dependent on EU membership, decide whether to harmonise with the regulatory process outlined in the Directive.

Research career opportunities

2.29 The current policy and operational framework for researchers is UK-wide. This much broader environment provides more opportunities for experience and progression.

2.30 UK researchers benefit from a number of initiatives to develop their skills and potential to build rewarding careers from PhD level onwards. In many cases these operate across the whole of the UK, with widespread practice sharing and benchmarking across England, Scotland, Wales and Northern Ireland for the benefit of all UK institutions.[11] Box 2H sets out examples of initiatives or activities relating to the professional development of researchers. Scotland currently benefits from engaging in UK initiatives such as Research Council Doctoral Training Centres. This includes the largest of ESRC's 21 Doctoral Training Centres (DTC) which is embedded within the wider Scottish Graduate School of Social Science (SGS) and also receives funding from the Scottish Funding Council and the Scottish Government for administration and additional studentships.

2.31 The ESRC has awarded 65 studentships annually to the SGS-DTC over the funding period (2011-16), based in ten Scottish universities and spread across the full range of social science disciplines. However, in 2012, the DTC awarded 82 studentships (due to their securing additional funding from non-ESRC sources). Scotland also has the flexibility to implement distinct local initiatives (e.g. the Scottish Research Pools for doctoral training, and different visa conditions for graduates) where they add significant advantage. In the event of a vote for independence Scotland would no longer enjoy the best of both worlds and access to such Research Council schemes would no longer be guaranteed.

[11] Vitae operates through 8 regional Hubs which cover England, Scotland, Wales and Northern Ireland.

Box 2H: Enhancing research career opportunities

- Consultation with Scottish institutions about a recent SFC initiative to explore ways to enhance the levels of support available for career development and employability of researchers within Scotland (CHORUS) revealed a firm desire to continue to be part of the UK-wide Vitae network. Scottish institutions expressed a clear preference to continue to work collaboratively with institutions across the UK.
- Scottish institutions are active participants in the biennial UK benchmarking surveys relating to researchers and run by Vitae and the HE Academy.[1] The surveys are valued in benchmarking provision, not only against other Scottish institutions, but against the UK aggregate and other benchmarking groups such as the Russell Group institutions.
- There is a UK-wide process for organisations to gain the European HR Excellence in Research Awards, which has been highly beneficial for the UK, compared to other member states.[2] The UK currently has over 80 Awards (the most in Europe), including 10 Scottish institutions and the SFC.[3]
- Scottish institutions engage in, and benefit from, the knowledge, experiences and practice sharing relating to the professional development of researchers. For example, the internationally recognised Vitae Researcher Development Framework was developed pan-UK with input from Scottish institutions and is now widely used in Scottish (and the rest of UK) institutions to inform the strategy and practice of researcher development.
- The Concordat to Support the Career Development of Researchers[4] has had a significant impact on enhancing provision for research staff in UK universities. The implementation has been funded by the UK HE funding bodies and the Research Councils, latterly through the Vitae programme and including annual progress reviews and benchmarking. A similar arrangement is in place for a UK-wide equality and diversity project, 'Every Researcher Counts'[5] where activities and outcomes are able to be achieved across England, Wales, Scotland and Northern Ireland through one consolidated programme.
- With all of these UK-wide systems an independent Scottish state would need to decide if it wished to negotiate new terms of operation to enable continued use of these frameworks.

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1 See <www.vitae.ac.uk/policy-practice/265681-590881/How-to-create-the-2013-Careers-in-Research-Online-Survey-CROS.html>.

2 See <www.vitae.ac.uk/policy-practice/353501/European-Commission-HR-Excellence-in-Research-Award-.html>.

3 The Scottish HEIs are: Heriot-Watt, Queen Margaret, Edinburgh, Edinburgh Napier, Aberdeen, Glasgow, Stirling, Strathclyde, Dundee and St Andrews.

4 See <www.vitae.ac.uk/policy-practice/505181/Concordat-to-Support-the-Career-Development-of-Researchers.html>.

5 See <www.vitae.ac.uk/policy-practice/355881/Every-researcher-counts-equality-and-diversity-in-researcher-careers-in-HEIs.html>.

2.32 The UK's independent National Academies and learned and professional societies represent the interests of scientists and researchers across the UK. They promote an academic discipline or profession, or a group of related disciplines or professions, and may also regulate the activities of their members. This includes awarding professional accreditation within the UK, and taking forward issues of collective interest to their

membership. They disseminate emerging research through journals (often internationally recognised), are an important source of authoritative impartial advice, and may help to develop research links and collaborations with the best researchers overseas. They include:

- National Academies: the Royal Society (UK national academy of science), the Royal Society of Edinburgh (Scotland's National Academy of Science and Letters), the Royal Academy of Engineering and British Academy (which promotes and champions the humanities and social sciences); and
- Learned Societies: such as the Royal Society of Chemistry, the Institute of Physics, and the Society of Biology.

Most are UK bodies, drawing their membership from and representing their interests across the UK, including Scotland.

2.33 UK researchers also benefit from a unified labour market which allows them to move freely within the UK, supporting the flow of knowledge and allowing skilled researchers to move to where they can perform to their highest potential. Many top UK researchers have benefited from spells researching in universities and institutes across the UK.

2.34 Much of the literature on researcher mobility is about international and intra-European mobility in the context of the European Research Area.[12] The data on mobility within the UK is very limited as there are no obstacles to mobility for researchers.

2.35 The reasons for choosing to move between institutions across Europe include:

- Access to research infrastructures which may not have been easily accessible before and resources such as funding and support staff.
- Ability to work in a centre of excellence/high quality research environment which has benefits in terms of knowledge-sharing networking and academic credibility.
- Ability to gain research experience and improve professional development.[13]
- Promotion and career progression.[14]

As demonstrated earlier in the report, these key factors for attracting leading academics can be more readily provided as part of the larger UK research base and funded by the large and diverse tax base. Indeed the UK was ranked 7th out of 59 by the Institute for Management Development in 2012 as an attractive location for scientists and researchers.[15]

[12] See for example, <www.ec.europa.eu/research/innovation-union/pdf/innovation-union-communication_en.pdf#view=fit&pagemode=none>; <www.ec.europa.eu/euraxess/pdf/research_policies/ExpertGrouponResearchProfession.pdf>; and the ESF Science Policy Briefing – New Concepts of Researcher Mobility (ESF 2013) also summarises the challenges of mobility.

[13] See European Charter for Researchers and Code of Conduct; RCUK Research Concordat.

[14] Vitae, *What Do Researchers Do?* 2010.

[15] International Institute for Management Development, *World Competitiveness Yearbook 2012,* retrieved April 2013, <www.imd.org.uk/research/publications/wcy/index.cfmIMD>.

Conclusion

2.36 The UK research policy and operational framework is highly integrated and effective. This success comes as a result of a large interconnected and interdependent research base backed by considerable funding and UK-wide strategic oversight. The many opportunities available to UK researchers are due to the openness and networking that exists within the UK. This integration supports the flow of people, funding and ideas creating a vibrant and thriving research base across the UK, including Scotland.

2.37 In the event of independence, access to the UK research policy and operational framework could not be guaranteed. It would be up to the government of an independent Scottish state to design and implement a policy and operational framework that supports research activity. Inevitably, over time, divergence in the policy and operational framework for research in the continuing UK and an independent Scottish state could increase the administrative burdens of research collaborations with a negative impact on flow of funding, knowledge and people. This would be detrimental to researchers in both states.

2.38 A well established method for assessing research excellence is vital for attracting funding and people, especially from overseas. If Scotland became independent it would lose automatic access to the Research Excellence Framework which would continue to operate for the continuing UK – unless an independent Scottish state sought, and was able, to negotiate and fund continued membership of it. There is no precedent for cross-border collaboration in defining national excellence criteria. The government of an independent Scottish state could find it a challenge to design and implement a mechanism for assessing excellence due to the size of the Scottish research base, a smaller number of peer reviewers and fewer institutions to benchmark performance against. The continuing UK would need to consider the potential impact of opening the arrangements to include international participants, and whether such a change would be in its best interests.

2.39 Crucially the Scottish science and research community would risk losing its direct involvement and influence in the future development of strategic priorities for science and research, as the Research Councils would operate on behalf of the continuing UK. Currently academics working in Scotland play an active role on the Councils of the UK-wide Research Councils. For example the Scottish Government's Chief Scientific Adviser for Rural & Environment is a member of the Council of the Natural Environment Research Council.[16] The contribution of academics based in Scotland includes influencing the allocation of funding to specific priorities, development of future research programmes and the prioritisation and specification of key research infrastructure, data sets and facilities. This helps ensure resources are focused on key priorities and reduces duplication of funding.

[16] <www.nerc.ac.uk/about/work/boards/council/members.asp>.

Conclusion

The current research environment within the UK serves Scotland well. Together, Scotland and the rest of the UK have a large, heavily integrated and thriving research base. This helps drive improvements in economic competitiveness and productivity, as well as improving the way people live their lives.

The analysis in this paper shows that, in this integrated environment, research activity in Scotland has flourished. Scotland has five universities in the world's top 200 and Scotland's share of the world's top one per cent most cited publications (a key internationally recognised indicator of excellence) is on an upward trend, rising from 1.4 per cent over 1996-2000 to 1.7 per cent over 2006-2010.

In recognition of its excellent research base, in 2012-13, Scotland secured £257 million of Research Council grants (excluding Research Council institutes and infrastructure). This represents 13.1 per cent of the UK total, while Scotland only accounts for 8 per cent of UK GDP, or 8.4 per cent of the UK population. In addition to public funding, the UK's network of charitable organisations also fund significant amounts of research in Scotland: approximately 13 per cent of funding raised by members of the Association of Medical Research Charities in 2011 was spent on research in Scotland.

The UK's broad fiscal base supports significant levels of public investment in world-leading research facilities. Researchers across all of the UK also benefit from access to shared infrastructure, such as advanced computing facilities and large longitudinal data sets as well as international facilities.

Across the UK a coordinated framework aligns research activity behind a common set of strategic priorities reflecting national and global research challenges and opportunities. A shared set of policy guidelines, rules and regulatory arrangements provide a consistent grounding for research excellence and a shared framework on which research collaborations can be built. A strong science and innovation network in British Embassies and consulates across the world supports international collaborations.

The analysis in this paper highlights that, if Scotland were to become independent, its continued success in these areas could not be guaranteed. Research Councils would continue to set strategic priorities and distribute funding for the continuing UK: it would be up to the government of an independent Scottish state to decide at what level, and how to allocate, research funding. Access to shared infrastructure would also need to be examined in detail.

Divergence in research frameworks could make the flow of funding, people and knowledge harder. Domestic collaborations would become international collaborations and would carry larger risks.

An independent Scottish state might wish to share arrangements and facilities with the continuing UK. But this would be subject to negotiations and there is little international precedent for such arrangements.

The Scottish research base is thriving as part of the UK, bringing benefits to all. The UK's integrated research framework is at the heart of this, allowing funding, ideas and people to flow unhindered across the UK in the pursuit of excellence.

Annex A: Devolution and research

A.1 Devolution within the UK means the Scottish Parliament and Scottish Government are empowered to take decisions on, and fund, a wide range of issues that serve to develop the knowledge base and encourage research in Scotland. A number of organisations and networks play a vital role at the devolved level in supporting the Scottish science and research base. Those bodies work closely with UK-wide bodies such as the UK Research Councils and Technology Strategy Board.

Support for research in Scotland

A.2 The Scottish Government is responsible for setting out the broad education and economic development framework in Scotland. Its economic strategy highlights the important role of science, technology and innovation in increasing competitiveness and improving Scotland's economic performance. The Scottish Government allocates the budget for education and lifelong learning, enterprise bodies, grants for research and development (R&D), and work in the area of innovation and industries.

A.3 The Scottish Further and Higher Education Funding Council (more commonly known as the Scottish Funding Council) is the national, strategic body responsible for funding teaching and learning provision, research, innovation, knowledge exchange and other activities in Scotland's colleges, universities and HEIs. Its funding priorities are specifically designed to support the Scottish Government's national priorities. It performs a similar role as the Higher Education Funding Council for England.

A.4 Scottish Enterprise is the enterprise, innovation and investment agency in the North East, Central and Lowland Scotland. In partnership with industry, academia and the public sector, it aims to build a globally competitive Scotland by helping businesses to start and grow, encouraging innovation, and creating the right conditions for companies to access property, markets and finance.

A.5 Highlands and Islands Enterprise is the economic and community development agency for the highlands and islands of Scotland. It aims to improve the region's performance and its contribution to the economic growth of Scotland, by: supporting high growth businesses and sectors; creating the infrastructure and conditions to improve regional competitiveness; and strengthening communities.

UK-wide bodies

Research Councils

A.6 UK Research Councils are responsible for investing public money in research in the UK to advance knowledge and generate new ideas which lead to a productive economy, healthy society and contribute to a sustainable world.

A.7 Each Research Council funds research and training activities in a different area of research ranging across the arts and humanities, social sciences, engineering and physical sciences and the medical and life sciences. Together UK Research Councils support over 50,000 researchers including 19,000 doctoral students, around 14,000 research staff, and 2,000 research fellows in UK universities and in their own Research Institutes.

A.8 There are seven UK Research Councils:

- Arts and Humanities Research Council (AHRC);
- Biotechnology and Biological Sciences Research Council (BBSRC);
- Engineering and Physical Sciences Research Council (EPSRC);
- Economic and Social Research Council (ESRC);
- Medical Research Council (MRC);
- Natural Environment Research Council (NERC); and
- Science and Technology Facilities Council (STFC).

They are all part of Research Councils UK (RCUK). This partnership supports the Research Councils in working together to enhance the overall impact and effectiveness of their research, training and innovation activities, contributing to the delivery of the Government's objectives for science and innovation.

A.9 The Research Councils are at the heart of UK science, and play a vital role in driving academic success and associated economic benefit. Although in some cases their structure and form has varied, they largely have long historical roots, and have built up prestigious reputations and strong relationships in their respective academic communities. This brings tangible benefits – for instance that academics are prepared to provide unpaid peer review for the Councils – as well as improving the UK's prestige and international reputation in less measurable ways.

A.10 UK Research Councils undertake considerable work to support collaboration between researchers and business for the benefit of the wider economy. They fund research in collaboration with over 2,500 businesses – of which at least 1,000 are SMEs. Company partners include the BBC, Tesco, Google, Lloyds of London, Marks & Spencer, Waitrose, Arup, Aggregate Industries, AZ, Rio Tinto, BE, JLR, Unilever, Nestlé Kraft, GSK, AstraZeneca and Yorkshire Water.

Technology Strategy Board

A.11 The Technology Strategy Board is the UK's innovation agency and promotes, supports and invests in technology research, developments and commercialisation. It runs a number of UK-wide programmes including the Catapult Centres, which invest in large-scale technological development. The Technology Strategy Board's programmes are open to businesses from across the UK and operate on a purely competitive basis.

Intellectual Property Office

A.12 The Intellectual Property Office (IPO) is responsible for granting intellectual property rights in the UK, including patents, designs, trade marks and copyright. A trusted intellectual property framework is essential to enable creators, users and customers to benefit from research and development, knowledge and ideas. The role of the IPO and the potential implications in the event of a vote in favour of independence were considered in *Scotland analysis: Business and microeconomic framework*.[1]

[1] HM Government, *Scotland analysis: Business and microeconomic framework*, July 2013.

Annex B: UK Research Council owned and operated facilities in Scotland

Facility	Location	Operating Council
ARK-Genomics	Roslin Institute Edinburgh	BBSRC
Transgenic Chicken Facility		
Roslin Institute Edinburgh	BBSRC	
TSE Resource Centre	Roslin Institute Edinburgh	BBSRC
Argon Isotope Facility	SUERC, East Kilbride	NERC
Cosmogenic Isotope Analysis Facility	SUERC, East Kilbride	NERC
Field Spectroscopy Facility	Edinburgh University	NERC
Geophysical Equipment Facility – Edinburgh Node	Edinburgh University	NERC
Isotope Community Support Facility	SUERC, East Kilbride	NERC
Ion Microprobe Facility	Edinburgh University	NERC
Life Sciences Mass Spectrometry Facility – East Kilbride Node	SUERC, East Kilbride	NERC
NERC Biomolecular Analysis Facility – Edinburgh Node (high throughput sequencing)	Edinburgh University	NERC
NERC EO Data Acquisition & Analysis Service – Dundee (was DSRS)	Dundee University	NERC
NERC Facility for Scientific Diving	SAMS Dunstaffnage	NERC
NERC Radiocarbon Facility – Environment (formerly RCL)	SUERC, East Kilbride	NERC
MRC Institute of Hearing Research	Glasgow Royal Infirmary	MRC
The UK Astronomy Technology Centre	Edinburgh Royal Observatory	STFC

Annex C: Large scale UK-wide research facilities and infrastructure

The following list is informed by the Big Science and Innovation Report[1], compiled by Technopolis Group for the Department for Business Innovation and Skills. It has been derived from the inventory of facilities compiled by the European Union's FP7 project, MERIL (Mapping of the European Research Infrastructure Landscape), which is being run by the European Science Foundation with active support from the UK and in particular Dr Peter Fletcher (STFC) and Professor James Hough (University of Glasgow). It includes a number of facilities, centres, projects and research studies.

Whilst this is not a definitive list of all EU and UK research facilities, the project has compiled an extensive inventory of research infrastructure, gathering substantial descriptive data on some 2,400 facilities across Europe, covering all disciplines. The UK makes use of 360 and hosts 180 of these facilities. The report also includes some additional facilities identified through correspondence with the individual UK research councils. Facilities located in Scotland are shaded.[2]

No.	Name	Primary research Domain	Form
1	Institute of Aquaculture	Earth and Environmental Sciences	In situ Marine/Freshwater Observatories
2	Mosquito Genetic Facility (MGF)	Biological & Medical Sciences	Genomic, Transcriptomic, Proteomics and Metabolomics Facilities
3	Centre for Environment, Fisheries & Aquaculture Science	Earth and Environmental Sciences	In situ Marine/Freshwater Observatories
4	Coastal Observatory Liverpool bay	Earth and Environmental Sciences	In situ Marine/Freshwater Observatories
5	Planetary Simulators - OU	Physics, Astronomy, Astrophysics and Mathematics	Space Environment Test Facilities
6	Planetary Simulators - UWA-MAPS	Physics, Astronomy, Astrophysics and Mathematics	Space Environment Test Facilities
7	UCAM-CCP	Biological & Medical Sciences	Genomic, Transcriptomic, Proteomics and Metabolomics Facilities
8	BLADE	Engineering & Energy	Civil Engineering Research Infrastructures
9	Centre for Atmospheric Science	Earth and Environmental Sciences	Atmospheric Measurement Facilities
10	Culham Centre for Fusion Energy (including Mega Amp Spherical Tokamak)	Physics, Astronomy, Astrophysics and Mathematics	Nuclear Research Facilities

[1] Published on 11 October 2013 and available from https://www.gov.uk/government/publications/big-science-and-innovation--2

[2] The MERIL database can be searched online through an interactive online portal (<http://portal.meril.eu/converis-esf/publicweb/startpage>).

No.	Name	Primary research Domain	Form
11	Central Laser Facility	Chemistry and Material Sciences	Intense Light Sources
12	Diamond Light Source (Phases I, II and III)	Chemistry and Material Sciences	Intense Light Sources
13	Medium Energy Ion Scattering Facility	Chemistry and Material Sciences	Intense Light Sources
14	National Centre for Electron Spectroscopy and Surface Analysis (NCESS)	Chemistry and Material Sciences	Analytical Facilities
15	Solid State NMR	Chemistry and Material Sciences	Analytical Facilities
16	EPCC	Information Science & Technology	Centralised Computing Facilities
17	National III V Centre (Sheffield)	Physics, Astronomy, Astrophysics and Mathematics	Micro- and Nanotechnology facilities
18	The Ecotron (Imperial)	Earth and Environmental Sciences	Environmental Management Infrastructures
19	Forestry Research Spatial Modelling GIS	Biological & Medical Sciences	Agronomy, Forestry, Plant Breeding Centres
20	Health and Safety Laboratory	Engineering & Energy	Environmental Health Research Facilities
21	Total Environment Simulator	Engineering & Energy	Marine & Maritime Engineering Facilities
22	Institute for Animal Health (Now Pirbright Institute)	Biological & Medical Sciences	Environmental Health Research Facilities
23	UK Longitudinal Studies Centre	Social Sciences	Registers and Survey-led Studies/ Databases
24	ISIS Neutron and Muon Source (including ISIS Target Station 2 - Phases II and III)	Chemistry and Material Sciences	Intense Neutron Sources
25	James Clerk Maxwell Telescope	Physics, Astronomy, Astrophysics and Mathematics	Telescopes
26	Mary Lyon Centre	Biological & Medical Sciences	Genomic, Transcriptomic, Proteomics and Metabolomics Facilities
27	Moredun	Biological & Medical Sciences	Environmental Health Research Facilities
28	National Centre for Research Methods	Social Sciences	Data Mining and Analysis (Methodological) Centres, including statistical analysis
29	British Geological Survey	Earth and Environmental Sciences	Solid Earth Observatories, including Seismological Monitoring Stations
30	National Institute for Medical Research	Biological & Medical Sciences	Translational Research Centres
31	Henry Wellcome Building for NMR	Biological & Medical Sciences	Structural Biology Facilities
32	Mass Spectrometry Service (Swansea)	Chemistry and Material Sciences	Analytical Facilities
33	Centre of Plant Integrative Biology	Biological & Medical Sciences	Agronomy, Forestry, Plant Breeding Centres
34	National Physical Laboratory - Fuel Cells	Engineering & Energy	Energy Engineering Facilities (non nuclear)
35	Sample Analysis - Open University	Physics, Astronomy, Astrophysics and Mathematics	Space Environment Test Facilities
36	UOXF Protein Production	Biological & Medical Sciences	Genomic, Transcriptomic, Proteomics and Metabolomics Facilities
37	MicroKLab	Physics, Astronomy, Astrophysics and Mathematics	Extreme Conditions Facilities
38	Scottish Marine Institute (Scottish Association for Marine Science)	Biological & Medical Sciences	In situ Marine/Freshwater Observatories
39	Wellcome Trust Sanger Institute	Biological & Medical Sciences	Genomic, Transcriptomic, Proteomics and Metabolomics Facilities
40	SuperSTEM (Daresbury)	Chemistry and Material Sciences	Analytical Facilities

No.	Name	Primary research Domain	Form
41	Ion Beam Facility (Surrey)	Physics, Astronomy, Astrophysics and Mathematics	Intense Light Sources
42	Aston Labs	Engineering & Energy	Energy Engineering Facilities (non nuclear)
43	UOXF.AL	Biological & Medical Sciences	Structural Biology Facilities
44	Laboratory for Molecular Biology	Biological & Medical Sciences	Analytical Facilities
45	Schofield Centre	Engineering & Energy	Civil Engineering Research Infrastructures
46	UEDIN-LS	Chemistry and Material Sciences	Materials Synthesis or Testing Facilities
47	Manufacturing Engineering Centre	Physics, Astronomy, Astrophysics and Mathematics	Micro- and Nanotechnology facilities
48	Leeds Nanoscience and Nanotechnology Equipment Nanoequipment Facility	Physics, Astronomy, Astrophysics and Mathematics	Micro- and Nanotechnology facilities
49	European Marine Energy Centre	Engineering & Energy	Energy Engineering Facilities (non nuclear)
50	New and Renewable Energy Centre Limited	Engineering & Energy	Energy Engineering Facilities (non nuclear)
51	Queen's University Marine Laboratory	Engineering & Energy	Energy Engineering Facilities (non nuclear)
52	UEDIN - The Edinburgh Curved Wave Tank	Engineering & Energy	Energy Engineering Facilities (non nuclear)
53	South West Mooring Test Facility	Engineering & Energy	Energy Engineering Facilities (non nuclear)
54	PRIMaRE HF Radar Environmental Monitoring Facility	Engineering & Energy	Energy Engineering Facilities (non nuclear)
55	National Oceanography Centre	Earth and Environmental Sciences	In situ Marine/Freshwater Observatories
56	National Centre for Atmospheric Science	Earth and Environmental Sciences	Earth, Ocean, Marine, Freshwater, and Atmosphere Data Centres
57	National Centre for Earth observation	Earth and Environmental Sciences	Atmospheric Measurement Facilities
58	Plymouth Marine Laboratory	Earth and Environmental Sciences	Earth, Ocean, Marine, Freshwater, and Atmosphere Data Centres
59	Sea Mammal Research Unit	Earth and Environmental Sciences	Earth, Ocean, Marine, Freshwater, and Atmosphere Data Centres
60	The North Wyke Farm Platform	Biological & Medical Sciences	Agronomy, Forestry, Plant
61	The Genome Analysis Centre (TGAC)	Biological & Medical Sciences	Genomic, Transcriptomic, Proteomics and Metabolomics Facilities
62	The ARK-Genomics Centre for Comparative Functional Genomics	Biological & Medical Sciences	Genomic, Transcriptomic, Proteomics and Metabolomics Facilities
63	High Performance Computing Facility, ARCHER	Information Science & Technology	Centralised Computing Facilities
64	Research Complex at Harwell	Physics, Astronomy, Astrophysics and Mathematics	Micro- and Nanotechnology facilities
65	UK Centre for Medical Research and Innovation (UKCMRI) - renamed Francis Crick Institute	Biological & Medical Sciences	Translational Research Centres
66	Energy Recovery Linac Prototype	Physics, Astronomy, Astrophysics and Mathematics	High Energy Physics Facilities
67	HECToR: UK National Supercomputing Service	Information Science & Technology	Centralised Computing Facilities
68	European 3rd Generation Gravitational Wave Observatory (Einstein Telescope)	Physics, Astronomy, Astrophysics and Mathematics	Telescopes
69	British Antarctic Survey (BAS)	Earth and Environmental Sciences	Polar and Cryospheric
70	Centre for Ecology and Hydrology	Earth and Environmental Sciences	Frestwater Research Infrastructures
71	Argon Isotope Facility	Chemistry and Material Sciences	Analytical Facilities

No.	Name	Primary research Domain	Form
72	Chilbolton Facility for Atmospheric Radio Research	Chemistry and Material Sciences	Atmospheric Measurement Facilities
73	Facility for Nanoparticle Analysis and Characterisation	Chemistry and Material Sciences	Analytical Facilities
74	Field Spectroscopy Facility	Chemistry and Material Sciences	Analytical Facilities
75	Geophysical Equipment Facility	Earth and Environmental Sciences	In situ Earth Observatories
76	Ion Microbe Facility	Chemistry and Material Sciences	Intense Light Sources
77	Isotope Community Support Facility	Earth and Environmental Sciences	Earth, Ocean, Marine, Freshwater, and Atmosphere Data Centres
78	Mesosphere, Stratosphere and Troposphere Radar Facility	Earth and Environmental Sciences	Atmospheric Measurement Facilities
79	Molecular Spectroscopy Facility (moving to NERC pay-as-you-go recognised status)	Chemistry and Material Sciences	Analytical Facilities
80	National Marine Equipment Pool	Earth and Environmental Sciences	In situ Marine/Freshwater Observatories
81	NERC Isotope Geosciences Laboratory	Chemistry and Material Sciences	Analytical Facilities
82	Space Geodesy Facility	Physics, Astronomy, Astrophysics and Mathematics	Telescopes
83	Airborne Research & Survey Facility	Earth and Environmental Sciences	Research Aircraft
84	Facility for Airborne Atmospheric Measurements	Earth and Environmental Sciences	Research Aircraft
85	RRS James Clark Ross (research)	Earth and Environmental Sciences	In situ Marine/Freshwater Observatories
86	RRS Ernest Shackleton (primarily logistics)	Earth and Environmental Sciences	In situ Marine/Freshwater Observatories
87	RRS Discovery	Earth and Environmental Sciences	In situ Marine/Freshwater Observatories
88	RRS James Cook	Earth and Environmental Sciences	In situ Marine/Freshwater Observatories
89	RV Prince Madog	Earth and Environmental Sciences	In situ Marine/Freshwater Observatories
90	STFC Campus Centres (Hartree Centre, Harwell Imaging Partnership, International Science and Innovation Centre and CALTA)	Physics, Astronomy, Astrophysics and Mathematics	Micro- and Nanotechnology facilities
91	UK Brain Banks network	Biological & Medical Sciences	Biobanks including Seed banks
92	UK DNA Banking Network	Biological & Medical Sciences	Biobanks including Seed banks
93	Chemistry Database Service (Daresbury)	Chemistry and Material Sciences	Chemical Libraries and Screening Facilities
94	Census of Population Programme (UK Data service)	Social Sciences	Data Mining and Analysis (Methodological) Centres, including statistical analysis
95	ACTRIS Data Centre	Earth and Environmental Sciences	Atmospheric Measurement Facilities
96	ECRIN	Biological & Medical Sciences	Communication Networks
97	UK Data Service (formerly Economic and Social Data Service)	Social Sciences	Data Mining and Analysis (Methodological) Centres, including statistical analysis
98	EMMA-MRC	Biological & Medical Sciences	Animal facilities
99	Understanding Society	Social Sciences	Registers and Survey-led Studies/ Databases
100	Digital Social Research (old name National Centre for e-Social Science)	Social Sciences	Data Mining and Analysis (Methodological) Centres, including statistical analysis
101	Virtual Microdata Laboratory	Social Sciences	Data Mining and Analysis (Methodological) Centres, including statistical analysis
102	Species 2000	Earth and Environmental Sciences	Registers and Survey-led Studies/ Databases

No.	Name	Primary research Domain	Form
103	Archaeology Data Service	Humanities & Arts	Databases
104	The Rothamsted Long-Term Experiments, Sample Archive and e-RA database	Biological & Medical Sciences	Agronomy, Forestry, Plant Breeding Centres
105	British Election Study	Social Sciences	Registers and Survey-led Studies/ Databases
106	English Longitudinal Study of Ageing	Social Sciences	Registers and Survey-led Studies/ Databases
107	Administrative Data Liaison Service	Social Sciences	Data Archives, Data Repositories and Collections
108	Birth Cohort Study and Cohort Resources Facility	Social Sciences	Registers and Survey-led Studies/ Databases
109	Environmental Omics Bioinformatics Facility	Biological & Medical Sciences	Bio-informatics Facilities
110	British Atmospheric Data Centre (BADC)	Earth and Environmental Sciences	Earth, Ocean, Marine, Freshwater, and Atmosphere Data Centres
111	National Geoscience Data Centre (NGDC)	Earth and Environmental Sciences	Earth, Ocean, Marine, Freshwater, and Atmosphere Data Centres
112	British Oceanographic Data Centre (BODC)	Earth and Environmental Sciences	Earth, Ocean, Marine, Freshwater, and Atmosphere Data Centres
113	Polar Data Centre (PDC)	Earth and Environmental Sciences	Earth, Ocean, Marine, Freshwater, and Atmosphere Data Centres
114	Environmental Information Data Centre (EIDC)	Earth and Environmental Sciences	Earth, Ocean, Marine, Freshwater, and Atmosphere Data Centres
115	Earth Observation Data Centre (NEODC)	Earth and Environmental Sciences	Earth, Ocean, Marine, Freshwater, and Atmosphere Data Centres
116	British Isles continuous GNSS Facility	Earth and Environmental Sciences	Earth, Ocean, Marine, Freshwater, and Atmosphere Data Centres
117	British Ocean Sediment Core Research Facility	Earth and Environmental Sciences	Solid Earth Observatories, including Seismological Monitoring Stations
118	Cosmogenic Isotope Analysis Facility	Chemistry and Material Sciences	Analytical Facilities
119	NERC Biomolecular Analysis Facility (formerly Molecular Genetics Facility)	Biological & Medical Sciences	Genomic, Transcriptomic, Proteomics and Metabolomics Facilities
120	NERC Earth Observation Data Acquisition and Analysis Service	Earth and Environmental Sciences	Earth, Ocean, Marine, Freshwater, and Atmosphere Data Centres
121	CABI Bioservices	Biological & Medical Sciences	Biobanks including Seed banks
122	National collection of pathogenic viruses	Biological & Medical Sciences	Biobanks including Seed banks
123	Royal Botanic Gardens Kew	Earth and Environmental Sciences	Natural History Collections
124	Natural History Museum, London	Earth and Environmental Sciences	Natural History Collections
125	Royal Botanic Gardens Edinburgh	Earth and Environmental Sciences	Natural History Collections
126	UK Biobank	Biological & Medical Sciences	Biobanks including Seed banks
127	British Library	Humanities & Arts	Research Libraries
128	British Museum	Humanities & Arts	Collections
129	Imperial War Museum	Humanities & Arts	Collections
130	The National Archives	Humanities & Arts	Research Archives
131	The National Gallery	Humanities & Arts	Collections
132	The National Maritime Museum	Humanities & Arts	Collections
133	National Museum Wales	Humanities & Arts	Collections
134	National Portrait Gallery	Humanities & Arts	Collections

No.	Name	Primary research Domain	Form
135	Royal Commission on the Ancient and Historical Monuments of Scotland	Humanities & Arts	Research Archives
136	Tate	Humanities & Arts	Collections
137	Victoria and Albert Museum	Humanities & Arts	Collections
138	National Museums Liverpool	Humanities & Arts	Collections
139	National Museum of Science and Industry	Humanities & Arts	Collections
140	National Museums Scotland	Humanities & Arts	Collections
141	John Innes Germplasm Resources Unit	Biological & Medical Sciences	Biobanks including Seed banks
142	European Arabidopsis Stock Centre	Biological & Medical Sciences	Biobanks including Seed banks
143	UK Stem Cell Bank	Biological & Medical Sciences	Biobanks including Seed banks
144	Cape Verde Observatory	Earth and Environmental Sciences	Atmospheric Measurement Facilities
145	Rothera Research Station R	Earth and Environmental Sciences	Polar and Cryospheric Research Infrastructures
146	Halley Research Station	Earth and Environmental Sciences	Polar and Cryospheric Research Infrastructures
147	Bird Island and Signy Research Stations	Earth and Environmental Sciences	Polar and Cryospheric Research Infrastructures
148	King Edward Point Research Station	Earth and Environmental Sciences	Polar and Cryospheric Research Infrastructures
149	Ny-Ålesund Arctic Research Station	Earth and Environmental Sciences	Polar and Cryospheric Research Infrastructures
150	LT (Liverpool Telescope)	Physics, Astronomy, Astrophysics and Mathematics	Telescopes
151	ING (Isaac Newton Group of Telescopes)	Physics, Astronomy, Astrophysics and Mathematics	Telescopes
152	UKIRT	Physics, Astronomy, Astrophysics and Mathematics	Telescopes
153	DuneXpress observatory	Physics, Astronomy, Astrophysics and Mathematics	Astro-particle and neutrino detectors and observatories
154	Mars Exploration Mission	Physics, Astronomy, Astrophysics and Mathematics	Space Environment Test Facilities
155	Cluster	Physics, Astronomy, Astrophysics and Mathematics	Space Environment Test Facilities
156	James Webb Space Telescope	Physics, Astronomy, Astrophysics and Mathematics	Telescopes
157	Europe Jupiter System Mission (JUICE)	Physics, Astronomy, Astrophysics and Mathematics	Space Environment Test Facilities
158	Laser Interferometer Space Antenna	Physics, Astronomy, Astrophysics and Mathematics	Gravitational wave detectors and Observatories
159	Marco Polo	Physics, Astronomy, Astrophysics and Mathematics	Space Environment Test Facilities
160	PLAnetary Transits and Oscillations of Stars	Physics, Astronomy, Astrophysics and Mathematics	Telescopes
161	Hubble Space Telescope	Physics, Astronomy, Astrophysics and Mathematics	Telescopes
162	Solar Orbiter: Exploring the Sun-heliosphere Connection	Physics, Astronomy, Astrophysics and Mathematics	Space Environment Test Facilities
163	Far-Infrared Interferometer	Physics, Astronomy, Astrophysics and Mathematics	Telescopes

No.	Name	Primary research Domain	Form
164	Space Infrared telescope for Cosmology and Astrophysics	Physics, Astronomy, Astrophysics and Mathematics	Telescopes
165	Solar Dynamics Observatory	Physics, Astronomy, Astrophysics and Mathematics	Telescopes
166	Lunar Radio Explorer/ Lunar Low Frequency Array/Lunar Dark Ages Mapper	Physics, Astronomy, Astrophysics and Mathematics	Telescopes
167	The Dark Universe Explorer (now combined with SPACE in EUCLID)	Physics, Astronomy, Astrophysics and Mathematics	Telescopes
168	CryoSat-2	Earth and Environmental Sciences	Earth Observation satellites
169	X-ray Observatory, now part of IXO	Physics, Astronomy, Astrophysics and Mathematics	Telescopes
170	Herschel Telescope	Physics, Astronomy, Astrophysics and Mathematics	Telescopes
171	Data Processing and Analysis Consortium (GAIA mission)	Information Science & Technology	Complex Data Facilities
172	Envisat	Earth and Environmental Sciences	Earth Observation satellites
173	Probing Heliospheric Origins with an Inner Boundary Observing Spacecraft	Physics, Astronomy, Astrophysics and Mathematics	Space Environment Test Facilities
174	X-ray Multi-Mirror Mission	Physics, Astronomy, Astrophysics and Mathematics	Telescopes
175	Titan and Enceladus Mission	Earth and Environmental Sciences	Earth Observation satellites
176	Multi-spacecraft Mission to Detect Earth-like Planets	Physics, Astronomy, Astrophysics and Mathematics	Telescopes
177	European Incoherent Scatter	Earth and Environmental Sciences	Atmospheric Measurement Facilities
178	European Synchrotron Radiation Facility	Chemistry and Material Sciences	Intense Light Sources
179	Very Large Telescope	Physics, Astronomy, Astrophysics and Mathematics	Telescopes
180	X-ray Free Electron Laser	Chemistry and Material Sciences	Intense Light Sources
181	Extreme Light Infrastructure	Chemistry and Material Sciences	Intense Light Sources
182	European High Power laser Energy Research facility	Chemistry and Material Sciences	Intense Light Sources
183	Square Kilometre Array	Physics, Astronomy, Astrophysics and Mathematics	Telescopes
184	European Spallation Neutron Source (ESS)	Chemistry and Material Sciences	Intense Neutron Sources
185	Institut Laue-Langevin (ILL)	Chemistry and Material Sciences	Intense Neutron Sources
186	Large Hadron Collider	Physics, Astronomy, Astrophysics and Mathematics	High Energy Physics Facilities
187	European Extremely Large Telescope	Physics, Astronomy, Astrophysics and Mathematics	Telescopes
188	La Silla Observatory (incl. New Technology Telescope and Max-Planck-ESO telescope)	Physics, Astronomy, Astrophysics and Mathematics	Telescopes
189	APEX (the Atacama Pathfinder Experiment)	Physics, Astronomy, Astrophysics and Mathematics	Telescopes
190	Atacama Large Millimeter/submillimeter Array	Physics, Astronomy, Astrophysics and Mathematics	Telescopes
191	Euro-Argo	Biological & Medical Sciences	Agronomy, Forestry, Plant Breeding Centres

No.	Name	Primary research Domain	Form
192	MaRINE Renewables Infrastructure Network for Emerging Energy Technologies	Engineering & Energy	Marine & Maritime Engineering Facilities
193	Council of European Social Science Data Archives	Social Sciences	Data Archives, Data Repositories and Collections
194	Gigabit European Academic Network	Information Science & Technology	Communication Networks
195	EMECO	Earth and Environmental Sciences	In situ Marine/Freshwater Observatories
196	Biobanking and Biomolecular Resources Research Infrastructure (BBMRI)	Biological & Medical Sciences	Biobanks including Seed banks
197	Infrastructures for Clinical Trials and Bio-therapy (ECRIN)	Biological & Medical Sciences	Telemedicine laboratories and E-Health technologies
198	European Multidisciplinary Seafloor Observatory (EMSO)	Earth and Environmental Sciences	Earth, Ocean, Marine, Freshwater, and Atmosphere Data Centres
199	Integrated Carbon Observation System (ICOS)	Earth and Environmental Sciences	Atmospheric Measurement Facilities
200	Svalbard Integrated Arctic Observing System (SIOS)	Earth and Environmental Sciences	Earth Observation satellites
201	European Centre for Systems Biology	Biological & Medical Sciences	Structural Biology Facilities
202	European Advanced Translational Research Infrastructure in Medicine (EATRIS)	Biological & Medical Sciences	Translational Research Centres
203	ComBase Resource for Predictive Food Microbiology	Biological & Medical Sciences	Biobanks including Seed banks
204	Food Information Data banks	Biological & Medical Sciences	Bio-informatics Facilities
205	PHI-base: The Pathogen Host interactions Database	Biological & Medical Sciences	Bio-informatics Facilities
206	Common Language Resources and Technology Infrastructure	Humanities & Arts	Research Facilities
207	e-Science and Technology Infrastructure for Biodiversity Data and Observatories	Earth and Environmental Sciences	In situ Marine/Freshwater Observatories
208	Enabling Grids for E-sciencE III	Information Science & Technology	Distributed Computing Facilities
209	Integrated Structural Biology Infrastructure (INSTRUCT)	Biological & Medical Sciences	Bio-informatics Facilities
210	Zeplin 111 (United Kingdom)	Physics, Astronomy, Astrophysics and Mathematics	Astro-particle and neutrino detectors and observatories
211	European Life Sciences Infrastructure for Biological Information	Biological & Medical Sciences	Bio-informatics Facilities
212	European Social Survey	Social Sciences	Registers and Survey-led Studies/ Databases
213	Near-Earth Space Data Infrastructure for e-Science	Information Science & Technology	Complex Data Facilities
214	European Bioinformatics Institute	Biological & Medical Sciences	Bio-informatics Facilities
215	Infrastructure for Systems Biology-Europe	Biological & Medical Sciences	Systems Biology/Computational Biology Facilities
216	IBC; The European infrastructure for phenotyping and archiving of model mammalian genomes	Biological & Medical Sciences	Animal facilities
217	UK Astronomy Technology Centre	Physics, Astronomy, Astrophysics	Telescopes
218	Heliophysics Integrated Observatory	Information Science & Technology	Communication Networks

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List of abbreviations

AHRC	Arts and Humanities Research Council
AIDA	Advanced Implantation Detector Array
AMRC	Association of Medical Research Charities
ATC	Astronomy Technology Centre
BAS	British Antarctic Survey
BBSRC	Biotechnology & Biological Sciences Research Council
BERD	Business Enterprise Research & Development
BIS	Department for Business, Innovation and Skills
CCS	Carbon Capture and Storage
CERN	European Centre for Nuclear Research
CIDLID	Combating Infectious Diseases in Livestock for International Development
DfID	Department for International Development
DTC	Doctoral Training Centres
EPSRC	Engineering and Physical Sciences Research Council
ERC	European Research Council
ESO	European Southern Observatory
ESRC	Economic and Social Research Council
FAIR	Facility for Antiproton and Ion Research
FDI	Foreign Direct Investment
FP7	EU Seventh Framework Programme for Research and Development
GDP	Gross Domestic Product
HE	Higher Education
HE-BCI	Higher Education-Business and Community Interaction Survey

HEFCE	Higher Education Funding Council for England
HEIs	Higher Education Institutions
HERD	Higher Education Research and Development
HESA	Higher Education Statistics Agency
IKC	Innovation and Knowledge Centre
IOM	Institute of Occupational Medicine
IPO	Intellectual Property Office
IPPR	Institute for Public Policy Research
IRO	Independent Research Organisation
MoD	Ministry of Defence
MoU	Memorandum of Understanding
MRC	Medical Research Council
NAREC	National Renewable Energy Centre
NERC	Natural Environment Research Council
OSCHR	Office for Strategic Coordination of Health Research
R&D	Research & Development
RCUK	Research Councils UK
REF	Research Excellence Framework
SAMS	Scottish Association for Marine Science
SFC	Scottish Funding Council
SGS	Scottish Graduate School of Social Science
SIN	Science and Innovation Network
STEM	Science, Technology, Engineering and Maths
STFC	Science and Technology Facilities Council
TRAC	Transparent Approach to Costing
UK RPIF	UK Research Partnership Investment Fund

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ISBN 978-0-10-187282-9

9 780101 872829