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**Coordination and governance of the
UK science, technology and innovation
(STI) system between the national and
sub-national level**

A briefing paper

Coordination and governance of the UK science, technology and innovation (STI) system between the national and sub-national level

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Coordination and governance of the UK science, technology and innovation (STI) system between the national and sub-national level

1. Introduction and background

This paper is part of the project “Transfer of best practices in coordination and governance of the UK science, technology and innovation (STI) system between the national and sub-national level” that has been co-founded by the Foreign and Commonwealth Office and the Peruvian National Council of Science and Technology (CONCYTEC).

The main objective of this project is to share the UK experience on coordination and governance tools and mechanisms through which public policy on STI are implemented. This paper summarises the main features of the National Science, Technology and Innovation System in the UK. This is no simple task, as this a very mature system with a high level of complexity. In that sense the paper intends to offer an overall overview of the system and will avoid going into to me more fine details of its arrangements.

The paper is organised to provide some insights into the three main interest areas for the Peruvian government as expressed by Concytec: (i) governance mechanisms, (ii) programmes and instruments and funding strategies put in place to provide support to the research and innovation system and (iii) the regional-national dimension with regards to the two previous points.

The remaining sections are organised as follows:

- Section 2 provides a conceptual framework to analyse R&D governance. This conceptual framework highlights the existence of a vertical and horizontal dimension when we talk about coordination and governance in a research and innovation system.
- Section 3 uses this model to provide an overview of the research and innovation system in the UK and briefly explains how vertical coordination takes place in the system.
- Section 4 develops some concrete examples of horizontal coordination, including actions taken to coordinate policy regarding the low carbon economy and clinical research, among other examples.
- Section 5 departs from the issue of governance, providing some examples of the tools and incentives used in the UK to support research and innovation that may be relevant for the Peruvian context. These examples have been identified after a visit to the UK of representatives from Concytec, PRODUCE and the National Council of Competitiveness.
- Section 6 provides a description of the regional innovation dimension in the UK and Section 7 offers some final reflections.

2. R&D Governance: a conceptual framework

In order to provide an overview of the UK research and innovation governance landscape we need a conceptual framework. We rely on the framework developed by Arnold *et. al* (2011)¹, which has been used to assess national R&D systems in Europe.

With regards to governance, the authors state that:

“governance refers to the effective implementation of state supported actions and the management of research and innovation by organisations that have been allocated responsibilities from the state”.

(...) Governance is a systemic activity, where “the boundaries between individual institutions become less significant than the question of how the whole ensemble dances (or fails to dance) together.”²

*Thus in research and innovation governance we do not look only at policy but also at the interplay between the various actors that together determine the priorities, strategies, activities and outcomes in research and innovation. The focus is on the **processes** of policy formulation and implementation, rather than on the contents. Governance is about handling of complexity and the management of dynamic flows. It is fundamentally about interdependence, linkages, networks, partnerships, co-evolution and mutual adjustment.³*

To operationalise this concept of governance the authors devise a 4-level scheme that can be used as a general representation of a national R&D and innovation system (see Figure 1). These four levels of policy co-ordination are described below:

- *“**Level 1** is the highest level. This involves setting overall directions and priorities across the whole National Innovation System. It may be achieved through advice to government or by more binding means, such as decisions of a cabinet sub-committee*
- ***Level 2** is co-ordination among ministries, whose sectoral responsibilities otherwise encourage them to pursue independent policies. In practice this level of co-ordination may involve administrative aspects, policy issues or both.*
- ***Level 3** is more operational, in an attempt to make the actions of funding agencies into a coherent whole. This level, too, can involve administrative co-ordination as well as more substantive co-ordination of funding activities, such as co-programming*
- ***Level 4** involves co-ordination among those who actually perform research and innovation. Co-ordination at this level tends to be achieved through self-organisation rather than using formal mechanisms”*

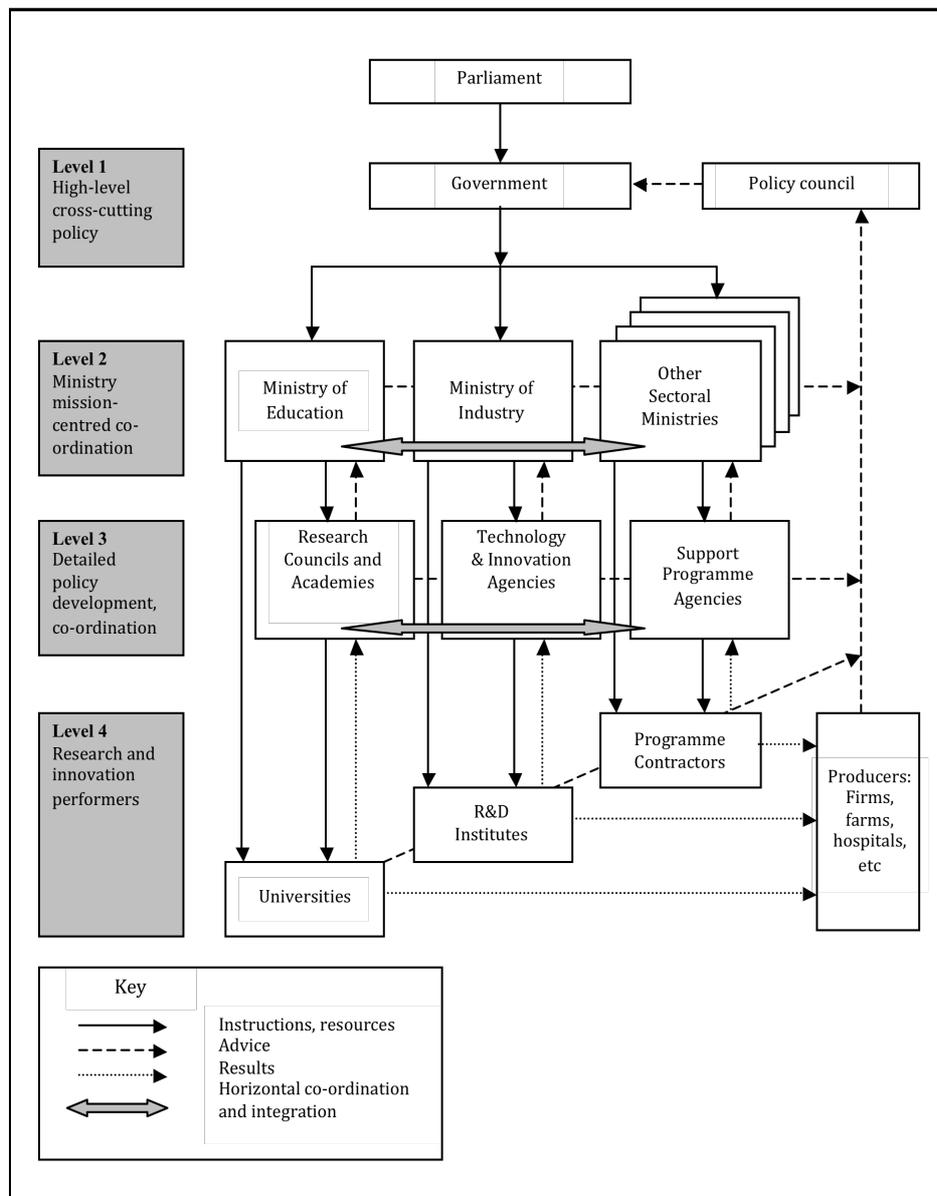
The authors point out that this somewhat complicated diagram is actually a simplified picture of the network of flows of information and resources that actually takes place in reality.

¹ Erik Arnold, Bea Mahieu, Andrej Horvath, *R&D Governance in the Czech Republic*, International Audit of R&D&I in the Czech Republic, Final Report - 2, Ministry of Education, Youth & Sports, Czech Republic, 2011

² Pollitt, C., Bouckaert, G., *Public Management Reform, A Comparative Analysis*, Oxford University Press, 2000.

³ John de la Mothe, *Knowledge Politics and Governance*, in: John de la Mothe (ed), *Science Technology and Governance*, Continuum, London, New York, 2001.

Figure 1: Generic Organisational Structure for Research and Innovation Policy



Source: Arnold, Mahieu and Horvath (2011)

According to the authors, **the vertical dimension involves steering**, where an organisation at one level in Figure 1 tells another at a lower level what to do and receives an upward flow of information in return. In practice, governance mechanisms need to combine the ability to plan strategically with a role in mediating among stakeholders to produce alignment among objectives. In that sense governance is not just about ‘steering’ but about **creating arenas**, to decide the right direction in which to steer, and generate consensus-based commitment to steering in that direction. It is also about balancing and sharing **strategic intelligence** capabilities between the ministry and agency levels.

In addition, **horizontal co-ordination** is also required given that societal actors and institutions outside the research community are likely to be involved in the governance of research and innovation and they need to be included when defining strategic priorities and actions. Furthermore, governance mechanisms need to handle the systemic nature of research and innovation and guarantee coherence in the actions

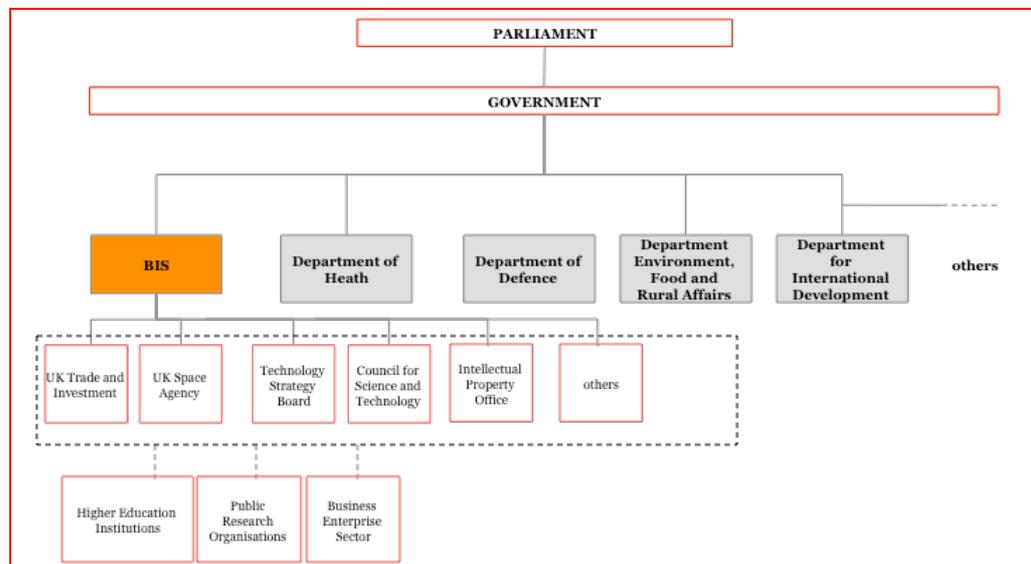
of the different institutions involved in planning and executing research and innovation policy. A clear example of the need for **horizontal co-ordination** is the combination of knowledge from different disciplines to tackle interdisciplinary research needs (e.g. bio-technology) and overarching societal problems that need such an interdisciplinary approach (e.g. climate change).

3. Vertical coordination in the UK research and innovation system

The UK has a pretty large and quite complex national research and innovation system, which comprises a series of different public and private research funders and distinct groups of research performers.

Figure 2 follows the generic model presented in Figure 1 to show an overview of the UK system. The four levels in the model are then explained in the following subsections of this chapter.

Figure 2: Organisational structure of the UK research and innovation system



Source: Technopolis (2014)

3.1 Central Government (Level 1)

The UK is governed by a parliamentary system where the head of government (the Prime Minister) is a member of the legislature and is the leader of the largest party in parliament.

The government has 24 ministerial departments including Department for Business Innovation and Skills (see below), Department for Environment, Food and Rural Affairs, and the Department for Education, among others. It also has 23 non-ministerial departments, which usually undertake regulatory roles, and 300 agencies and public bodies. Departments and their agencies are responsible for putting government policy into practice.

3.2 Ministerial level (Level 2)

The UK has a single ministry with overall responsibility for science and innovation nationally, the Department for Business Innovation and Skills (BIS). Furthermore, BIS

also takes responsibility over Higher Education, giving this ministry a very unique configuration in comparison with its peers around the globe.

BIS plays the lead executive role in research issues, and maintains the national research strategy as well as being the major source of funds for research in the public sector.

BIS provides funds for the seven Research Councils, each organised on a broad disciplinary basis, which in turn support R&D both in Higher Education Institutions (HEIs) and in their own institutions. Thus, BIS has oversight for the majority of R&D policy formulation, and is the principal author of national strategy for research and innovation, albeit each Research Council is required to develop its own research strategy and implementation plan (following a standard format).

Furthermore, BIS is responsible for the overall UK science budget, and the single best source of data on UK funding for science is the Allocation of Science and Research Funding (ASRF) 2011/12 to 2014/15. It includes splits for capital and recurrent expenditure for the overall national science budget and also for the individual RCs / FCs⁴.

Figure 3 and Figure 4 show the distribution and evolution of national funding over the 5-year period from 2010/11 for the resource budget and capital budget respectively. The resource component of the science and research budget was around £4.5 billion a year in 2011/12, while the capital budget is around £0.5 billion presently.

Figure 3: Allocation of resource funding within the science budget (£000s, 2010 prices)

	2010-11	2011-12	2012-13	2013-14	2014-15
Research Councils	2,549,353	2,596,196	2,573,678	2,586,641	2,599,812
AHRC	100,717	99,881	98,370	98,370	98,370
BBSRC	362,341	370,306	359,471	351,471	351,471
EPSRC	771,289	759,720	748,150	748,150	748,150
ESRC	158,061	155,690	153,319	153,319	153,319
MRC	545,585	536,172	546,243	559,894	574,641
NERC	298,071	298,600	297,129	300,129	289,129
STFC - Core Programme	177,519	190,060	172,200	172,200	172,190
STFC - Cross-Council facilities [1]	66,800	77,170	79,280	81,410	89,470
STFC - International Subscriptions [2]	68,970	108,598	119,515	121,697	123,071
HEFCE	1,731,300	1,662,112	1,699,578	1,685,689	1,686,321
QR Research	1,618,300	1,549,112	1,586,578	1,572,689	1,573,321
HEIF [3]	113,000	113,000	113,000	113,000	113,000
National Academies	87,832	87,465	86,547	86,547	86,547
Royal Society	48,558	47,830	47,101	47,101	47,101
British Academy	26,448	27,001	27,005	27,005	27,005
Royal Academy of Engineering	12,826	12,634	12,441	12,441	12,441

⁴ The individual RCs and FCs publish more detailed financial accounts, which link back to the headline figures presented in the BIS overarching report. Each ASRF report provides the budget for the year it was published and a forward-looking account for the three years following. In addition to presenting financial data, the report also includes a qualitative account of key trends or changes within the period.

Other Programmes	43,616	24,496	24,140	24,165	24,005
Science & Society	15,441	13,000	13,000	13,000	13,000
International	5,104	5,095	4,740	4,765	4,605
Foresight	2,800	2,800	2,800	2,800	2,800
Evidence & Evaluation	20,271	3,600	3,600	3,600	3,600
UK Space Agency	163,805	205,637	191,963	192,864	179,221
Total S&R Resource	4,575,906	4,575,906	4,575,906	4,575,906	4,575,906

Source: Allocation of Science and Research Funding 2011/12 to 2014/15, BIS (2014)

[1] Operated by STFC on behalf of all Research Councils

[2] Managed by STFC on behalf of all Research Councils. Total resource expenditure on international subscriptions in 2010-11, including the additional exchange rate costs was £103m. The SR10 allocations are at the exchange rates prevailing in December 2010 and reflect a shift in funding from capital to resource

[3] HEIF will also include £37 m pa from HEFCE, taking the total for each year to £150m

Figure 4: Allocation of capital funding within the science budget (£000s, 2010 prices)

	2010-11	2011-12	2012-13	2013-14	2014-15
Research Councils	393,438	239,821	199,393	181,430	180,967
AHRC	3,150	0	0	0	0
BBSRC	66,480	38,000	29,700	29,700	29,700
EPSRC	49,261	31,000	35,000	25,000	25,000
ESRC	20,600	18,700	13,700	12,700	12,700
MRC	134,517	33,000	29,000	31,000	31,000
NERC	34,183	32,200	17,800	17,800	17,800
STFC – Core Programme		19,630	21,981	14,237	14,169
STFC–Cross-Council Facilities	85,247	21,070	21,919	22,463	22,931
STFC-Int. Subscriptions		46,221	30,293	28,530	27,667
Large Facilities Capital Fund	103,380	115,279	61,307	47,769	128,132
UK Space Agency	19,000	19,000	19,000	19,000	19,000
HEI Capital HEFCE	166,952	75,170	90,970	90,160	101,500
HEI Research Capital England	158,420	53,199	64,377	63,810	71,831
HEI Research Capital Scotland	23,622	8,620	10,431	10,339	11,639
HEI Research Capital Wales	6,031	2,113	2,557	2,535	2,854
HEI Research Capital NI	1,778	798	965	957	1,077
TOTAL	872,621	514,000	449,000	416,000	517,000

Source: Allocation of Science and Research Funding 2011/12 to 2014/15, BIS (2014)

A series of other government departments, which fund applied research of direct relevance to their own policy activities (departments) or operations (agencies), for example the Department of Health or the Highways Agency.

The main ‘big spenders’ at ministerial level (other than BIS) include:

- Department of Defence (£1,306 million)
- Department of Health (£904 million Net government expenditure on Science, Engineering and Technology, 2011/12)
- Department for International Development (£236 million)

- Department Environment, Food and Rural Affairs (£161 million)

3.3 Detailed policy development and coordination (Level 3)

BIS works with 47 agencies and public bodies, including 20 Executive non-departmental public bodies, whose functions span regulation, funding, promotion and coordination.

Following the conceptual framework presented above, these agencies are in charge of implementing detailed policy development and coordination and are also the main funders of research and innovation.

Figure 5: Agencies and bodies that work with BIS

Non-ministerial department		
Competition and Markets Authority	Land Registry	Ordnance Survey
UK Trade and Investment		
Executive agency		
Companies House	The Insolvency Service	Intellectual Property Office
Met Office	National Measurement Office	Skills Funding Agency
UK Space Agency		
Executive non-departmental public body		
Advisory, Conciliation and Arbitration Service	British Hallmarking Council	Capital for Enterprise Limited
Competition Service	Construction Industry Training Board	Consumer Futures
Engineering Construction Industry Training Board	Higher Education Funding Council for England	Office for Fair Access
Student Loans Company	Technology Strategy Board	UK Atomic Energy Authority
UK Commission for Employment and Skills	7 Research Councils	
Advisory non-departmental public body		
Council for Science and Technology	Industrial Development Advisory Board	Land Registration Rule Committee
Low Pay Commission	Regulatory Policy Committee	
Tribunal non-departmental public body		
Central Arbitration Committee	Competition Appeal Tribunal	Copyright Tribunal
Insolvency Practitioners Tribunal		
Other		
Certification Office	Government Office for Science	Groceries Code Adjudicator
Office of Manpower Economics	Office of the Regulator of Community Interest Companies	UK Green Investment Bank
Wave Hub		

Source: GOV UK

In the following sub-sections we focus our analysis on the agencies that provide funds to research performers.

3.3.1 The grant-awarding research councils

As in many other countries, the UK funds specific research projects and postgraduate training programmes through their thematic Research Councils.

The funding is allocated to UK Higher Education Institutions and independent research organisations that meet the eligibility criteria⁵.

They also invest in the Research Council Institutes (institutes for which the Research Councils have established a long-term involvement as major funder⁶), and fund access for UK researchers to international facilities. Grants are allocated after a process of independent, expert peer review. The councils' current level of investment into research totals around £3 billion per year.

There are seven grant-awarding research councils, covering all academic disciplines (see Figure 6).

Figure 6: Research councils the UK

Research Council		Examples of research areas funded
Arts and Humanities Research Council	AHRC	History, classics, archaeology, modern languages and linguistics, English language and literature, the visual arts and media, philosophy, law, religious studies, music and creative and performing arts
Biotechnology and Biological Sciences Research Council	BBSRC	Biosciences, including genomics, stem cell biology, food safety, plant and livestock breeding, bio-processing, whole organism biology relevant to the understanding of diet and health, ageing, animal health and welfare, biological populations and systems
Engineering and Physical Sciences Research Council	EPSRC	Mathematics; chemistry; physics; materials science; engineering; computer science, including high performance computing; energy research; research into the built environment; information and communications technology; research into innovative manufacturing.
Economic and Social Research Council	ESRC	Sociology; economics; anthropology; political science; area or regionally based research and geography; international relations; cultural and media studies; law and linguistics; psychology.
Medical Research Council	MRC	Full range of medical research from studies of molecules to the implementation of research findings into clinical practice
Natural Environment Research Council	NERC	Environmental research, survey and observation work across a wide spectrum of disciplines, including the geo- and earth sciences, atmospheric research and oceanography, biodiversity and ecology, climate change research, environmental chemistry and physics; satellite based Earth observation, polar research, and management of land and natural resources.
Science and Technology Facilities Council	STFC	Astronomy; computational science; energy; nuclear physics; particle physics; space science.

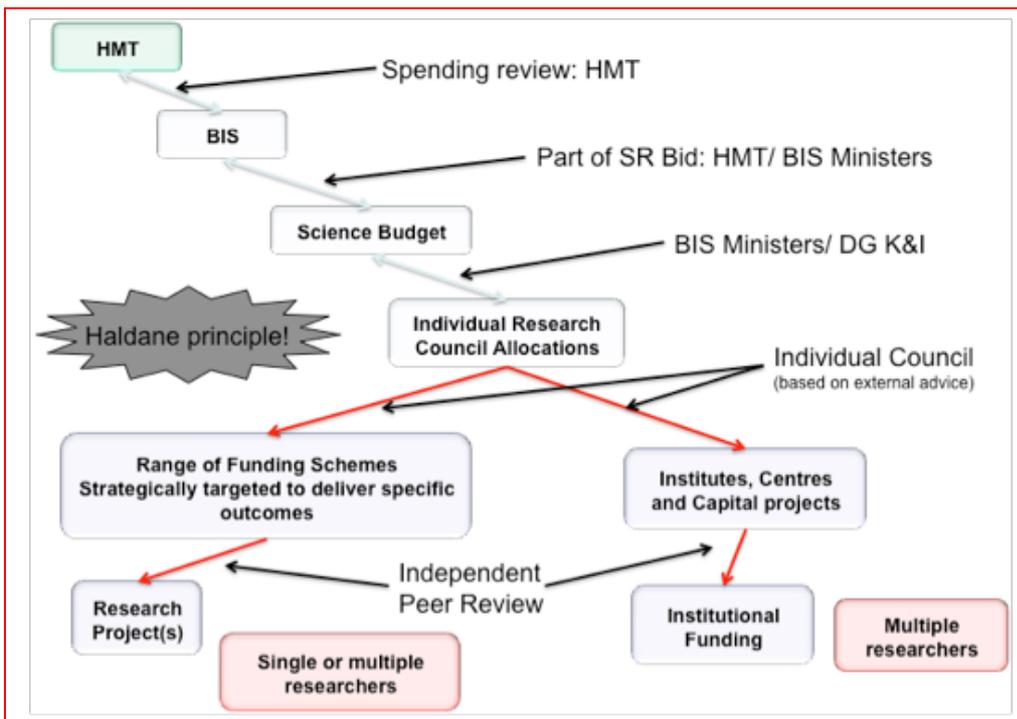
Each council develops its specific research strategy in consultation with the academic community and a wide range of users and stakeholders, against the backdrop of the national science and innovation strategy.

⁵ <http://www.rcuk.ac.uk/documents/documents/eligibilityviros.pdf>.

⁶ <http://www.rcuk.ac.uk/research/Pages/noparentrcs.aspx>

Funding for research allocated to the research councils operates under the so-called ‘Haldane principle’: while government sets the overall size of funding and its distribution between the research councils, it is left to the scientific community (coordinated by the Research Councils) to select specific projects within relevant fields on the basis of scientific merit, as assessed by peer review (see Figure 7). The government may however ask the research councils to consider addressing areas of strategic national importance in setting their funding programmes. The Haldane principle does not apply to the research budgets of Government Departments, which are used to fund research to support their departmental policies and objectives.

Figure 7: Graphic representation of the Haldane Principle



Source: RCUK

Coordination across the 7 research councils is managed through the **RCUK partnership**, which is led by the Research Council chief executives, who collectively own, drive and monitor the strategic and operational activities that deliver the RCUK mission. The RCUK Executive Group (RCUKEG) provides the forum through which the individual Research Council chief executives work together.

The Chair of the RCUKEG is selected from among serving Research Council Chief Executives; with the current chair being Professor Rick Rylance, Chief Executive of the Arts and Humanities Research Council. The term lasts for two years. Senior figures from the Higher Education Funding Councils, other research funders and stakeholder organisations are regularly invited to participate in RCUKEG discussions.

To enable RCUK to work with BIS to discuss high-level strategic issues and provide advice to the Director General of Knowledge and Innovation, **BIS has established the Joint Strategy Group (JSG)**. This group is chaired by the Director General of Knowledge and Innovation and meets quarterly.

RCUKEG and JSG replace the original Research Councils UK Strategy Group (RCUKSG), which led RCUK activities between May 2002 and July 2004.

3.3.2 UK funding bodies

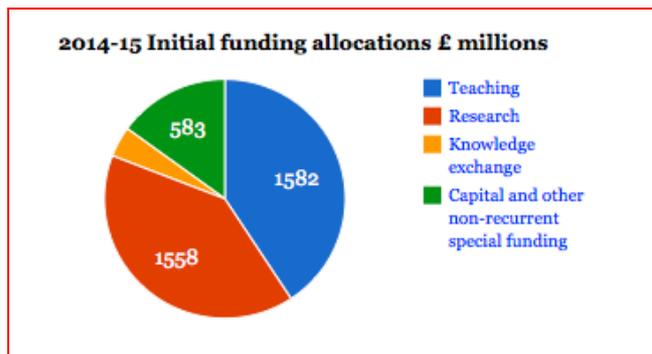
In addition to the 7 Research Councils the UK also has four funding councils, which provide block grants to support the underlying cost of research carried out at universities and colleges in each of the four nations of the UK. This includes:

- Higher Education Funding Council for England (HEFCE)
- Scottish Funding Council (SFC)
- Higher Education Funding Council for Wales (HEFCW)

In Northern Ireland, funding comes directly from the Department for Employment and Learning (DELNI). This ‘institutional’ funding complements the project funding provided by the research councils, and is the foundation of what is widely referred to in the UK as the ‘dual support’ funding system⁷.

In 2014/15 HEFCE allocated £3.9bn in recurrent and capital funding. Of that total, 41% and 40% has been allocated to teaching and research activities, respectively. Further information funding mechanisms can be found in Box 1.

Figure 8: HEFCE funding allocation 2014/15



Source: HEFCE

Box 1: Funding rules

Universities can choose how they use HEFCE funding within the framework provided by the Financial Memorandum (the agreement between the University and the HEFCE setting out the University’s obligations). Some elements of HEFCE funding are classed as ‘earmarked’ and can only be used specifically for the purpose for which they were provided.

Mainstream grants for teaching are calculated on the basis of the number of students enrolled and the subjects they study. Subjects are split into different price bands, which aim to reflect the relative costs of tuition.

Mainstream grants for research are calculated on the basis of the quality of the research (see section 5.3, page 26), the number of staff engaged in the research, and the relative cost of the research, with science research at the upper end of the spectrum.

Capital grants take account of the teaching grant, the research grant, and research project funding, e.g. from the research councils, charities, or central government.

In 2011, the government started a process of Higher Education reform, which shifted university income from public money (via teaching grants) to student fee loans. Since academic year 2012-

⁷ <http://www.hefce.ac.uk/whatwedo/rsrch/howfundr/>

2013, Universities in England and Wales can set their own level of fees up to a maximum of £9000, and Northern Ireland up to £3375. Students domiciled in Scotland continue to pay no tuition fees if they enrol at a Scottish institution. This shift reduces funding through HEFCE teaching grants by approximately £1 billion per year over the transition period (from £3.81 billion in 2011/12 to £1.96 billion in 2014/15).

3.3.3 Other executive agencies

Technology Strategy Board is the national innovation agency. The Technology Strategy Board (TSB) is the primary channel through which UK government supports business-led technology innovation in the UK. It provides funding for applied research and development, and demonstration projects to “accelerate the journey between concept and commercialisation”. Projects are required to be led by business, but can bring in partners from universities. In 2013, the TSB supported projects in 4,000 businesses, and committed £250m through 60 competitions (2012).

The TSB originally developed out of an in-house technology programme at the Department for Trade and Industries (now BIS), and was established as an Executive Non-Departmental Public Body in 2007 under the provisions of the Science and Technology Act 1965. It is the only organisation supported by the Government that provides funding support for R&D in business (rather than academic research institutions).

In addition to direct research funding to business, the TSB offers a suite of other R&D support tools, from longer-term awards for translational research facilities through to long-term core funding of knowledge transfer networks addressing the UK’s strategic technologies and industries. An example of the technology and innovation centres, termed ‘Catapults’ that offer research facilities and expertise for businesses with late-stage R&D. By the end of 2013, 7 Catapults will be operational; each Catapult focuses on an area of strategic importance for the UK with large global market potential, such as high value manufacturing and cell therapies.

The UK also has a **national space agency** (UK Space Agency, UKSA), which is an executive agency of BIS, responsible for the UK’s civil space programme. It was established on 1 April 2010 to replace the British National Space Centre (BNSC) and took over responsibility for government policy and key budgets for space exploration, and represents the UK in all negotiations on space matters. Historically, the BNSC operated as a coordination body for the different public bodies with an interest in space, from the industry ministry to the research councils and the Met Office. In recognition of the potential for growth related to or enabled by space, the UK government has committed to substantially increase its investment in space programmes and to bring together all civil space interests within a single body, the UKSA.

3.3.4 Advisory bodies - The Council for Science and Technology (CST)

The national Council for Science and Technology is the UK’s top-level independent advisory group on science and technology issues. It gives advice to the Prime Minister, senior ministers and the First Ministers of Scotland and Wales on strategic issues that cut across the responsibilities of individual government departments, with the objective of:

- Developing and sustaining science, engineering and technology (SET) in the UK, and promoting international co-operation in SET
- Fostering the practice and awareness of science, as an integral part of UK culture
- Promoting excellence in SET education

- Making more effective use of research and scientific advice in the development and delivery of policy and public services across Government
- Promoting SET-based innovation in business and the public services in order to support the sustainable development of the UK economy, the health and quality of life of UK citizens, and global sustainable Council for development

There is no single 'formal' mechanism by which this process of policy development in CST works. The work in CST has a medium to long-term approach and its work is organised around five broad topics: research, science and society, education, science and government, and technology innovation.⁸ The CST comprises senior figures from the fields of science, engineering and technology, both from the public and private sectors.

3.4 Research performers (Level 4)

3.4.1 Higher Education Institutions (HEIs)

As of August 2013, there were 165 HEIs in the UK of which 115 were universities (ERAWATCH, 2014). A complete list of these 'recognised bodies' is available online⁹.

Universities in the UK are autonomous bodies, with charitable status, and are free to seek funding from a variety of sources. However, the majority of their funding comes via what is known as the dual support system (as described above). The UK Higher Education sector comprises an extremely heterogeneous collection of institutions, which range from large, highly research intensive, internationally renowned institutions to small, teaching-focused institutes which often serve particular regional or sectoral demands (ERAWATCH, 2014).

3.4.2 Public Research Organisations (PROs)

Around 100 public sector research establishments that carry out (and possibly fund) applied research of relevance to their own requirements or those of their lead department, from the British Museum to the Health and Safety Laboratory.

3.4.3 Business Enterprise Sector

The UK has a large ecosystem of business that is actively engaged in R&D activities. In 2012, businesses that were classified to the 'Scientific research and development' industry, spent £4.7bn on R&D, which represents 27% of total R&D expenditure in that year. Other important industries active in R&D activities include (ERAWATCH, 2014):

- Computer programming, consultancy and related activities, £1.6bn (9% of total R&D expenditure);
- Manufacture of motor vehicles and trailers, £1.5n (9%);
- Manufacture of other transport equipment, £1.4bn (8%);
- Architectural and engineering activities, £1.2bn (7%);
- Manufacture of computer, electronic and optical products, £977m (6%).

However, according to Hughes and Mina (2012)¹⁰ "the business enterprise component of R&D expenditure in the UK is low by international standards, even after adjusting

⁸ www2.cst.gov.uk

⁹ <http://www.legislation.gov.uk/ukxi/2013/2992/made>

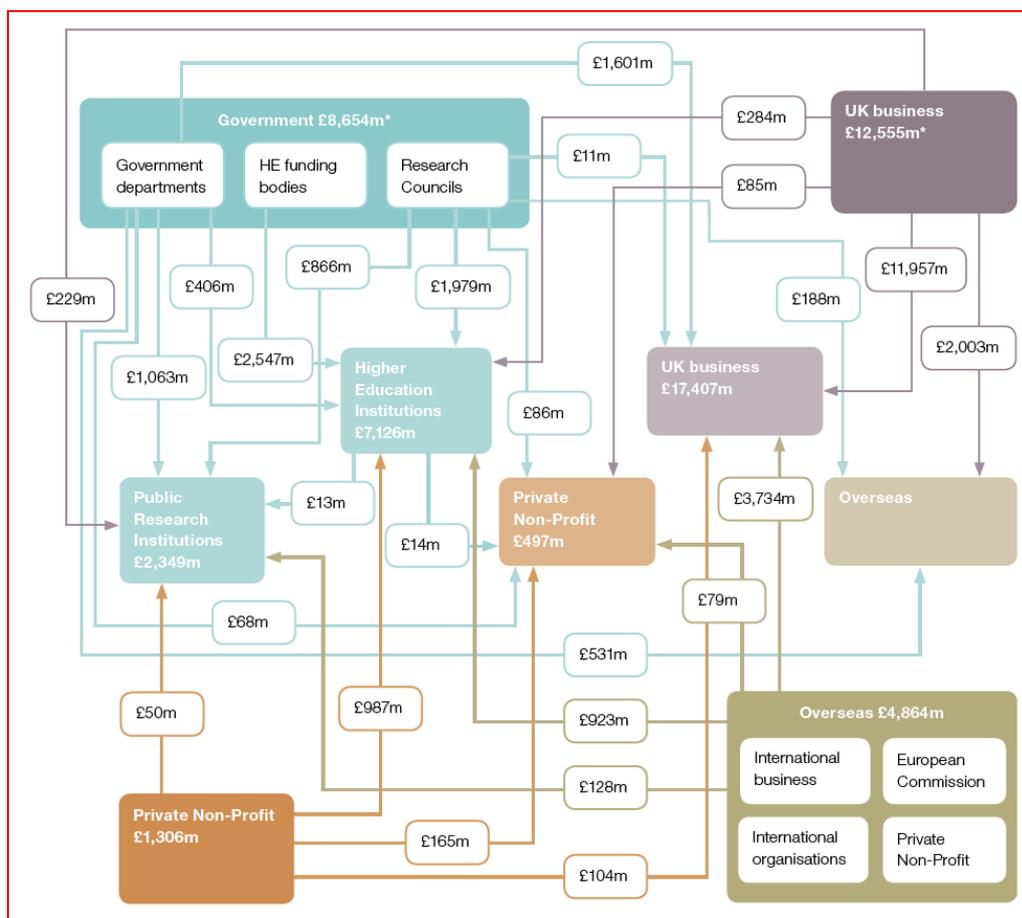
¹⁰ Hughes, Alan and Andrea Mina (2012) "The UK R&D Landscape" Enhancing Value Task Force, UK-IRC

for structural difference between countries”, appearing below France, the USA, Denmark, Japan, and Sweden.

3.5 Funding flows

Figure 9 lists all of the main actors in the text boxes while also attempting to show financial relationships between actors and the scale of the associated financial flows, within the £21 billion a year of national investment and approaching £5 billion of international investment.¹¹ It also shows that the system has also other important funders of public-sector research, including the UK’s research charities (e.g. Wellcome Trust) and the European Commission, which supports a substantial number of projects through its multiannual RTD Framework Programme (e.g. FP7).

Figure 9: UK research funders and performers, all sectors (2011)



Notes: 1 Government funding is the total for all Central Government Departments, Research Councils, Higher Education Institutions and Higher Education Funding Councils. 2 Higher Education funding is the total provided by the four Higher Education Funding Councils. 3 Public Research Institutions (carrying out research) is the total of government and Research Council sectors. 4 There are no ONS data on the Higher Education Institutions and Private Non-Profit sector’s funding to overseas entities. As a result of this: we have not included a total figure for R&D carried out overseas, but funded from UK entities (as this total would be incomplete)

Source: National Audit Office analysis of Office for National Statistics data.

¹¹ The underlying data used in the table / analysis can be found at: www.ons.gov.uk/ons/rel/rdit1/gross-domestic-expenditure-on-research-and-development/2011/tsd-gerd-2011.html

4. Horizontal coordination

There are several mechanisms used to guarantee **horizontal co-ordination** in UK research and innovation system. In this section we provide four examples of mechanisms and actions put in place to coordinate research and innovation around key economic and societal challenges that call for a multidisciplinary approach. Additionally, we also present four other examples.

4.1 Facing economic and societal challenges

4.1.1 Low carbon economy

In the UK the energy sector is an important part of the economy and a strong driver of growth. It benefits from a secure energy supply arising from a liberalised energy market, robust regulations and a diverse range of energy sources¹². However the system is facing a number of significant challenges:

1. Tackling the threat of climate change
2. Upgrading ageing infrastructure
3. Maintaining energy security
4. Minimising costs for industry and householders
5. Protecting the fuel-poor

Addressing these challenges provides vast opportunity for innovative UK businesses of all sizes to benefit from £110 billion of investment in UK energy infrastructure needed by 2020¹³ as well as benefiting from the global market for low carbon and environmental goods and services worth £3.4 trillion in 2011/12^{14,15}.

In 2013, the UK Government identified opportunities for low carbon technologies from key industrial sectors and in the UK's Industrial Strategy created a partnership between business and all parts of government to help create growth for the future from the different opportunities identified by developing new skills and securing critical investment to commercialising our research and inventions, the Low Carbon Innovation Co-ordination Group (LCICG). The function of the LCICG within this, is bringing together the major public sector backed organisations that invest in low carbon technology innovation in the UK with the shared aims of:

1. Delivering affordable, secure, low carbon energy for the UK
2. Delivering UK economic growth
3. Development of the UK's capabilities, knowledge and skills

The technologies of focus to the LCICG include Bio-energy, Carbon Capture and Storage, Domestic Buildings, Electricity Networks and Storage, Heat, Hydrogen for Transport, Industrial Sector, Marine, Non-domestic building, Nuclear Fission and Offshore Wind. It is clear from this list of technologies that innovation needs fall across a breadth of sectors, which subsequently requires a diversity of support activities. Support from the LCICG comes in several formats, the first is funding

¹² https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/254250/FINAL_PDF_of_AES_2013_-_accessible_version.pdf

¹³ Electricity Market Reform Delivery Plan, December 2013 update. See: DECC, Delivery Plan Impact Assessment, December 2013: <https://www.gov.uk/government/publications/electricity-market-reform-delivery-plan>

¹⁴ BIS, Low Carbon Environmental Goods and Services, Report for 2011/12. July, 2013

¹⁵ LCICG Strategic Framework

provided in the form of grants or direct investment into a project with pre-commercial procurement mechanisms being increasingly utilised.

In order to strengthen the coordination and delivery of public sector low carbon technology innovation the LCICG has also pursued a number of additional activities and in doing so have consulted with industry and academic experts, innovators and end users to gain a better understanding of their needs and to ensure support is provided in the right way.

These activities include:

- Developing and publishing a shared evidence base called the Technology Innovation Needs Assessment (TINA)
- Establishing the ‘Low Carbon Funding Landscape Navigator’, an online portal to help innovators to find funding.
- Developing complementary programmes and projects across the LCICG membership
 - For example the Carbon Trusts’ Offshore Wind Accelerator; a £45million programme which focuses on foundations, access systems, wake effects, electrical systems and cable installations aimed at reducing the costs of offshore wind by at least 10% by 2015. This programme involves nine offshore wind developers and brings together the Carbon trust’s expertise in delivering innovation and convening industry consortiums with the industrial partners’ technical knowledge and resources. The programme is two thirds funded by industry and one-third funded by DECC^{16,17}.
- Using the resources and expertise of members to deliver co-funded projects and programmes
 - For example, LCICG members are supporting the design, construction and installation of individual full-scale devices such as Scotrenewables’ 2MW full-scale SR2000 floating tidal turbine, which is being supported by the Wave and Tidal Energy R&D Support Programme, which is a joint venture between the Scottish Enterprise, Highlands and Islands Enterprise and the Scottish Government^{18,19}.
 - Creating a shared plan for future collaboration and prioritisation

Figure 10: The Low Carbon Innovation Co-ordination Group

Core LCICG Members	Associate LCICG Members
Department for Energy and Climate Change	Department for Transport
Department for Business Innovation and Skills	Department for Communities and Local Government
Scottish Government	Department for the Environment, Food and Rural Affairs
Carbon Trust	UK Trade and Investment
Energy Technologies Institute	Defence Infrastructural Organisation
Scottish Enterprise	Welsh Government
Engineering and Physical Sciences Research Council	Crown Estate
Technology Strategy Board	Ofgem
	Department for Enterprise, Trade and Investment

Source: LCICG

¹⁶ <http://www.carbontrust.com/our-clients/o/offshore-wind-accelerator>

¹⁷ LCICG Strategic Framework

¹⁸ <http://www.scotrenewables.com/news/58-major-new-investment-announced-13-december-2012>

¹⁹ LCICG Strategic Framework

4.1.2 Agri-food

Agriculture is one of the world’s rapidly growing markets, driven globally by changes in population, the rapid development of emerging economies and geopolitical instability concerning land shortages, water and energy. This combined with a technological revolution in which breakthroughs in nutrition, genetics, informatics, satellite imaging, remote sensing, meteorology, precision farming and low impact agriculture are driving major global investment in agri-tech creates an opportunity for the UK in agricultural innovation²⁰.

The UK has traditionally been a leader in agricultural science with the development of new approaches to sustainable practices developed in recent years. Therefore the UK is well placed to play a leading role in the global challenge of ‘sustainable intensification’. At present in the UK the economic performance of agriculture is compromised by a lack of investment in applied research and the translation of this research, following a decline since the 1980’s, resulting in the failure of basic research to be developed into new technologies, services, practices and systems on the farm that contribute to increased productivity. As a result the balance of funding between basic, translational and applied research is not aligned with the sector’s needs, contributing to low relative productivity when compared to competitors. Furthermore, addressing this gap could also help strengthen UK venture capital for agri-tech leading the UK to a position where it can offer a more vibrant and promising environment for start-ups and spin-outs and so complementing the innovation and investment of the larger players in the market.

In an attempt to address this it has developed a ‘**UK Industrial Strategy for Agriculture**’ to integrate science with the food and farming business with Government support for trade, investment and international development to address this challenge and to help unlock a new phase of global leadership in agricultural innovation. This strategy is supported by BIS, the Department for Food, Environment and Rural Affairs (DEFRA) and the Department for International Development (DfID) with a total investment of £160million (see Figure 11: Calls for proposals)²¹.

Figure 11: Calls for proposals

Competition Call	Competition Focus	Project type	Funds available	Projects Funded
New approaches to crop protection collaborative R&D call (2010)	<ul style="list-style-type: none"> Develop innovative solutions to help growers of arable, horticultural, forage and non-food crops respond to dual challenges of increasing productivity while reducing environmental impacts of crop reduction 	Business to business or science to business collaborations	£13 million	32
Sustainable Protein Production (2011)	<ul style="list-style-type: none"> Increasing domestic supply of sustainably produced vegetable protein for farmed animals (including land and marine based aquaculture); Increasing production efficiency and sustainability of domestically supplied animal and fish protein for food, and reducing waste in 	Business led, collaborative	£15 million	29

²⁰ HM Government (2013), “A UK Strategy for Agricultural Technologies” https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/227259/9643-BIS-UK_Agri_Tech_Strategy_Accessible.pdf.

²¹ “Competition Funding For New Business Innovation in UK.”

	the food chain to the point of retail sale.			
Food Processing and Manufacture (2012)	<ul style="list-style-type: none"> The development of new technologies and processes that will, for example, increase efficiency and reduce waste in the beef supply chain, increase bread manufacturing efficiency and sustainability and introduce more energy efficient air distribution systems for cooling food factories. 	Business led, collaborative	£23 million	30
Measurement Technologies (2013)	<ul style="list-style-type: none"> Developing new tools to help businesses develop innovative measurement technologies for efficient agri-food systems 	Business led, collaborative	£8.75 million	13
Engineering Solutions to Enhance Agri-Food Production (2013)	<ul style="list-style-type: none"> Enhance efficiency in use of resources in crop, livestock and food processing environments Maximise marketable yield and profit potential Minimise potentially negative environmental impacts associated with food production 	Business led, collaborative	£13 million	*TBA

Source: Technology Strategy Board²². *TBA – to be announced.

4.1.3 The UK Clinical Research Collaboration (UKCRC)

The UK Clinical Research Collaboration (UKCRC) was established in 2004 with the aim of re-engineering the clinical research environment in the UK through improved coordination and transparency, to benefit the public and patients by improving national health and increasing national wealth. The UKCRC approach means that complex, long-standing issues are tackled by key stakeholders working together.

The issues that need to be addressed in order to strengthen clinical research in the UK were highlighted in key reports from the Academy of Medical Sciences (AMS) and from the Bioscience Innovation and Growth Team (BIGT).²³

The UKCRC partnership comprises the major stakeholders that influence clinical research in the UK, including the main UK research funding bodies (e.g. MRC); academia; the NHS; regulatory bodies; the bioscience, healthcare and pharmaceutical industries; and patients.

The UKCRC Board provides strategic direction and oversight with broad stakeholder input into key issues. The Partnership is supported by a jointly funded, independent Secretariat and has a mixed model of working, where activities are:

- Led and administered by individual Partners on behalf of the Partnership
- Led by individual Partners and administered by the UKCRC Secretariat
- Led and administered by UKCRC Secretariat

Clinical research networks have been established in each of the four UK nations funded by the UK Health Departments. Together these national networks form the UK Clinical Research Network (UKCRN), strategic oversight for which is provided by the UKCRC. The structure of the networks varies between each country, but all share the common goal of providing the infrastructure to support high quality clinical research

²² “Competition Funding For New Business Innovation in UK” <<https://www.innovateuk.org/funding-competitions>> [accessed 20 February 2014].

²³ <http://www.bioindustry.org/document-library/bioscience-2015/>

studies for the benefit of patients. There is a commitment to ensure that the clinical research networks across the UK work together in an integrated manner to share experiences, develop joint initiatives and promote partnership and UK-wide working wherever possible.

4.2 Further examples of coordination around key issues

4.2.1 Open access

The UK government is firmly behind the increased use of Open Access of all outputs and data deriving from public research. There is no hard law. There is a growing body of soft law however, which includes the RCUK statement of principles on open access (the RCUK is the umbrella body for all grant awarding research councils). The RCUK essentially endorses the principles set out by the OECD in this area.

The RCUK / OECD overarching statement of principles is reflected in the data policies that are maintained and published by each of the UK's seven grant-awarding research councils, recognising publicly-funded research data as valuable, long-term resources that, where practical, must be made available for secondary scientific research. This includes any third party in any country. This commitment to open access is subordinate to primary legislation on data security and confidentiality and the research councils require grantholders – as a condition of their award – to adhere to all applicable data-related legislation.

The UK has several agencies (e.g. JISC) that are especially active in this area, promoting the principles of OA and developing the guidelines and infrastructure to realise that advice.

4.2.2 Research infrastructure

RCUK published a Strategic Framework for Capital Investment, 'Investing for Growth: Capital Infrastructure for the 21st Century,' in 2012, informed by

- The strategic plans of the individual Research Councils, and their advisors
- Input from the research community' through an RCUK consultation in spring 2012 (Capital Investment Consultation)
- Discussions with other agencies with an interest in capital investment, including the UK Funding Councils; the Technology Strategy Board and the UK Space Agency

The document provides a framework against which future investment decisions can be made, in a way that is flexible and adapts to developing research priorities, and does not amount to a prioritised list of funding requests. The new Framework will continue to include large facilities as previously described in RCUK Large Facilities Roadmaps, but has broadened to include other significant capital priorities.

RCUK has constituted a research infrastructure coordination group.

- Coordination and collaboration is also being promoted by the UK government and its funding agencies at the level of individual research centres.
 - Catapults
 - Innovation Platforms

HEFCE's UK Research Partnership Investment Fund is designed to support investment in higher education research facilities, in part to encourage strategic partnerships between HEIs and other organisations active in research. The fund was originally set up in 2012, however, the government has announced funding through to 2016/17, with at £100M of matched funding available annually to leverage private

investment. In rounds one and two over £300 million was allocated to 22 projects, attracting at least £826 million of private investment.²⁴

4.2.1 Management of ethics and misconduct

British laws regulate clinical trials and medicines for human use, taking EU directives fully on board. The NHS also has its own strict laws on research conduct and ethics, creating accountability and applying to all state funded medical research.

The UK Human Tissues Act 2004 regulates the use of human tissues (which include stem cells and embryos). The law is highly detailed and strict on many fronts and establishes a Human Tissue Authority with a remit for overseeing research and other activities.

The UK Research Councils publish detailed guidelines on research conduct, including how projects are to be managed and reported on, as well as best practices and relevant laws on discipline designed to fit around existing internal procedures. These are exemplary in covering all fields of science (including economic and social sciences) separately, as opposed to focusing exclusively on the life sciences, as many countries do.

UK Laws on the treatment and mistreatment of animals are watertight and very closely regulated in terms of research.

Finally, there exists a widely-encompassing guide called the UK Research Integrity Office Code of Practice for Research, which takes on a range of issues arising at various stages of a research project, offering a checklist for researchers and further support, if needed.

4.2.2 Research career paths

In the UK, research careers are dealt with through soft law and codes of practice. The Concordat to Support the Career development of Researchers (June 2008) is a voluntary code of practice expressly concerned with career development. The code has 7 main principles, including:

- Principle 3 - Researchers are equipped and supported to be adaptable and flexible in an increasingly diverse, mobile, global research environment.
- Principle 4 - The importance of researchers' personal and career development, and lifelong learning, is clearly recognised and promoted at all stages of their career.

Although the Concordat is soft law, the major research funders expect all HEIs to adopt the principles of the Concordat, and this requirement is detailed in their Terms and Conditions of grants. Moreover, it has been adopted by employers and is used and referenced in their institution-level HR policies.

The Joint Negotiating Committee for Higher Education Staff (JNCHES) published its Academic Role Profiles (2004), which comprise model profiles for all academics at all stages of their career. The guidelines include a detailed elaboration of skills needs, competence thresholds and staff grades for all academics.

²⁴ For example, Imperial College London secured a £35M grant to help finance the setting up of a new Research and Translation Hub as the centrepiece of its Imperial West Campus. The hub provides high specification, multidisciplinary research space on a campus that has created a single location for researchers, global business, small and medium-sized enterprises, spin-outs and large international universities. The University of Birmingham won a grant to set up a High Temperature Research Centre, which will carry out collaborative research and development into manufacturing technologies, especially the metal-forming technique, 'investment casting'. The new facility builds on a long-standing relationship between the University of Birmingham and Rolls-Royce. It will receive £20 million from HEFCE matched with £40 million from Rolls-Royce.

The Researcher Development Framework (RDF) – published by Research Councils UK (RCUK) and endorsed by all research funders and employers develops the JNCHES guidelines and provides a more comprehensive and structured elaboration of the various skills (domain knowledge, methods, finance, people management...) required by researchers at different stages in their career, which is an increasingly widely used model that is now being championed abroad by the European Science Foundation. The RDF is run by *Vitae*, a national organisation funded by the grant-awarding research councils to support researcher training and career development.

4.2.3 Cross-border and international mobility

The UK does not participate in the EU's *Scientific Visa* scheme, but runs its own points-based system for skilled immigrants. The system is comprehensive and makes various provisions for different skills and different fields of research.

The UK's international strategy (Research Councils UK's [RCUK] International Strategy) has four headline objectives, the second of which is to “provide opportunities for excellent UK researchers to flourish in global research collaborations.” The RCUK web site presents some basic statistics, which show that more than 50% of research students based in the UK are non-nationals and approaching 20% of academic staff.

The RCUK Research Careers and Diversity Strategy sets out a nationally agreed (funders, employers and researcher representatives) approach to skills training, which includes a commitment to enhancing the mobility of UK researchers. To that end, the RCUK and each of the seven grant awarding Research Councils supports international mobility through a long list of schemes to support short trips (e.g. visits, workshops...) and longer stays (e.g. scholarships, fellowships, exchanges...).

The UK *Concordat to Support the Career Development of Researchers* offers clear statements in support of expanding international mobility and promoting diversity, acting as a highly influential guideline for British research institutions.

4.2.4 International S&T cooperation

UK research funders and universities are allowed to participate in international collaborations, as necessary. It is customary for such collaborations to be left to the individual researchers wherever possible, except where there is a clear case to actively promote or administer such interactions. The government's global science and innovation strategy stands as a piece of soft law that has resulted in the research councils signing new agreements with strategic partners in emerging countries and opening national offices in critical regions, like China, India and the US.

IPR policy tends to be defined on a case-by-case basis, however the Research Councils are strongly committed to open access as a default policy and generally make it a condition of contract (grant) for any study or fellowship to deposit a report and any related data in an appropriate repository for access and reuse.

5. Other key characteristics of the UK System

As explained in the introduction to this paper, this section departs from the issue of governance, but provides some examples of the tools and incentives used in the UK to support research and innovation that may be relevant for the Peruvian context. These examples have been identified after a visit to the UK of representatives from Concytec, PRODUCE and the National Council of Competitiveness.

5.1 Defining strategic priority and actions

In the last years, the UK has returned to using industrial policy and strategy as a mechanism to help the UK economy and business compete and grow, an approach that was discarded and even demonised in the late 80's and 90's.

The current UK strategy is the Innovation and Research Strategy for Growth (IRS), published in December 2011, which is the central guiding document for UK research and innovation policy and priorities nationally.²⁵ This policy document is supported by an Economics Paper, which provides an analysis of the general context within which the research strategy was situated.²⁶

The UK policy on science is inextricably linked with the broader issues of innovation and growth. As such the IRS²⁷ sets out the potential for the UK to be a world leader in innovation, making the most of the UK's manifold inventions and discoveries in the public and private sectors. The Strategy recognises that the costs of cutting-edge research and the latest high-tech processes are greater than ever before, and are often too large for any one company and that other countries are spending more on research and working to develop clusters of knowledge and innovation hotspots; multi-partner collaborations can add more than the sum of their parts. Furthermore, levels of investment in R&D differ significantly across the various parts of the UK.

The national strategy emphasised the need to strengthen the country's ability to accelerate the commercialisation of emerging technologies, and to capture the value chains linked to these. Commercialisation of research is recognised globally as a vital part of Research and Innovation and is a key policy and public sector area for investment. There are no established metrics for measuring it, but commercialisation is where the benefits of research and innovation can be realised and the impact felt in the economy and through supply chains. The national strategy also notes that the UK needs to do more to encourage the development of technician-level skills and higher-level skills to support this innovation work.

Multi-partner collaborations not just within the UK but transnationally, should also be encouraged as they can add more than the sum of their parts. To ensure an effective innovation environment there is also a need to do more to support the development of technician-level skills and higher-level skills.

The evidence set out in 2011²⁸ and in the 2012 Innovation Report (Nov. 2012) shows that, compared to other leading economies, the UK innovation system has many strengths. The UK research base is among the best in the world, producing high-quality output with unmatched efficiency. The UK also performs well on international collaboration; ranks second in the world for university-industry collaboration and has high levels of inward investment. The UK is a world leader in social innovation, (including the emerging social investment market) with a market value estimated to be worth £1 billion in 5 years.

It is also worth noting that in addition to the research and innovation strategy, the Government published a new industrial strategy in 2012 – focusing on 11 strategic sectors – and where technology and innovation in the broadest sense are expected to be critical to future success. The Government worked in partnership with business and has developed 11 sector strategies from aerospace to agriculture.²⁹

²⁵ www.bis.gov.uk/assets/biscore/innovation/docs/i/11-1387-innovation-and-research-strategyfor-growth

²⁶ Innovation and Research Strategy for Growth, BIS Economics Paper No 15, December 2011

²⁷ <http://www.bis.gov.uk/assets/BISCore/innovation/docs/I/11-1387-innovation-and-research-strategy-for-growth.pdf>

²⁸ [BIS Economics Paper NO. 15 - Innovation and Research Strategy for Growth – December 2011](#)

²⁹ www.gov.uk/government/publications/uk-agricultural-technologies-strategy

The UK Industrial Strategy (2012)³⁰³¹ also lists a series of ‘eight great technologies’ in which the government (with advice from the RCs and TSB) has judged the UK can gain a competitive advantage globally and which have real potential for economic and social benefits in the UK (and internationally too). **BIS worked with the RCs and TSB to select the eight great technologies after carefully analysing UK existing scientific and business capabilities.** Each technology:

- Is an area in which the UK has world-leading research
- Has a range of applications across a spectrum of industries
- Has the potential for the UK to be at the forefront of commercialisation

The eight great technologies are:

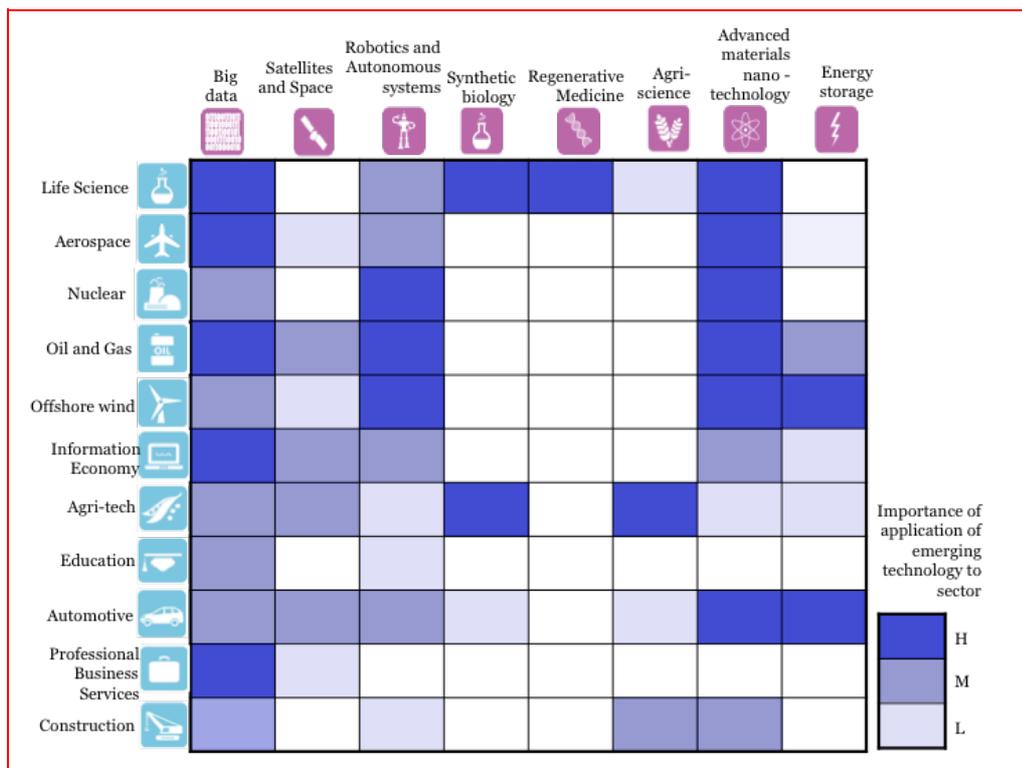
- Big data and energy-efficient computing
- Satellites and commercial applications of space
- Robotics and autonomous systems
- Synthetic biology
- Regenerative medicine
- Agri-science
- Advanced materials and nanotechnology
- Energy and its storage

The targeting of these technology areas shows how the government is working with researchers and industry to foster world-class technology capability in the UK. They are not exclusive or exhaustive, and there are many other important areas of science and innovation in which the UK excels and will excel in future.

³⁰ www.gov.uk/government/policies/using-industrial-strategy-to-help-the-uk-economy-and-business-compete-and-grow

³¹ The UK Industrial Strategy is complemented by a series of home nation strategies focusing on key growth sectors, allowing each part of the UK to build on its assets through Smart Specialisation, and identifying local strengths and building collaborative networks.

Figure 12 Strategic sectors and technology areas



Source: BIS

Over the past year (2013/14) the “Government has allocated more than £2 billion to industrial strategy objectives, a clear indicator of commitment in a period of fiscal constraint” (HM Government, 2014)³². These efforts have been matched by industry, which has invested time and financial resources to set the strategic direction and to provide match-funding the majority of investments made by the government.

5.2 Supporting research from ideas to markets

The TSB has adopted a clear strategy to facilitate the link between R&D and innovation. This is expressed in its current strategic document “Concept to Commercialisation: a strategy for business innovation, 2011-15”. Here the TSB outlines the five strategic areas in which it is currently working:

- “Accelerating the journey between concept and commercialisation”: support in these areas includes (and will include) support for small and early stage companies, the creation of a network of technology and innovation centres, and promotion of knowledge exchange and open innovation (see Box 2 for a brief description on the UK approach to knowledge exchange).
- “Connecting the innovation landscape”: act as a connector of the different organisations involved in innovation activities, from funders to performers.

³² HM Government (2014) “Industrial Strategy. Government and Industry Partnership”. Progress Report.

- “Turning government action into business opportunities”: to identify areas where policy, standards, and regulation can stimulate business innovation, creating innovation platforms as appropriate.
- “Investing in priority areas based on potential”: which links back to the government industrial policy explained above.
- “Continuously improving TSB’s capabilities”: which includes a process of accountability and monitoring to assure that the TSB is delivering its support in an efficient way and generating tangible impact. This approach to demonstrating impact is further explained in the next subsection.

The Catapult Centres are a good example on how TSB is putting this strategy into practice. The Catapults are technology and innovation centres specialised in seven specific areas, related to the strategic sectors and the key technology areas identified in the current industrial policy. The 7 centres include:

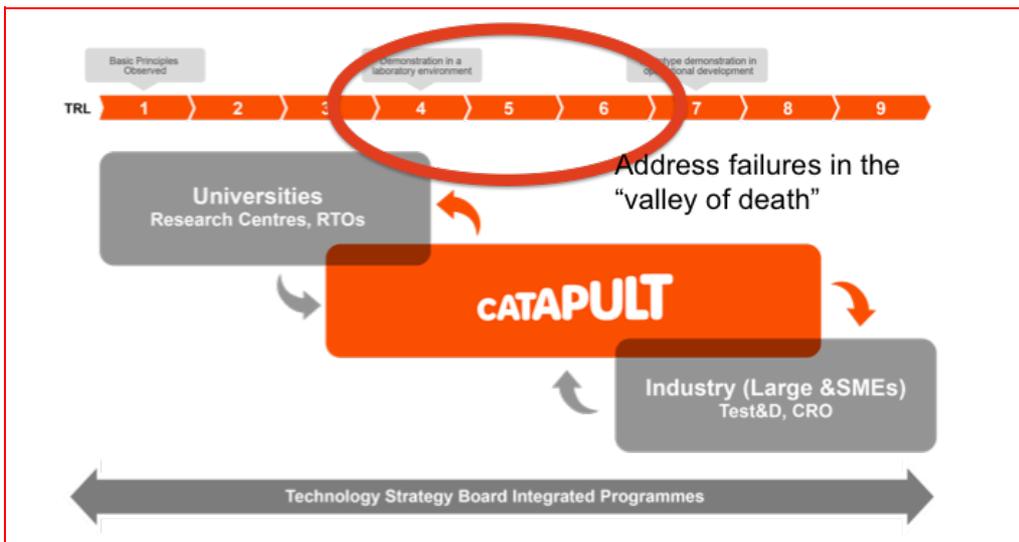
- High value manufacturing
- Cell therapy
- Offshore renewable energy
- Satellite applications
- Connected digital economy
- Future cities
- Transport systems

The Catapults have been designed to bridge the gap between businesses, academia, research and government. The Catapults will provide support for projects and technologies that are ready for demonstration and testing and that are still not ready to enter the market. The aim is to guarantee that ideas and technologies can evolve until the commercialisation stage and address a potential gap in funding and economic incentives where private economic agents (such as venture capitalists, angel investors) are less willing to invest in developments at a stage with higher risk of not succeeding (see Figure 13 and Figure 14).

The Catapults gain their funds from a mix of competitively earned commercial funding and core TSB investment. In fact, funding can be expressed in simplified terms as following the one-third, one-third, one-third model: (i) core public funding for long-term investment in infrastructure, expertise and skills development (ii) business-funded R&D contracts, won competitively. (iii) collaborative applied R&D projects, funded jointly by the public and private sectors, also won competitively. This could include for instance, R&D projects funded by the EU Framework Programme Horizon 2020 (the main instrument used by the European Commission to fund research and technology development). TSB estimates that each centre will need to attract around £10m to £15m per annum from the private sector to be viable.

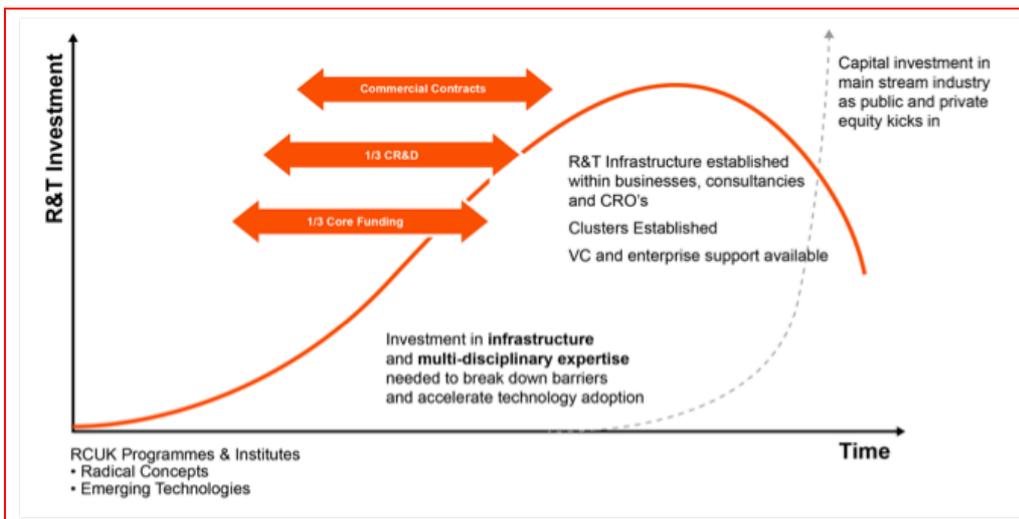
Overall, the funds allocated to the Centres so far has supported the construction of state of the art facilities, employment of highly skilled people and domain experts (which are available to provide advice to projects), and the infrastructure dedicated to provide advice and support related to commercialisation, routed to funding, networking and intellectual property.

Figure 13: Technology Readiness Levels



Source: TSB

Figure 14: Catapult's role



Source: TSB

Box 2: Knowledge transfer and knowledge exchange

Supporting knowledge transfer and knowledge exchange is a key element to nurture and foster a system that is able to transfer the ideas and research from research institutions and universities to the private sector and society at large.

In the UK, knowledge transfer is addressed explicitly in the national science and innovation strategy, which addresses a number of relevant issues and new tactics and seeks to stimulate economic success. Though still in place, the framework is a little archaic for its age and the fact that the government ministry that implemented it no longer exists in the same form.

There are no specific hard laws dealing with this issue in the UK, although national laws on IPR are hard and binding and national reviews of this area have shown that the system is in reasonably good shape. Regarding soft law, the Lambert Toolkit provides a framework of instruction and law for universities and businesses wishing to collaborate with one another on research projects, offering guidelines on ownership and exploitation and how research may be financed and published. Another soft guide assists universities in managing their intellectual

assets, providing a very helpful tool for the public sector. The Intellectual Property Office (IPO) has become increasingly important in the codification and creation of good practice guides and toolkits. Most recently, the IPO has led the design of the UK's new tax relief measure for innovators, the Patent Box, which allows companies to pay a reduced rate of corporation tax in connection with profits derived from a company's patented products and services.³³

The Technology Strategy Board has published a 'concept to commercialisation' strategy, showcasing the Technology and Innovation Centres (Catapults) ambitions to enhance collaboration between different sectors. Each of the Research Councils has a KT strategy within its broader strategy, which summarise their policies on the matter and explains their use of various knowledge exchange mechanisms. RCUK has supported a working group relating to innovation and non-academic research impact, as a means by which to coordinate KT activities across councils and facilitate learning.

HEFCE has been especially important within this area, having run a national fund to support the development of institutional KT policies, structures and capacities over the past 20 years. This fund, the Higher Education Innovation Fund (HEIF) has had a significant and positive impact on the contribution of higher education to innovation.³⁴

5.3 Research and innovation performance measurement

The UK government uses performance measurement extensively to steer the research and innovation system and encourage and reward certain kinds of behaviour.

In fact, the UK is among the few countries that heavily use performance indicators to make decisions regarding core research funding. As shown in Figure 15, the UK and the Czech Republic are the only examples, among 13 European countries, for which 50% of the total allocation of core research funding depends on recipients' ability to demonstrate research excellence. The remaining 50% depends on standard indicators of size such as number of students.

Figure 15: Influence of performance on core research funding

	No influence on core funding		Influence on core funding		
	Not linked to funding decisions	Additional to the block grant	Less than 20%	Between 20% and 50%	More than 50%
Austria - BMWF			X		
Belgium (Flanders) - EWI		X	X		
Czech republic – Council of RD&I					X
Denmark - Agency for Science, Technology and Innovation (FI)			X		
Finland – Min. of Education & Culture (MINEDU)			X		
France - AERES				X	
Italy - ANVUR			X		
Netherlands – KNAW/NWO/VSNU	X				
Norway - RCN			X		
Slovak republic – Council of RD&I			X		
Spain - CNEAI		X			
Sweden - Vetenskapsrådet, SRC			X		
UK - HEFCE					X

Source: Mahieu et al (2012)³⁵

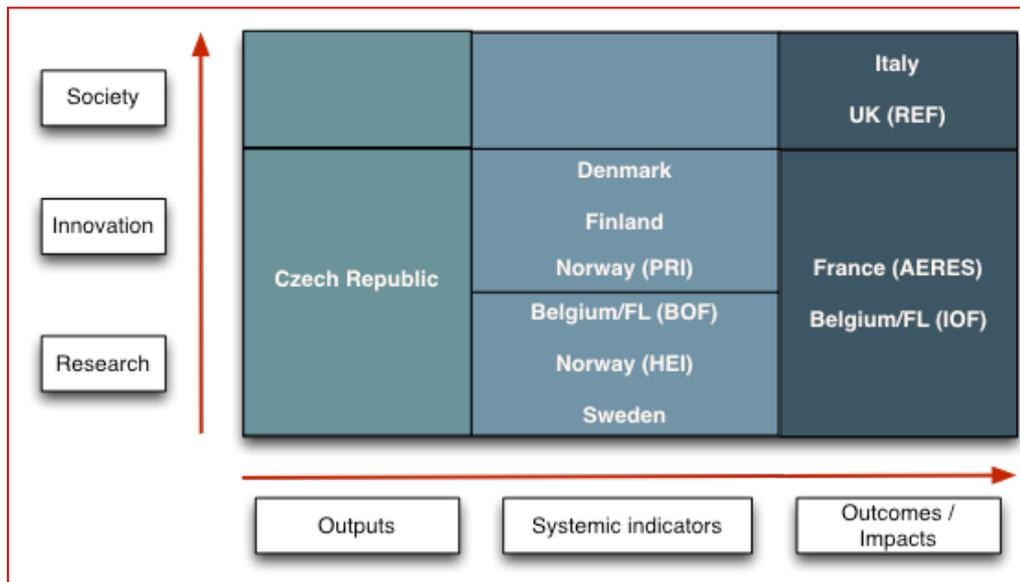
³³ <http://www.ipo.gov.uk/types/patent/p-patentbox.htm>

³⁴ <http://www.hefce.ac.uk/whatwedo/kes/heif/>

³⁵ Mahieu, B., Arnold, E., Kolarz, P., *Measuring scientific performance for improved policy making*, Technopolis, European Parliament, STOA - Science and Technology Options Assessment, 2014

Furthermore, the UK not only tracks indicators related to outputs (e.g. number of publications, number of patents, etc) or systemic indicators (e.g. value of collaborative R&D projects) but it also tracks achievements related to final outcomes and its effect on the private sector and society at large (e.g. additional economic activity generated, jobs created and safeguarded).

Figure 16: Measuring performance based on outputs and outcomes



Source: Mahieu et al (2012)³⁶

Additionally, there is a growing use of impact indicators to make budgetary decisions and the government departments make a constant effort to demonstrate the impact of their activities. For instance, BIS has recently begun to publish an Annual Innovation Report, which provides an assessment of progress made in the implementation of the 2011 Strategy, offering a number of lines of evidence against each of the identified innovation challenges and outlines new measures and other developments³⁷

BIS requires the Research Councils to monitor and report annually on their activities and achievements, using a standard reporting template. The Economic Impact Reporting Frameworks (EIRFs) form a part of the Performance Management System introduced across all Research Councils in April 2005.

The EIRFs capture a suite of performance metrics to show progress against the objectives set out in each Council's Delivery Plan³⁸, combining quantitative and qualitative material and a narrative to explain the context. The Economic Impact Reporting Frameworks are structured around the following categories to ensure they are consistent with the BIS "Economic impacts of investment in research and innovation" report:

³⁶ Idem

³⁷ Department for Business, Innovation and Skills, Annual Innovation Report: Innovation Research and Growth, November 2012.

³⁸ The EPSRC Delivery Plan is typical. Each Delivery Plan provides a high-level overview of a Council's plans for the 4-year period 2011/12-2014/15. The Delivery Plan is accompanied by a Delivery Plan Scorecard, which records progress against each objective in the plan. Both documents can be downloaded at <http://www.epsrc.ac.uk/newsevents/pubs/corporate/deliverystrategic/Pages/plans.aspx>

- Overall economic impacts
- Innovation outcomes and outputs of firms and governments
- Knowledge generated by the research base
- Investment in the research base and innovation
- Framework conditions
- Knowledge exchange efficiency
- Demand for innovation

Performance against the EIRFs is reported to BIS and published annually on each Council's website.³⁹ **These reports provide a critical tool by which the ministry can follow the work and achievements of its funding agencies, and will also feed into discussions about staff bonuses and new investments**

The EIRF reports form part of the argumentation used by BIS in its negotiations with the finance ministry (HM Treasury) to determine the overall science budget (in competition with other policy areas). In theory, the government's Comprehensive Spending Reviews (led by the Chancellor and the Treasury) work with a zero-based budgeting system, which means future budgets need have no relationship to historical spend. In practice, there is substantial path dependency and budgets tend to move up or down by small fractions (e.g. 3-5% annually over a 3-year or 5-year budgeting cycle)

The division of funding between the RCs and FCs is determined by BIS (i.e. institutional versus project funding), as is the split between disciplines (e.g. environmental science versus humanities). There is a high-degree of path dependency however and any substantive change in either the overall funding levels or the distribution of funding by broad discipline would be carefully discussed and implemented gradually.

The decision on the split between for example physics and chemistry is a matter for the governing bodies of the relevant research councils (in this case the Engineering and Physical Sciences Research Council), as is the decision on the split between basic and applied research or research and researcher education.

There are several other national monitoring exercises, which serve to inform government policy and that of individual funders and research performers. The annual review of the international standing of British Science is one example and the annual survey of higher education and business and community interaction (HEBCI) is another. There is also substantial additional data collection operating across the higher education community, which provides the basis for annual reports on a variety of aspects from research income to completion and dropout rates through to staffing levels and pay bands (Higher Education Statistics Agency [HESA]).

The **Research Excellence Framework (REF)**, successor to the Research Assessment Exercise (RAE), which was first introduced in 1986, is another important mechanism for ensuring quality and consistency across the public sector research base.

As explained above in a prior section of this paper HEFCE provides block grant funding for institutions to support the research infrastructure and enable groundbreaking research in keeping with their own mission, while the Research Councils, charities, the EU, and UK government provide grants for specific research projects and programmes. This the so-called 'dual support' system.

³⁹ For example, www.epsrc.ac.uk/newsevents/news/2013/Pages/impactreport.aspx

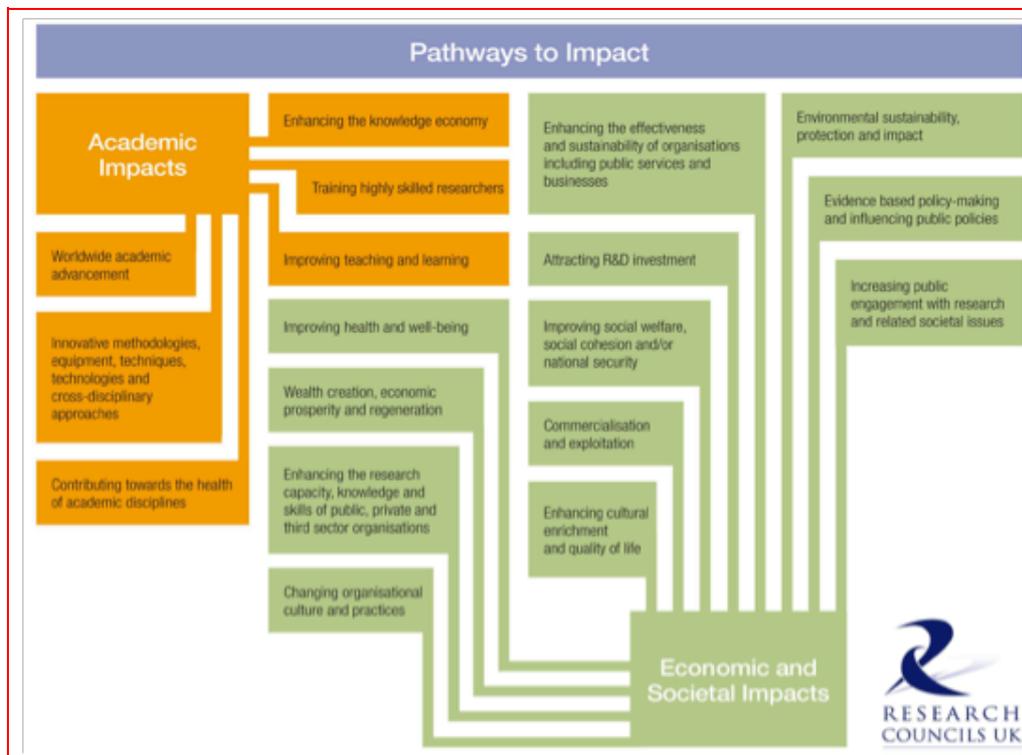
The majority of **HEFCE’s funds for research are distributed on the basis of research quality**, taking into account the volume and relative cost of research in different areas. This is called ‘mainstream quality-related research funding’.

The REF is HEFCE’s periodic assessment exercise use to assess the quality of research in order to make funding decisions. The REF also provides a means by which government can shape behaviour at the faculty level, with the original focus on scientific excellence having been broadened over time to encompass excellence in science and several other factors from departmental strategies through to (non-academic) impact.

The REF is based on a process of expert review. HEIs are invited to make submissions across all research disciplines providing details of their main achievements in terms of academic and economic and societal impacts. An expert sub-panel then assesses these submissions, applying a set of generic assessment criteria and level definitions to produce an overall quality profile for each submission. The primary outcome of the assessment process is an overall quality profile awarded to each submission.

The REF, as it is implemented at the moment, has gone through an extensive consultation process to generate awareness among researchers and other stakeholders and to generate a common understanding of the type of impacts that universities can demonstrate. Many of those impacts are yet not materialise at the moment the exercise takes place and HEIs are invited to propose and estimate the types of economic and societal impacts that could emerge from their academic work. Figure 17 shows a schematic version of the links between academic and economic and societal impacts. The diagram has been prepared by the RCUK and provides some guidelines on how to think about the connections between academic and economic and societal impacts.

Figure 17: Pathways to impact



Source: RCUK

In addition to the mechanisms already described, the UK government increasingly uses one-off topical reviews led by eminent individuals to help to determine the detailed design of new policies or policy refreshments (e.g. Witty Review of the role of universities in economic growth).

There is no UK policy or programme that determines what is evaluated when or by whom, however most major policies or programmes are evaluated at some point, partly to provide examples of successful achievements but also to support learning about the efficient and effective operation of key institutions or programmes (e.g. Triennial review of the Technology Strategy Board).

6. Regional innovation in the UK

As with most countries, R&D activity is rather unevenly distributed across the UK, with the South East and East of England dominating overall expenditure on R&D (public and private combined), as can be seen in Figure 18.

Figure 18 – R&D expenditure (GERD), by UK region, 2001, 2007 and 2011 (£Ms, 2011 prices)

	2001	2007	2011
North East	350	593	491
Northern Ireland	306	370	520
Wales	469	646	554
Yorkshire and the Humber	884	1,044	1,096
East Midlands	1,535	1,583	1,590
West Midlands	1,320	1,452	1,597
Scotland	1,613	1,814	1,925
South West	1,835	1,991	2,126
North West	2,517	2,904	2,920
London	2,473	3,117	3,205
East of England	4,395	5,360	4,478
South East	5,475	5,575	6,383
	25,173	28,456	28,896

Source: National Audit Office analysis of Office for National Statistics data.

Historically, the UK government has addressed science and innovation policy as a national rather than a regional issue, however the creation of a series of Regional Development Agencies (RDAs) in 1998 (Regional Development Agencies Act 1998) did give a regional dimension to research policy. The RDAs were concerned primarily with regeneration and skills, however, they did invest in the creation of various regional centres of excellence, science parks and networks in an attempt to strengthen regional capacity and increase influence in national debates.

In most cases, the RDAs created regional Science and Innovation Councils to bring together stakeholders from the public and private sectors to advise the agency in question on its research and innovation strategy. The RDAs were abolished by the incoming government in 2010 on the grounds that they were large and rather wasteful bureaucracies, whose role would be fulfilled more effectively and efficiently by smaller coalitions of business-led public and private partnerships.⁴⁰ The abolition of the RDAs was successful inasmuch as it reduced public expenditure on regional economic growth initiatives from around £1.5bn a year in 2010 to less than £300M in 2012. The cut in public investment was not made up by private investment, and there was a similarly precipitous impact on job creation. The government has realised that the

⁴⁰ In 2010, the Government set out a new approach for local economic growth, in the White Paper Local growth: realising every place's potential. This involved the closure of the Regional Development Agencies and their replacement with new local growth organizations and funds, such as Local Enterprise Partnerships and the Regional Growth Fund.

growth agenda needs a stronger local dimension⁴¹ and a recent National Audit Office report states that public expenditure will recover to £1.7 billion in 2014-15 (RDA levels of investment) through various mechanisms including the Regional Growth Fund.⁴²

Research and innovation policy has retained a regional dimension, in some small degree at least, post RDAs:

- The Local Enterprise Partnerships (LEPs), which were created in 2010 at sub-regional level, are business-led, private-public partnerships focused on private sector growth and job creation (rather than innovation per se). They are active at the scale of ‘functional economic areas’ – meaning that local stakeholders have been able to design and build partnerships that span geographical areas as they see fit. There are currently 39 LEPs, typically involving anywhere between six and 30 smaller administrative areas (i.e. Local Authorities)
- Regional Growth Fund - a £3.2 billion fund, helping companies throughout England to create jobs between now and the mid-2020s. The payment of Regional Growth Fund money is spread over a 7-year period ending in 2017. Regional Growth Fund supports projects and programmes that are using private sector investment to create economic growth and sustainable employment
- Individual LEPs have been required by the national government to develop what are termed Smart Specialisation Strategies (S3) in order to be eligible to bid in to key national and European Funds. Smart Specialisation is a European Commission inspired initiative designed to encourage Europe’s regions and cities to develop more robust economic strategies that are evidence-based and reflect their respective comparative advantages in the global marketplace. In addition to specialisation, the concept also encourages integration of the local economy and stronger connections elsewhere. The Commission has said that access to European Structural Funds will be conditional on these strategies, and the UK has adopted a highly coordinated approach to developing strategies in order to optimise European income and maximise the benefits that will flow from those investments. The toolkits for developing these strategies are available online, and can be used by other regions and cities around the world
- As an example, the South East LEP’s draft plan (Innovation Driving Prosperity - Our Growth Deal and Strategic Economic Plan [SEP], December 2013) bids for £1.2 billion from Government to leverage £10 billion investment into the South East by 2021.⁴³ The LEP aims to generate 200,000 private sector jobs and 100,000 new homes by 2021 through a coordinated programme of activity to deliver growth, supported by major new public/private investment funds, new road and rail infrastructure. The LEP is also proposing to develop 2,015 new homes across the SE LEP area by 2015 through a ‘new ways of working’ pilot which aims to bring development forward more quickly. The Plan outlines the SE LEP’s bid for its local Growth Deal – a share of the £2bn national Single Local Growth Fund and it sets out the ‘asks’ of Government to support the delivery of business and economic investment in new ways. The Plan will seek to deliver economic growth in Kent and Medway, Essex, Southend, Thurrock and East Sussex.

⁴¹ This recognition was given rather more urgency with the publication of Lord Heseltine's Review into economic growth, 'No Stone Unturned,' (October 2012). www.gov.uk/government/publications/no-stone-untuned-in-pursuit-of-growth

⁴² Funding and structures for local economic growth

⁴³ <http://www.sctp.org.uk/documents/SELEPSESubmissionDec2013.pdf>

6.1 Unfolding regional policy

In the national context. The government is preparing a Single Local Growth Fund (SLGF)⁴⁴ Strategy that is expected to make available a total of £2billion a year to the 39 LEPs, from April 2015 for five years. The SLGF is a response to Lord Heseltine's recommendations to devolve substantial powers and funding to local areas for a wide range of issues, from housing to transport. In return, local areas will be challenged to put in place the right governance across local authorities, pool resources, and find match funding from the private sector. Strategic Economic Plans submitted by the Local Enterprise Partnerships (LEPs) will feed into this process

In the recent years, alliances of regional universities have been formed and designed to produce the scale of activity / investment to allow those institutions to operate at the forefront of research and education internationally. Two examples are:

- Scottish Universities Life Sciences Alliance (SULSA) is a research pooling partnership between the Universities of Aberdeen, Dundee, Edinburgh, Glasgow, St Andrews and Strathclyde that is supported by the Scottish Funding Council
- The N8 Research Partnership is a collaboration of the eight most research intensive universities in the North of England: Durham, Lancaster, Leeds, Liverpool, Manchester, Newcastle, Sheffield and York

In a European context. The UK Partnership Agreement which is being currently finalised, sets out the UK's strategy and rationale for how the ESI Funds are to be deployed across the UK to complement the Europe 2020 objectives of Smart, Sustainable and Inclusive Growth and domestic initiatives for sustainable jobs and growth. In its drafting BIS made use of individual Structural and Investment Fund (SIF) strategies submitted by the Local Enterprise Partnerships

7. Final reflections

This document provides an overview of the UK research and innovation system. A system that has create and has been evolving for the last decades and that builds on a very strong academic and scientific tradition that dates even further than that.

It is worth noting that research and innovation systems have very different structures across the globe and even across Europe. They are built on the social, economic and institutional traditions of each country and it is difficult, if not impossible, to assess which system works better or is more efficient at attaining its goals. For instance, policy design in the UK is not heavily driven by legislative frameworks and hard laws, as it is the case of Peru and other Latin American countries.

In this sense, the UK system is not necessarily a model that a country (in this instance Peru) should look to replicate. There are, nonetheless, some valuable lessons from the UK system, in terms of their coordination mechanisms and their instruments to support research and innovation that could serve as guiding points for less mature systems.

Those lessons have been mainly highlighted in Section 5 of this report, and they revolved around identifying strategic sectors and technology based on existing capabilities, providing support at different stages of research promoting the transition from ideas to market, funding and incentivising excellence, building a tradition of demonstrating impact.

⁴⁴ Single Local Growth Fund - from 2015 the UK government will create a fund that will include the key economic levers of skills, housing and transport funding.

Those are lessons that could potentially be taken forward by Peru. However, each of them will entail a multi-stage process which would not only require a strong political commitment at the highest spheres of the central government, but also a long process of consensus-building across the community of funders, researchers and businesses.

7.1 Recommendations

As this is a complex arena, it is perhaps sensible to present recommendations in defined groups, or “stages”, each of which starts with an overall aim – for example, creating conducive conditions to build and operationalise a strategy – while also providing a distinct action or starting point.

In this spirit, below are 5 key action points with descriptions of how this could aid the Peruvian government in boosting national innovation performance:

1. Clearly identify and understand your contemporary advantages in science.

This entails investigating, documenting and mapping those areas of science, research and technology that are strongest nationally, regionally or internationally, the institutions, firms or teams behind them and any applications. This could be in public, private or hybrid organisations

2. Understand your upcoming grand societal challenges

These could comprise issues such as reducing inequality, fuel or food security, climate or energy issues, or any number of others. Articulating these, their nature and the timescales will aid an understanding of how latent innovations in step one could help to address them, or indeed where gaps may exist that should be addressed.

3. Align those strengths and challenges, and either i) issue national innovation challenges or b) structure funding or other mechanisms – like Catapult Centres – around them to accelerate collaborations and solutions.

These approaches are both relatively mature models for increasing innovation and supporting the commercialisation of innovation structured around a concrete demand and supply. The former allows for a programme-based approach with varying awards and project sizes, even including individuals. The latter follows the same approach as UK Catapult centres in clustering expertise and structuring approaches to building innovation solutions. Both, in the right circumstances could aid in increasing the demand-side innovation measures, and with the right support overcoming the “valley of death”. Careful considerations of funding partners will be required, and potentially feasibility studies on constructing and evaluating either approach.

4. Boost horizontal and vertical integration

The complexity of the British system, while at times confusing, has its benefits in that governance structures contain many overlaps in terms of actor organisation, meaning that the degree of separation between arenas is often relatively small. This is largely a product of history, evolution and career trajectories but in principle could be replicated meaningfully in a Peruvian context, with some careful mapping of actors and assessing the degree of overlapping / connected structures, introducing connection points consciously where desirable.

5. Uncover the views of stakeholders, in particular in relation to enablers and blockers for innovation in the system.

Uncovering the most common enablers and blockers – i.e. what these are, how they manifest and where they exist – will help the government to design solutions that most efficiently tackle those commonly-held beliefs. As an example, in the UK, businesses often report risk and finance provision (often related) as the main blockers to innovation. This helped to inform in part the design of programmes and initiatives such as the Catapult centres, as well to understand more broadly

shortcomings in the business base, particularly in terms of younger firms. Similarly, this could help the government to understand what is working well and where, meaning that not only would it be possible to find and address potential problems, but also to reinforce good practice.

The above are presented essentially as a nested list of recommendations that would be valuable taken either in isolation or, to greater effect, as a structured and staged process aimed concretely at informing approach and boosting performance at a national level. As always, considerations will be required at how best to transpose policy recommendations to a local context, as straight transplants invariably don't work. That isn't to say, however, that there is not great potential in learning from a number of examples from extant practice in other contexts, and that is how these are presented.

Appendix A Summary of UK statistics

Figure 19 – UK key social and economic metrics

Indicator	Description
Population (UK)	63.7 million (2012) Statistical bulletin: Annual Mid-year Population Estimates, 2011 and 2012
GDP	£1.44 trillion / \$2.44 trillion (2011) ONS
GDP / capita	\$38,032, 2012
People in employment	29.95 million (September 2013) 1.5% agriculture 18.8% industry 79.7% services Labour Market Statistics, November 2013, Office for National Statistics
Employment rate, among those aged from 16 to 64	71.8% The unemployment rate for July to September 2013 was 7.6% of the economically active population, down 0.2 percentage points from April to June 2013. There were 2.47 million unemployed people, down 48,000 from April to June 2013.
Average gross salary	£2,308 / €2,756 / \$3,729 monthly (2011) (9th highest in world)
Exports	\$481 billion (2012 estimate) "UK Trade statistical bulletin". Office for National Statistics, June 2011
Imports	\$646 billion (2012 est) "UK Trade statistical bulletin". Office for National Statistics, June 2011
FDI	\$1.3 trillion in \$1.8 trillion out "Country comparison: stock of direct foreign investment - at home." CIA World Factbook. 2012
Fuel Use	UK Environmental Accounts, 2013 Fuel use of 193.6 Million tonnes of oil equivalent (Mtoe) in 2011 is the lowest since the series began in 1990. In 2011 fuel use was 9.3% lower than in 1990 and 7.7% lower than in 2010. Greenhouse gas emissions in 2011 were at their lowest level at 634.8 million tonnes of carbon dioxide equivalent, 21.3% lower than when the series began in 1990. In 2012 the UK government received £44.5 billion from environmental taxes, equivalent to 2.9% of Gross Domestic Product.

Figure 20 – UK Innovation Performance

	EU27	UK
ENABLERS		
Human resources		
1.1.1 New doctorate graduates	1.4	2.1
1.1.2 Population completed tertiary education	32.3	41.5
1.1.3 Youth with upper secondary level education	78.6	79.3
Open, excellent and attractive research systems		
1.2.1 International scientific co-publications	266	841
1.2.2 Scientific publications among top 10% most cited	0.11	0.13
1.2.3 Non-EU doctorate students	19.45	35.85
Finance and support		
1.3.1 Public R&D expenditure	0.75	0.67
1.3.2 Venture capital	0.110	0.263
FIRM ACTIVITIES		
Firm investments		
2.1.1 Business R&D expenditure	1.25	1.16
2.1.2 Non-R&D innovation expenditure	0.71	N/A
Linkages & entrepreneurship		
2.2.1 SMEs innovating in-house	30.31	N/A
2.2.2 Innovative SMEs collaborating with others	11.16	24.98
2.2.3 Public-private co-publications	36.2	61.7
Intellectual Assets		
2.3.1 PCT patent applications	4.00	3.51
2.3.2 PCT patent applications in societal challenges	0.64	0.73
2.3.3 Community trademarks	5.41	4.74
2.3.4 Community designs	4.75	2.35
OUTPUTS		
Innovators		
3.1.1 SMEs introducing product or process innovations	34.18	25.10
3.1.2 SMEs introducing marketing/organisational innovations	39.09	31.06
Economic effects		
3.2.1 Employment in knowledge-intensive activities	13.03	16.69
3.2.2 Medium and high-tech product exports	47.36	51.85
3.2.3 Knowledge-intensive services exports	49.43	67.97
3.2.4 Sales of new to market and new to firm innovations	13.26	7.31
3.2.5 Licence and patent revenues from abroad	0.21	0.59

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