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ERAWATCH Country Report 2008
An assessment of research system and policies

United Kingdom

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ERAWATCH
COUNTRY REPORT 2008
An assessment of research system and policies
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Executive Summary

Research-related policies aimed at increasing investment in knowledge and strengthening the innovation capacity of the EU economy are at the heart of the Lisbon Strategy. The strategy reflects this in guideline No. 7 of the Integrated Guidelines for Growth and Jobs which aims to increase and improve investment in research and development, in particular in the private sector. The report aims at supporting the mutual learning process and the monitoring of Member States efforts. The main objective is to characterise and assess the performance of the national research system of the United Kingdom and related policies in a structured manner that is comparable across countries. In order to do so, the system analysis focuses on key processes relevant for system performance. Four policy-relevant domains of the research system are distinguished, namely resource mobilisation, knowledge demand, knowledge production and knowledge circulation. This report is based on a synthesis of information from the ERAWATCH Research Inventory and other important available information sources.

Over the last twenty years or so, the UK research system and its associated policies has become increasingly integrated into the governance of the broader innovation system, characterised by a strong focus on the processes of review and evaluation in the formulation of policy. A consequence has been recognition of the pivotal role of research in national innovation performance and a strong long-term strategic orientation for research policy.

The main results of the analysis are summarised in the tables below:

Domain	Challenge	Assessment of strengths and weaknesses
Resource mobilisation	Justifying resource provision for research activities	Coordinated long term S&T policy framework with associated budgetary process
	Securing long term investment in research	Public sector spending on R&D has generally increased over last decade but business investment in R&D relative to GDP remains consistently low
	Dealing with barriers to private R&D investment	Range of policies in place, coordinated and led by new Technology Strategy Board
	Providing qualified human resources	Increasing overall supply of STEM skills although overall skill levels of population exhibit lags compared to international leaders and there are concerns over numbers of graduates in certain key S&T disciplines
Knowledge demand	Identifying the drivers of knowledge demand	Variety of sources and processes used to assess and address the demand for knowledge
	Co-ordination and channelling knowledge demands	Coordinated long term S&T policy framework and strengthened public engagement
	Monitoring of demand fulfilment	Increased exploitation of publicly funded research, some successful high tech sectors and a sizeable population of high tech SMEs; Strong non technology based innovation in high value added sectors but low demand for university-industry interactions in knowledge transfer and exploitation (cf. competitors) and limited technology diffusion from the research base

Domain	Challenge	Assessment of strengths and weaknesses
Knowledge production	Ensuring quality and excellence of knowledge production	Scientific quality of science base high: strong performance and world ranking in research outputs (publications and citations) UK tends to have proportionately fewer researchers in workforce (UK is sixth in G7), with little change over the last decade Significant minority of non-innovating businesses
	Ensuring exploitability of knowledge	Use of and competence in the evaluation and review, including excellence based funding allocation Rate of business start-up and SME growth still lag behind US Variability in innovation performance and capability across the UK regions
Knowledge circulation	Facilitating circulation between university, PRO and business sectors	Comprehensive and long-term policy mix to stimulate knowledge transfer Positive trends in knowledge transfer indicators from science base to private sector Success story of UK science parks
	Profiting from international knowledge	Strong, central strategy for international R&D activities Open economy, attractive to FDI and high level of foreign participation by UK researchers
	Enhancing absorptive capacity of knowledge users	Persistent shortcomings in business skills base and general poor demand for skills Poor innovation management skills in majority of business sector There is still a gap between research performance and its translation into commercially competitive products, processes and services

In terms of the mobilisation of resources, a key strength of the UK research system is the core policy emphasis on maintaining and enhancing the high quality of the UK science base, as well as promoting its role in providing both a rich source of innovation potential and a supply of human resources. The UK's public system of funding research at universities, based on the dual support system with the competitive allocation of funds both to institutions and researchers, can also be highlighted as a strength. This is in a general policy context of long term policy planning, backed up by long term funding commitments. In the private sector, particular areas of strength include high levels of R&D in pharmaceuticals and aerospace, and, more generally, the mobilisation of foreign research investments. Overall, however, the relatively low research intensity of business R&D is a perceived weakness.

In the articulation of demand, the comprehensive process of review, monitoring progress and the role and value of evaluation contribute to long term policy planning. While complex, the incorporation of stakeholder views across government, industry and academia provides a sound basis for policy decisions.

The quality of knowledge production by the UK science base is an evident strength, as is the Government commitment to build on these strengths. One of the UK's relative weaknesses is, however, in the circulation of knowledge and the translation of this potential into the market. Transfer of knowledge from the science base, however, does benefit from a high position on the policy agenda and from increasing orientation towards collaborative R&D and innovation. This builds on the generally strong international outlook of the UK science base, both in terms of collaboration and education and research training.

While aspects of the UK system have already been highlighted above as strengths, the current long-term policy framework can also be seen as providing opportunities across all four domains of the current report's analytical framework, identifying and addressing challenges.

Domain	**Main policy opportunities**	**Main policy-related risks**
Resource mobilisation	Good identification of resource mobilisation issues and challenges Promoting attractiveness of UK to foreign researchers and foreign corporate investors	Unstable global macro-economic conditions which may impact research and innovation budgets
Knowledge demand	Strategic identification of issues and challenges in a long term perspective Role of Technology Strategy Board	Significant minority of non-innovating businesses
Knowledge production	Policy emphasis on the sustained renovation of research infrastructure Close monitoring of the social and economic impacts of research Development of innovation potential and scope to build on the strength of the science and engineering base	Introduction of Full Economic Costs may discourage industry spending in higher education sector Uncertainty over long-term supply of human resources for science and technology in key strategic areas
Knowledge circulation	Establishment of and enhanced role for Technology Strategy Board Rationalisation of Research Evaluation Framework metrics to include knowledge transfer objectives	Policy focus on UK attractiveness could lead to dependence on high level of (potentially ephemeral) FDI

As an example of policy-related risks, the current policy context which encourages inward private R&D investment might strengthen the relatively high dependence on FDI in research in the UK. This may have an erosive effect on the UK's domestic competences and identity.

Finally, with regard to the system and policy dynamics from the perspective of the ERA, in general policy terms, the UK is supportive of various EU research developments, including the development of the ERA, whilst also seeking to direct these in order to ensure their optimal performance. UK participation in all the EU research funding frameworks is strongly supported and is matched by good levels of participation by UK public sector researchers (notably from HEIs) although business participation is somewhat disappointing in comparison with similar sized EU neighbours. Broadly speaking, UK policies in the areas covered by this report tend to be fully consistent with the relevant Integrated Guidelines of the Lisbon Treaty.

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1 - Introduction and overview of analytical framework

1.1 Scope and methodology of the report in the context of the renewed Lisbon Strategy and the European Research Area

As highlighted by the Lisbon Strategy, knowledge accumulated through investment in R&D, innovation and education is a key driver of long-term growth. Research-related policies aimed at increasing investment in knowledge and strengthening the innovation capacity of the EU economy are at the heart of the Lisbon Strategy. The strategy reflects this in guideline No. 7 of the Integrated Guidelines for Growth and Jobs. This aims to increase and improve investment in research and development (R&D), with a particular focus on the private sector. One task within ERAWATCH is to produce analytical country reports to support the mutual learning process and the monitoring of Member States' efforts.

The main objective is to analyse the performance of national research systems and related policies in a comparable manner. The desired result is an evidence-based and horizontally comparable assessment of strength and weaknesses and policy-related opportunities and risks. A particular consideration in the analysis is given to elements of Europeanisation in the governance of national research systems in the framework of the European Research Area, relaunched with the ERA Green Paper of the Commission in April 2007.

To ensure comparability across countries, a dual level analytical framework has been developed. On the *first level*, the analysis focuses on key processes relevant to system performance in four policy-relevant domains of the research system:

1. Resource mobilisation: the actors and institutions of the research system have to ensure and justify that adequate public and private financial and human resources are most appropriately mobilised for the operation of the system.
2. Knowledge demand: needs for knowledge have to be identified and governance mechanisms have to determine how these requirements can be met, setting priorities for the use of resources.
3. Knowledge production: the creation and development of scientific and technological knowledge is clearly the fundamental role of a research system.
4. Knowledge circulation: ensuring appropriate flows and distribution of knowledge between actors is vital for its further use in economy and society or as the basis for subsequent advances in knowledge production.

These four domains differ in terms of the scope they offer for governance and policy intervention. Governance issues are therefore treated not as a separate domain but as an integral part of each domain analysis.

Figure 1: Domains and generic challenges of research systems

Resource mobilisation	Knowledge demand	Knowledge production	Knowledge circulation
• Justifying resource provision • Long term research investment • Barriers to private R&D funding • Qualified human resources	• Identification of knowledge demand drivers • Co-ordination of knowledge demands • Monitoring of demand fulfilment	• Quality and excellence of knowledge production • Exploitability of knowledge production	• Knowledge circulation between university, PRO and business sectors • International knowledge access • Absorptive capacity

On the *second* level, the analysis within each domain is guided by a set of generic "challenges" common to all research systems that reflect conceptions of possible bottlenecks, system failures and market failures (see figure 1). The way in which a specific research system responds to these generic challenges is an important guide for government action. The analytical focus on processes instead of structures is conducive to a dynamic perspective, helps to deal with the considerable institutional diversity observed, and eases the transition from analysis to assessment. Actors, institutions and the interplay between them enter the analysis in terms of how they contribute to system performance in the four domains.

Based on this framework, analysis in each domain proceeds in the following five steps. The first step is to analyse the current situation of the research system with regard to the challenges. The second step in the analysis aims at an evidence-based assessment of the strengths and weaknesses with regard to the challenges. The third step is to analyse recent changes in policy and governance in perspective of the results of the strengths and weaknesses part of the analysis. The fourth step focuses on an evidence-based assessment of policy-related risks and opportunities with respect to the analysis under 3) and in the light of Integrated Guideline 7; and finally the fifth step aims at a brief analysis of the role of the ERA dimension.

This report is based on a synthesis of information from the European Commission's ERAWATCH Research Inventory[1] and other important publicly available information sources. In order to enable a proper understanding of the research system, the approach taken is mainly qualitative. Quantitative information and indicators are used, where appropriate, to support the analysis.

After an introductory overview of the structure of the national research system and its governance, chapter 2 analyses resource mobilisation for R&D. Chapter 3 looks at knowledge demand. Chapter 4 focuses on knowledge production and chapter 5 deals with knowledge circulation. Each of these chapters contains five main subsections in correspondence with the five steps of the analysis. The report concludes in chapter 6 with an overall assessment of strengths and weaknesses of the research system and governance and policy dynamics, opportunities and risks across all four domains in the light of the Lisbon Strategy's goals.

[1] ERAWATCH is a cooperative undertaking between DG Research and DG Joint Research Centre and is implemented by the IPTS. The ERAWATCH Research Inventory is accessible at http://cordis.europa.eu/erawatch/index.cfm?fuseaction=ri.home. Other sources are explicitly referenced.

1.2 Overview of the structure of the national research system and its governance

The United Kingdom research system comprises three main types of actor: policy bodies, research funders and research performers, with certain actors combining these functions (see Figure 1 below).

The last 20 or so years have witnessed the evolution of UK S&T policy into an innovation policy, with S&T issues increasingly integrated into the broader national system of innovation. Following the appointment of Gordon Brown as Prime Minister in June 2007, the role of science in innovation has been given further emphasis, with the disbandment of the DTI and the transfer of many of its functions, including responsibilities for science and innovation, to a new Department for Innovation, Universities and Skills (DIUS). DIUS also has responsibility for further and higher education and skills. DIUS also works closely with the new Department for Business, Enterprise and Regulatory Reform (BERR), which assumed other functions of the former DTI. DIUS now plays the lead executive role in research issues, and is the home of the recently created Government Office for Science (GO-Science), which replaced the former Office of Science and Innovation (OSI) located in the DTI. GO-Science is headed by the Government's Chief Scientific Adviser (CSA) and plays the lead role in improving the quality of science in the UK. The CSA reports directly to the Prime Minister and the Cabinet.

The CSA also chairs the principal high-level national policy making and coordination body, the Council for Science and Technology, which in turn draws on policy advice from a range of bodies both within and outside the Government structure, including dedicated committees in both the upper and lower houses of Parliament. High-level UK science policy making also places particular emphasis on the use of systemic reviews and evaluations.

DIUS is the major provider of research funds for the public sector, with the Director General, Science and Innovation (DGSI) within the DIUS responsible for the allocation of the UK Science Budget. In particular, the Science Budget provides funds for the seven Research Councils, which in turn support R&D both in HEIs and in their own institutions with a total annual budget approaching €5b. These provide research grants both for projects and for research students. In addition, they fund research facilities in the UK and abroad for researchers, investing around 60% of their annual budget (€2b) in research in UK universities.

The Research Councils are organised on a broad disciplinary basis, each with its specific separate identity. Using a range of flexible funding mechanisms, they support a highly diversified portfolio of research, comprising the full spectrum of academic disciplines. Research funded ranges from basic, blue skies investigator-led research, through longer-term strategic research, observation and survey, to more applied research activities. Funds are awarded to UK universities, the Research Councils' own institutes, other PSREs and independent research organisations in the form of research grants, based on independent, expert peer review. Each Research Council sets out its research priorities in a strategic plan, developed through extensive consultation with both the academic community and a wide range of users and stakeholders, from Government Departments, industry, the wider public sector and the public more generally. Established as a strategic and equal partnership between the seven Research Councils, Research Councils UK, oversees and coordinates their work.

The UK government provides support to research and innovation activities in the private sector through a number of mechanisms, including tax credits for R&D investment administered via the Treasury, and the work of the Technology Strategy Board (TSB), which has responsibility for the formulation and delivery of the national technology strategy. The TSB was established with the aim of ensuring that the promotion of technology and innovation in business is led by business itself. The TSB operates at "arm's length" from the government as a non-Departmental government body. Its current focus is the translation of knowledge into innovation and new and improved products and services. It is sponsored by DIUS and, in 2007, targeted funding of €275m to support technology and innovation, largely through collaborative work between businesses or between businesses and academia. The TSB's budget allocation (without the contribution of partners) is expected to reach approximately €310m in 2010/11 (~35% increase). On the whole, the budget of TSB for 2008-2011 is around €850m, plus aligned funding of €210m from the Regional Development Agencies and a minimum of €140m from the Research Councils. According to the 2007 CSR, the overall budget that TSB will coordinate will reach around €1.25b during the period 2008-2011, including contributions from the Devolved Administrations and Government Departments.

Other Ministries and Departments, particularly the Department for Environment, Food and Rural Affairs (DEFRA), the Ministry of Defence and the Department of Health, also have significant research portfolios within their areas of responsibility, and commission R&D through their own laboratories and institutes (or, in many cases, their former institutes which are now privatised or have intermediate agency status).

The main actors in the performance of UK public sector research are the Higher Education Institutes, most of which are universities. The major part of their research funding is provided in the form of grants from the Research Councils, awarded to individual researchers as well as to longer running programmes, units and centres. Other funds, including research funding, in England, Wales and Scotland are provided by DIUS through dedicated non-departmental funding councils. In Northern Ireland, funding for research comes directly from the Department for Employment and Learning, Northern Ireland (DEL or DELNI).

The private sector is both a major funder and performer of R&D. In 2004, the sector's total expenditure on R&D amounted to some €18.9b, including just under €3b on defence. Just over 10% (€1.97b) of this came from Government sources and 23% from overseas sources. However, the majority – 66% (€12.5b) – came from within the private sector itself.

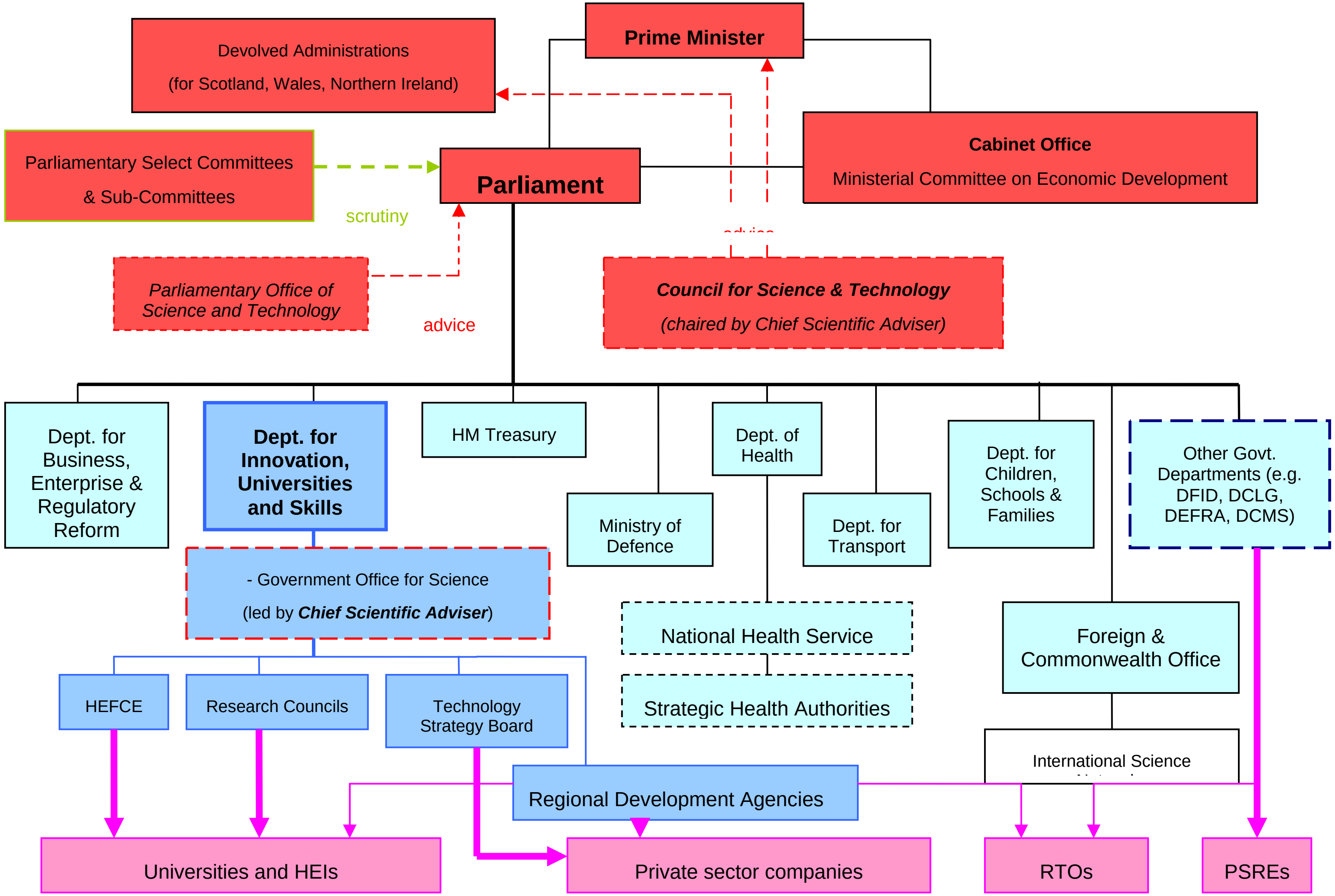
The private non-profit sector is also a significant actor in both the funding and performance of R&D. In 2004, it contributed over €1.5b in research expenditure and performed €759m worth of R&D activities. It is composed of a range of foundations and charities, the largest of which are in the medical and health sector. These charities make a substantial contribution to medical research in the UK, over €1b per year. The Wellcome Trust is the major funder of research in the medical and health sector in the UK (annual spend €800m), and is one of the largest charitable foundations in the world, supporting clinical and basic scientific research in biomedical science and the history of medicine. In terms of annual volume of research expenditure, the four next largest, foundations and charities are: Cancer

Research UK (€300m), the British Heart Foundation (€140m), the Arthritis Research Campaign (€26m) and the Nuffield Foundation (€16m).

The UK comprises nine English Regions and three Devolved Administrations (Scotland, Wales and Northern Ireland) all categorised at the NUTS 1 level. Regional coordination of science and research is closely linked to that of innovation at the regional level. BERR is aiming to build the capability of regions, with emphasis on regional growth, strengthening the building blocks for economic success and boosting regional capacity for innovation and enterprise. The Government's Ten-Year Science and Innovation Investment Framework (2004-2014), includes the aim of developing closer working relationships between the regions and central Government departments in order to ensure the best use of resources at national and regional level. Consequently, certain elements of Government funding are now being managed at the regional level to ensure that business support for innovation, and access to relevant expertise, is tailored to the individual needs of local, innovative businesses.

Recent significant developments in UK innovation policy (within which research policy is closely integrated) include a review of the UK innovation system conducted by the former Science Minister, Lord Sainsbury, in 2007 (HM Treasury, 2007) together with the Government’s March 2008 Innovation White Paper (DIUS, 2008b) and its accompanying Background Report (DIUS 2008a).

Figure 2: Structure of the research system of the United Kingdom



Source: ERAWATCH Research Inventory 2008, Structure of the Research System

2 - Resource mobilisation

The purpose of this chapter is to analyse and assess how challenges related to the provision of inputs for research activities are addressed by the national research system. Its actors have to ensure and justify that adequate financial and human resources are most appropriately mobilised for the operation of the system. A central issue in this domain is the long time horizon required until the effects of the mobilisation become visible. Increasing system performance in this domain is a focal point of the Lisbon Strategy, with the Barcelona EU overall objective of a R&D investment of 3% of GDP and an appropriate public/private split as orientation, but also highlighting the need for a sufficient supply of qualified researchers.

Four different challenges in the domain of resource mobilisation for research which need to be addressed appropriately by the research system can be distinguished:

- Justifying resource provision for research activities;
- Securing long term investment in research;
- Dealing with uncertain returns and other barriers to private R&D investment; and
- Providing qualified human resources.

2.1 Analysis of system characteristics

In 2006, the UK spent €33.14b on R&D[2]. R&D intensity, measured as R&D expenditure (GERD) as a percentage of GDP is 1.78% (2006)[3], which falls just below the EU average of 1.84%. It has fluctuated around this level for more than a decade. The share financed from abroad is significant, at 17.0% (2006), while the UK contributes 15.9% of the aggregate EU 27 R&D expenditure (2006).

The UK Government takes the view that adequate levels of investment from both the public and private sector are required to sustain a well-functioning R&D system, which is seen as a vital component of the national research and innovation system and fundamental to national competitiveness. Therefore, the main lines of government support for research have shifted away from more traditional disciplinary lines to the constituent and contributory processes of innovation and include:

- the promotion of linkages between higher education and industry and the flow of research ideas from the Science Base into the commercial environment.
- support for Science Base infrastructure
- maintaining an appropriately skilled and educated workforce
- promotion of linkages at the regional level and with specific communities

2.1.1 Justifying resource provision for research activities

The UK Government's main objectives concerning R&D policy are an integral part of its broader policy on innovation. These objectives are most recently set out in its

[2] Office of national Statistics: http://www.statistics.gov.uk/STATBASE
[3] If not referenced otherwise, all quantitative indicators are based on Eurostat data.

"Science and Innovation Investment Framework 2004-14", which formed the outcome of an extensive consultation exercise launched in March 2004. According to this document, the Government's overall long-term objective for the UK economy is to increase the level of knowledge intensity (expressed as R&D as a percentage of GDP) from its current level of around 1.9% to 2.5% by around 2014.

In the context of increasing R&D intensity, the UK Government's priorities may thus be summarised as:

- Promoting HEI-industry and public laboratory-industry linkages through a range of measures
- Continued support for the Science Base infrastructure
- Promotion of linkages at the regional level and with specific communities
- Promotion of the flow of research results and ideas from the Science Base into the commercial environment.

The UK's policy mix in support of research has been strongly shaped by a set of governance practices involving review, evaluation and assessment. This operates within a broader three-year Government-wide, Comprehensive Review process and is tied to performance targets set by the Treasury (Public Service Agreements), and is reinforced by the setting of verifiable objectives and milestones, with regular performance reviews. Consequently, it may be stated that the current policy mix addresses the major challenges faced by the research system.

One challenge addressed in the Framework is to build confidence and increase awareness across UK society in scientific research and its innovative applications. It seeks to demonstrate improved public awareness of science against a variety of measures, such as trends in public attitudes, public confidence, media coverage, and the responsiveness to public concerns of both policy-makers and scientists.

2.1.2 Securing long term investment in research

UK Government funding, across all ministries, is allocated through the Comprehensive Spending Review (CSR). Conducted every three years, the CSR sets firm and fixed three-year Departmental Expenditure Limits and defines the key improvements that the public can expect from these resources. Providing longer-term stability for expenditure planning by public bodies, this mechanism ensures that public money is being spent, efficiently and effectively, according to defined priorities. Public Service Agreements (PSAs) were introduced with the 1998 CSR to set performance targets, leading to improvements in service delivery and outcomes. The CSR applies to all funding, not just that for R&D or S&T purposes although funding in these areas is also subject to broad PSAs.

The Ten-Year Framework was published alongside the 2004 CSR. It aims to ensure sustainability in research funding accompanied by demonstration by universities and public laboratories of robust financial management to achieve sustainable levels of research activity and investment. In the Framework, the UK Government has adopted a long-term perspective on research investment within the UK economy, with science and technology a high spending priority (HM Treasury *et al.* 2006). The Framework sets out the Government's long-term funding commitments for research and provides a stable long-term strategy. Progress is assessed according to milestones and targets on an annual basis, with published annual reports highlighting areas for policy action.

Since 1997, the Government science budget has more than doubled and is currently around €5.5b[4]. UK government funding is split between government departments, the Higher Education Funding Councils (which provide block grant funding to UK universities) and the Research Councils (which fund research, again largely in universities and in their own in-house institutes). Almost half of government funded R&D is currently performed in the higher education sector and 20% by the private sector. Of the total amount of GERD in 2006, 33% was funded by the public sector (including higher education), and 45% by the business enterprise sector. In terms of the execution of research, the business sector accounted for 62% of GERD and the public sector for 34% (the majority - 24% - in the higher education sector). In 2006, GBAORD as a percentage of GDP stood at 0.74, slightly below the EU25 average of 0.76, having fluctuated around this level over the past five years between 0.68 in 2001 and 0.77 in 2002.

In the 2004 CSR, an additional €1b funding was allocated for the Science Base until 2007, including dedicated capital funding for the renewal of university infrastructure. This built on the response to concerns in the late 1990s on the declining quality of the UK research infrastructure in the HE sector, which had resulted from a long-term under-investment, and the subsequent launch of the Science Research Investment Fund (SRIF) to support university research infrastructure and Research Council Institutes. More recently, the SRIF programme (viewed as a temporary measure) has been replaced by a permanent capital funding stream – the Research Capital Investment Fund. In addition, progress has been made towards the introduction of a new methodology for costing research and to ensuring that research funders (notably the Research Councils) pay a greater proportion (now 80%) of the full economic costs (FEC) of research. The 2004 CSR also included a €104m Strategic Fund to provide more targeted support for energy and clinical research, which has been taken through, for example, by the creation of the Energy Technologies Institute and Research Council programmes. The 2007 CSR continues to underpin this investment, with a planned 2.7% real terms increase over the three-year period covered.

2.1.3 Dealing with uncertain returns and other barriers to business R&D investment

The UK Office of National Statistics[5] estimates indicate that some 11,000 companies are engaged in R&D in the UK. In 2006, UK BERD stood at 1.1% of GDP, a ratio that had been in gradual decline for more than a decade, although this has levelled out in recent years. In 2006, total expenditure on R&D performed within UK enterprises was around €20b, an increase of 7% on the previous year. According to the 2007 DIUS (formerly DTI) R&D Scoreboard[6], the proportion of UK companies with R&D

[4] £3.451 billion in 2007-08: currency fluctuations during 2008 preclude precise conversions.

[5] In April 2008, the Office of National Statistics was replaced by the UK Statistics Authority, an independent body accountable to Parliament.

[6] The UK Government monitors business R&D activity, with the aim of benchmarking the performance of UK companies against the best in the world. The annual Scoreboard examines expenditures on R&D and capital equipment for 1,250 companies from abroad and 850 from the UK, and presents a series of analyses.

above €5m and with high R&D intensity (above 10%) is rising and is significantly above that of the rest of the EU although still below the USA. In 2006 (Office of National Statistics), 61% of BERD was financed by industry itself.

Almost one quarter (23%) of business sector research funding comes from abroad. The Scoreboard also notes the significant role of multinational investment in the UK, with the top ten foreign–owned UK companies accounting for just over half of the €7b (i.e. one-third of the total) R&D performed by foreign–owned UK companies. Eight of the 2006 top ten UK companies have higher R&D intensities than their overseas parents, which emphasises the advantages of the UK as a location for corporate R&D activities. In 2006, around 8% of UK BERD was accounted for by businesses with fewer than 100 employees, 31% by firms with less than 1000 employees and only 18% by firms with 5000 or more employees. More generally, SMEs represent a very important part of the UK economy (particularly in the services sector) and account for half of total employment and turnover in the UK.

Among its targets for research investment, the Ten-Year Investment Framework includes increased business investment in R&D, together with increased business engagement with the UK science base as a key source of ideas and talent. The UK government operates a grant scheme for R&D in small and medium sized firms, although the main emphasis is on the use of indirect measures to promote and stimulate civil industrial R&D. However, Government funding for defence-related R&D does constitute a considerable proportion of UK GOVERD (almost 50% of total government R&D expenditure).

The UK Government's general approach to promoting private sector investment is to maintain a stable macroeconomic environment and to remove microeconomic barriers that prevent the market from functioning properly. UK Government enterprise policy has, in recent years, focused on increasing the incentives for and removing the obstacles to entrepreneurial activities and promoting an enterprise culture more generally.

The UK exhibits relatively low administrative burdens for businesses and has low start up costs. Its capital markets are relatively well-developed. Access to debt finance and total private equity funds invested in the UK have increased over the last decade, although venture capital remains relatively difficult for early-stage businesses to obtain. The Government has made significant progress in creating one-stop-shops for business start-ups and support services, as well as in improving SMEs' access to public procurement contracts. Strengths in entrepreneurship training and in improving regulation for small businesses have been reinforced, and the UK is committed to reduce administrative burdens by 25%. The aim of the Business Support Simplification Programme (BSSP) is to make it easier for companies and entrepreneurs to understand and access government funding and advice to help start and grow their business. The aim is to reduce the current 3,000 plus schemes to around 100 by 2010[7].

Tax incentives for start-up firms, including for R&D activities, have also increased the incentives to start new businesses, together with improvements to the regulatory environment. Initiatives to reduce barriers to enterprise have focused primarily on access to finance, especially for early-stage businesses. In 2000, the Government

[7] Malik, K., Gagliardi, D. and Cunningham, P. INNO-Policy TrendChart - Policy Trends and Appraisal Report, United Kingdom 2008, August 2008.

introduced an R&D tax credit for SMEs, extending the scheme to large companies two years later. The aim of the scheme is to encourage greater R&D spending. The 2007 Budget announced an increase in the rates of the relief from 150 to 175% for SMEs, and from 125 to 130% for large companies to take effect from April 2008. The 2007 Finance Act included legislation to extend the SME scheme to companies with up to 500 employees, also subject to EU approval. The scheme has shown strong take-up with over 22,000 claims received by early 2006 – around 19,000 under the SME scheme and 3,000 under the large companies' scheme - amounting to a total of around €2.6b of support claimed. Recent figures show that over 4,800 small firms claimed the small firms R&D Tax Credit in 2005/6 (DIUS, 2008a).

Among the schemes improving access to finance, the Small Firms Loan Guarantee (SFLG), which has recently been modified to ensure that support is provided to the newest businesses, guarantees loans from the banks and other financial institutions for small firms that have viable business proposals but lack security. Planned changes will increase the amount of lending available by €80m to a total of €480m providing greater SFLG capacity at a time when the provision of debt finance to young and growing SMEs needs to be strengthened due to financial market disruption. Eligibility will also be extended to businesses with growth ambitions that are more than five years old.

2.1.4 Providing qualified human resources

The Ten-Year Investment Framework has among its targets "a strong supply of scientists, engineers and technologists." In particular, the following are targeted for increases and improvements:

- The quality of science teachers and lecturers across the educational system;
- The results for students studying science at GCSE level (16 years old);
- The numbers choosing SET subjects in post-16 education and in higher education;
- The proportion of better qualified students pursuing R&D careers; and
- The proportion of ethnic minority and women participants in higher education.

The UK performs well in terms of inward student and graduate mobility, attracting a high number of foreign-born students, particularly in terms of their participation in advanced research programmes. In 2004/05, just over half (52%) of masters students were non-UK domiciled, the proportions being 39% for doctorates and 12% for first degrees (Royal Society, 2008). High numbers of highly qualified UK-educated people are resident in other OECD countries. This reflects the quality and attractiveness of the UK education system but also implies an outward flow of high-level human resources. Moreover, there is no guarantee that a significant number of the foreign-born researchers will not become a ‘foot-loose’ resource and eventually return to their country of origin or other countries.

Over the past decade, participation of UK-domiciled students in higher education has increased significantly as part of a longer-term trend. The current higher education initial participation rate is 43% (DIUS, 2008a). Less than half of UK graduates in engineering and physical sciences go on to pursue science related careers, including research and there are strong concerns that the demand for qualified researchers, in both academia and industry, will not be met by the supply. However, graduate numbers in STEM (Science, Technology, Engineering and Mathematics) disciplines have increased overall in recent years. In 2005/06 about 42% of all first degrees were in STEM subjects, a proportion that has been relatively stable, although the pattern has not been uniform across all subjects (DIUS, 2008a). Since 2002/03 there have been falling graduate numbers in chemistry and computer science, while some universities have met with difficulties in attracting sufficient numbers of students in subjects such as physics and chemistry and have been forced to merge, and even close, relevant departments. A report by the University College Union revealed that 10% of science and maths university courses have been discontinued over the last decade, while some 70 UK university science departments have closed over the last seven years. In order to deal with strategically important research areas that have been identified as 'at risk', the Government has launched the Science and Innovation Awards scheme to fund research staff. However, the situation is unclear and prone to fluctuations – recent data on "A Levels" (the normal prerequisite for university entrance) taken for England show an upward movement in a number of STEM disciplines (e.g. mathematics and chemistry) (DIUS, 2008a).

It might also be argued that a declining intake of science students, and thus the eventual supply of trained researchers could be indicative of a lack of job opportunities in R&D activities and of more attractive opportunities elsewhere, not least in the finance sector, particularly as large numbers of science graduates seem to find the rewards of jobs in the UK's financial institutions more attractive than those from a career in research (Cunningham, 2007a). Indeed, such an influx of highly qualified graduates may form a contributory factor in the international success of the UK's financial services sector.

Increased efforts to engage the wider society in scientific debate and issues have also been undertaken. For example, a 2005 MORI survey showed that 86% of adults believe that science contributes in a positive way to society and 82% of adults think that science will make our lives easier. However, only 14% of the public trust government scientists to provide accurate information about scientific facts. The 2007 survey on public attitudes to science, commissioned by DIUS Research Councils UK, reported in early 2008[8]. Overall results showed that public attitudes towards and confidence in science had increased along with the percentage of respondents who felt well informed about science issues. In addition, the number of Government policy issues serving as the basis for news stories increased by 5% between 2004 and 2006 and there was a significant increase in science and technology stories between 2004 and 2006. Nearly two thirds of the sample stories (64%) occurred in 2006, amounting to a 78% increase in the volume of stories (DIUS, 2007).

2.2 Assessment of strengths and weaknesses

The UK's formulation of and commitment to a long-term strategy for science and technology is clearly the most notable development in recent UK science and technology policy. It builds on a thorough review of the UK S&T landscape, including the associated policy mechanisms. Clear identification of the issues and challenges represents a considerable opportunity, and steps towards meeting these challenges are articulated.

8 http://www.rcuk.ac.uk/cmsweb/downloads/rcuk/scisoc/pas08guide.pdf

While setting long-term trajectories, the Science and Innovation Investment Framework also incorporates a degree of flexibility, in line with robust procedures for the monitoring and analysis of progress against targets. These reflect the UK's emphasis on the utility of evaluation and review in policymaking. It seeks to build on existing identified strengths, such as the already high scientific quality of the UK science base (and a commitment to sustained funding to support it, together with targeted funding to address STEM skills) but balances them against the relative weaknesses in UK resource mobilisation, such as relatively low levels of business R&D expenditure, the enduring (but diminishing) effects of protracted under-investment in scientific infrastructure, and concerns over human resource supply issues, particularly in relation to specific disciplines and skills.

To date, the review of progress in the implementation of policy has indicated steps towards further reinforcing areas of strength, such as scientific excellence, as well as addressing the perceived weaknesses, such as investment in S&T/research infrastructure. UK universities perform well in a range of international league tables and comparisons, and participation in higher education appears to be rising as do levels of STEM qualifications.

The main strengths and weaknesses of the UK research system in terms of resource mobilisation for R&D can be summarised as follows:

Main strengths	Main weaknesses
• Coordinated long term S&T policy framework with associated budgetary process • General increase in public sector spending on R&D over last decade • Strengthened public engagement • Increasing overall supply of STEM skills	• Relatively low business investment in R&D relative to GDP • Overall skill levels of population exhibit lags compared to international leaders • Concerns over numbers of graduates in certain key disciplines

2.3 Analysis of recent policy changes

The Science and Innovation Investment Framework provides a long-term policy context for the prioritisation of expenditure on science and technology. However, formal annual reviews enable changes and adaptations to be made in line with progress, measured against a series of indicators. So far, working within the Framework, these adaptations have been oriented towards improving the ways in which policy objectives are realised.

The framework seeks to retain a degree of flexibility to ensure a balance between bottom-up responsive research and top-down strategic direction. Therefore, research goals and priorities are likely to change in response to developments in knowledge, technologies and strategic economic and social needs. Through the Spending Review process, UK research funding is under continuous review, while seeking to maintain the strength of the research base in all key disciplines.

The third Annual Report, published in 2007 (HM Treasury and DIUS, 2007), notes further good progress in implementing the programme. The UK continues to maintain its international standing in scientific excellence while the historical lack of capital investment in research infrastructure is successfully being addressed. Knowledge transfer and commercialisation of results from the science base continue to display a positive trend, as evidenced by increases in licensing and consultancy income and the number of spin-outs. Business investment in R&D is growing in real terms and is keeping pace with growth in GDP, although the 2007 report notes the need for continued rapid growth to meet the long-term ambitions set out in the Ten-Year Framework. Further enhancement to UK innovation performance is expected from the TSB.

In May 2007, the Government reported on efforts to better measure the economic impacts of investment in research and innovation and the health of the system used to deliver economic impacts using a set of categories and influence factors that now comprise the new UK economic impact reporting framework (OSI, 2007). These include: Overall economic impacts; Innovation outcomes and outputs of firms and government; Knowledge generated by the research base; Investment in the research base and innovation.

In March 2008, the Government published its White Paper, *Innovation Nation* (DIUS, 2008). This builds on recommendations from the *Sainsbury Review of Science and Innovation* (October 2007), commissioned as part of the 2007 Comprehensive Spending Review, which emphasised that the best way for the UK to compete, in an era of globalisation, is to move into high-value goods, services and industries. *Innovation Nation* was accompanied by a report on progress towards implementing the 72 recommendations put forward in the *Sainsbury Review*[9]. In addition, the Government consulted over 600 businesses and business leaders to develop a better understanding of the challenges of building an enterprise economy, which resulted in the publication *'Enterprise: unlocking the UK's talent'* (March 2008). Of the policy actions outlined in *Innovation Nation*, the following are of particular relevance to the mobilisation of resources for research:

- NESTA (the National Endowment for Science, Technology and the Arts) will oversee the development of an 'Innovation Index' against which UK progress in innovation performance can be assessed;
- A new Innovation Research Centre is to be established, co-funded by DIUS, NESTA, ESRC, and the TSB;
- A framework has been developed for the further expansion of the HE sector (plus 20 new HE centres)
- DIUS will establish a National Skills Academy (NSA) in every major sector of the economy.
- DIUS will work to promote greater take-up of STEM subjects at all levels.
- DIUS will pilot a revenue based FE Specialisation and Innovation Fund to build the capacity of the FE sector businesses to raise their innovation potential.
- The Technology Strategy Board will bring forward five new Innovation Platforms over the next three years, including technology demonstrators to show innovative solutions in action.

Overall, the UK has undertaken a series of thorough reviews of the challenges facing the research system (as a key component of the broader national system of

[9] Department for Innovation, Universities and Skills. *Implementing 'The Race to the Top': the response to Lord Sainsbury's Review of Government's Science and Innovation Policies*, March 2008.

innovation) and has developed a comprehensive, long-term yet flexible approach to addressing these challenges. In this regard, there have not been significant policy changes; rather small-scale adjustments have been made within the context of the UK long-term Investment Framework.

Challenges	Main policy changes
Justifying resource provision for research activities	• Extensive systemic reviews such as Sainsbury Review • Aim to establish Innovation Index
Securing long term investments in research	• Extended support and remit for the TSB • Maintenance of long-term funding for science base
Dealing with uncertain returns and other barriers to business R&D investments	• Role of TSB • Skills academies
Providing qualified human resources	• Skills academies • Expansion of HE and FE sector capacities • Focus on STEM skills uptake at school level

2.4 Assessment of policy opportunities and risks

In the light of the Lisbon Strategy, the main opportunities and risks for resource mobilisation in the UK arising from recent policy responses can be summarised as follows:

Main policy opportunities	Main policy-related risk
• Good identification of resource mobilisations issues and challenges • Promoting attractiveness of UK to foreign researchers and foreign corporate investors	• Unstable global macro-economic conditions which may impact research and innovation budgets

As already noted the UK's well-embedded practice of review and evaluation provides a clear picture of resource needs and challenges which offers a firm basis for research policy governance. While further opportunities relate from efforts to promote the UK's attractiveness to foreign investment, particularly arising from its strong science base, and also its attractiveness as a place of study and research for foreign students, including postgraduates. However, unstable global and domestic market conditions (i.e. oil prices, the 'credit-crunch'), socio-political events all pose a risk to sustained levels of support to research policy goals, albeit outside the direct control of government.

2.5 Summary of the role of the ERA dimension

In general policy terms, the UK is supportive of various EU research developments, including the development of the ERA, whilst also seeking to direct these in order to ensure their optimal performance. The UK Government strongly encourages UK participation in all the EU research funding frameworks, on the basis of obtaining a maximal return on its EU payments and in order to ensure that the UK has a lead role, or at least a strong presence, in the governance of these initiatives.

More specifically, the UK Research Councils are involved in a wide range of ERA-NET activities (53 out of 94 in FP6) and projects with partners in the EU and other associated countries. Similarly, Government departments may also be involved in such activities. For example, DEFRA is involved in a number of ERA-Net activities with EU and other European countries, including co-ordination of projects on flood risk management, marine fisheries and phytosanitary (statutory plant health) research.

UK researchers are highly active participants in European research programmes, notably the Framework Programmes and EUREKA. Of a total science base expenditure of some €8.5m in 2003-04 about 8% originated from overseas: about half of this was from EU bodies. Figures from a review state that: UK organisations took part in 6,613 out of 16,251 (40.7%) projects funded under FP5 – a level of involvement higher than any other Member State. In addition, UK participants received a total of €2,047m of EC funding (16% of the total). Moreover, UK organisations coordinated 19% of all FP5 projects, again the highest share of any Member State. Most UK participations were undertaken by HEIs (46%) or by the UK enterprise sector (27%) and about half of the EC funding received by the UK went to HEIs, with just under a quarter going to the enterprise sector.

There is also strong support for JTIs, Article 169 actions and, under FP7, the European Technology Platforms, provided these are genuinely responsive, driven by end-user demands and funded on the basis of research quality. The UK also takes the position that collaboration is most often best driven as a bottom-up process.

3 - Knowledge demand

The purpose of this chapter is to analyse and assess how research related knowledge demand contributes to the performance of the national research system. It is concerned with the mechanisms to determine the most appropriate use of and targets for resource inputs.

The setting and implementation of priorities can lead to co-ordination problems. Monitoring processes identifying the extent to which demand requirements are met are necessary but difficult to implement effectively due to the characteristics of knowledge outputs. Main challenges in this domain are therefore:

- Identifying the drivers of knowledge demand;
- Co-ordinating and channelling knowledge demands; and
- Monitoring demand fulfilment

Responses to these challenges are of key importance for the more effective and efficient public expenditure on R&D targeted in Integrated Guideline 7 of the Lisbon Strategy.

3.1 Analysis of system characteristics

Looking at the sectoral structure of the UK economy in terms of BERD, the largest percentage share (over 40%) of R&D expenditure is in the high R&D-intensive sectors of Pharmaceuticals and Health. Another 16% is contributed by the Electronics and IT sectors and a further 8% by the Engineering and Chemicals sectors. However, the Pharmaceuticals sector represents less than 10% of UK industry's sales, which tend to be concentrated in low R&D-intensive sectors such as oil and gas production (40% UK sales), banking (12%), food retail (6%), mining (5%)

and mobile telecommunications (4%) (Bulli, 2008). Banking and food retail may be higher due to a possible under-reporting of activity in this area. Service industries account for 20% of BERD. In terms of BERD specialisation compared with the EU15 average, UK specialisations include financial services, aerospace, pharmaceuticals and petroleum.

Expenditure on defence R&D in the UK is also significant. The share of GERD used for defence objectives was almost 14% (in 2006). The Ministry of Defence is the leading government spender on defence-related research, and, as part of its programme of defence equipment procurement, has predominantly provided funds for experimental development work. In 2005, in cash terms and compared with 2004, total BERD increased by 7% to around €22b, with a decrease in Defence R&D expenditure of -14% to around €3b.

3.1.1 Identifying the drivers of knowledge demand

The UK draws on a wide network of committees and advisory groups for input into the formulation of science and research policy. These reflect the full spectrum of research related concerns from the general to the highly specific and are located at various levels of the government policymaking system, from Cabinet level, through Parliament and departmental levels, down to a range of both ad hoc and standing committees. Both the UK Houses of Parliament (the House of Commons and the upper chamber, the House of Lords) operate a number of Parliamentary Select Committees, the remit of which includes the conduct of reviews, the gathering of evidence and the production of reports to which the Government must respond. In particular, the House of Lords Select Committee on Science and Technology has a broad remit “to consider science and technology” and conducts, on its own initiative, inquiries into issues where science and technology affect public policy in order to provide a more independent view. In contrast, the House of Commons Committee for Innovation, Universities, Science and Skills (which recently replaced the Science and Technology Select Committee) has a narrow remit, centring its activities on selected topical issues in science policy.

Specific reviews or inquiries may be commissioned into aspects of science, technology and innovation policy, and may be conducted by individuals or groups drawn from any of the various committees and advisory groups, or independent consultants from the public or private sectors. Ongoing Government initiatives, such as Foresight and "horizon scanning", also feed into this policy making process. However, a particular strength of this approach is the variety it embraces, with no single predominant source of advice or information.

In 2005, the UK Science Forum was set up to support the UK's R&D and innovation goals and to inform future funding decisions, particularly within the context of the 10-year Framework. The forum was also intended to incorporate the views of business, together with those of Government and academia, and appointed an industrialist from the pharmaceuticals sector as its chair.

3.1.2 Co-ordinating and channelling knowledge demands

With a few exceptions, such as the defence and health sectors, the UK does not generally prioritise specific areas of research, but rather applies horizontal support to improve and maintain the overall performance of the research system. This is coupled with the objectives of ensuring the responsiveness of the science base to the needs of the economy and of increasing the level of investment by business in R&D as well as its level of engagement with the science base.

"Science in Government" is an initiative launched to improve cross government coordination of science and technology policy advice in relation to research and related activities. It brings UK government departments together to ensure that scientific advice is fully reflected in planning and policy issues. Improvement of the monitoring and delivery of high quality science and research in government departments, as well as the use of scientific advice in policy formulation and delivery is included as part of the Science and Innovation Framework 2004 - 2014. The Comprehensive Spending Review 2007 identified five trends with far-reaching implications for government and society and which clearly cross departmental boundaries. These were: demographic and socio-economic change, globalisation, climate and environmental change, global uncertainty, and technological change. Scientific research and advice plays a major role in meeting the challenges of these trends.

A key policy objective is improved responsiveness of the publicly funded research base to the needs of the economy and public services. To this end, the funding programmes of the Research Councils' are more strongly influenced by and delivered in partnership with the end users of research. Thus, research funding has been brought more in line with user needs and complements increased business investment in R&D, and increased business engagement with the UK science base. The Research Councils have a strong user orientation, through user representation on their Councils and advisory bodies, including their specific user advisory panels and in their peer reviews. In addition, a substantial proportion of the research funded is delivered in partnership with users as either joint funders or collaborators.

The TSB is also relevant in this context. Its role is to ensure that the promotion of technology and innovation in business is led by business itself. Originally established as part of the DTI to advise on business research, technology and innovation priorities for the UK, following a re-organisation in 2007, it now operates at "arm's length" from the government as a non-Departmental government body and its focus is the translation of knowledge into innovation and new and improved products and services. In particular, the TSB's *Innovation Platforms* have been set up to bring together Departments, business and academia to address major societal challenges and to open up market opportunities to increase business investment in R&D and innovation. Three Innovation Platforms, on 'Network Security', 'Intelligent Transport Systems and Services' and 'Low Carbon Vehicles' have been launched and five more are planned over the next three years including developing technology demonstrators to show innovative solutions in action (Malik, 2008).

An example of the improved articulation of and response to demand at sectoral level is the Government's Energy Research Partnership (ERP), an initiative aimed at the dual challenges of climate change and the need to address skills and research gaps. ERP brings together top energy industry executives, civil service officials and senior academics to provide greater strategic direction to UK energy research, development, demonstration and deployment. This includes addressing the high-level skills shortages in the energy sector. One of its aims was the establishment of an Energy Technologies Institute (ETI), which was realised in December 2007. In the same month, the ETI launched its first Call for Expressions of Interest, focusing on Marine and Wind projects. Another call followed in April 2008, on Distributed Energy.

3.1.3 Monitoring demand fulfilment

The UK Government has a long track record in carrying out reviews of both the entire UK research system and specific elements of it. Among the more recent of these, the 2003 "Lambert Report," presented to the DTI, the Treasury and the Department for Education and Skills concerned the demand for research from business. The report found that UK universities are developing their already strong international reputation for good quality research and enhancing their economic significance at national and regional levels. Nevertheless, cooperation with business could be further developed, through a combination of better identification by universities of their main areas of competitive strength, increased Government support for business-university collaboration, and better awareness among businesses of how to better exploit ideas developed in the university sector.

These findings fed directly into the DTI's 2003 Innovation Report, which in turn constituted a further system level review, contributing directly to UK Government research and innovation policy. The background report to the *Innovation Nation* White Paper noted that there had been increased exploitation of publicly funded research although there was still limited technology diffusion from the research base. It noted that several funding streams specifically designed to encourage HEIs and PSREs to engage with businesses and community interests had been introduced over the last ten years. The main scheme for this purpose in England is the Higher Education Innovation Fund (HEIF), which have enabled HEIs and PSREs to build internal capability and provide visible incentives collaboration and interaction. Systematic information on various forms of HEI-business interaction, such as income from business (contract research and consultancy), licensing income and numbers of spin-outs, graduate start-ups and patents granted, generally show an upwards trend (DIUS, 2008a).

The Government's Research Base Funders' Forum has been established to allow governmental and non-governmental funders of public good research to examine the collective impact of their strategies on the sustainability, health and outputs of the UK research base. The Forum meets quarterly and comprises representatives from charities, industry, Research Councils, Funding Councils, Regional Development Agencies, the Higher Education sector and Government departments.

Many government supported programmes and schemes, including most research and innovation support programmes, are subject to evaluation and assessment, either by in-house or independent teams. While the outcomes of such evaluations are not always reported publicly, as evaluation at programme level is generally focused on the operation, management and scope of the continuing programme, their findings may influence policy at a broader level and may feed into the general policy making process in a similar manner to that of other sources of advice.

3.2 Assessment of strengths and weaknesses

The strategic policy framework employed in the UK has attempted to identify both national strengths and the challenges faced in the creation and exploitation of knowledge. The mechanisms by which this framework has been articulated and is being progressively implemented and reviewed build on a variety of both long established and new mechanisms to articulate and capture knowledge needs and to target investments accordingly.

According to DIUS (2007), "fewer than 10% of UK enterprises regard uncertain demand for innovative goods and services as a factor of high importance in constraining innovation, whereas around 27% of UK firms regard the lack of qualified personnel as a factor of medium to high importance in constraining innovation. Knowledge-intensive services show the greatest proportion of employment with graduate level qualifications in science and engineering. Most sectors have recorded a slight increase over time in the proportion of employees educated to degree level in Science and Engineering subjects".

This framework has identified weaknesses in the UK system, and defines them as challenges to be addressed. A key issue in this respect is the transfer and exploitation of knowledge between academia and industry, which the establishment and reorientation of the Technology Strategy Board has specifically sought to address. The main strengths and weaknesses of the UK research system in terms of how the demand for knowledge demand is articulated can be summarised as follows:

Main strengths	Main weaknesses
• Coordinated long term S&T policy framework • Variety of sources used to assess and address the demand for knowledge • Increased exploitation of publicly funded research • Some successful high tech sectors and a sizeable population of high tech SMEs • Strong non technology based innovation in high value added sectors	• Low demand for university-industry interactions in knowledge transfer and exploitation (cf. competitors) • Limited technology diffusion from the research base

3.3 Analysis of recent policy changes

In terms of identifying the requirements for research knowledge demand, the major recent policy change concerns the expanded remit and role of the Technology Strategy Board. The broadened responsibility of the Technology Strategy Board and an accompanying increase in its funding to support both the development of five new Innovation Platforms and the expansion of the Knowledge Transfer Partnerships (and their extension to the Further Education sector) can be expected to have a policy impact in terms of addressing business needs for research in key technology areas. Similarly, the creation of the Energy Research Partnership and the establishment of the Energy Technologies Institute should also go some way in meeting the demands for energy-related R&D.

At the regional level, around €3.75m will go to support the increased introduction of innovation vouchers (already piloted in some English regions) to encourage interaction between SMEs and the knowledge base, with the target of enabling 1,000 businesses per year to acquire vouchers by 2011. The success of the piloted schemes suggests that there is a demand for this type of instrument which has proved successful in other countries.

In terms of assessing research demand, DIUS, BERR, the TSB and NESTA will continue work into innovation in the service sector to better understand its role and as a possible input to future policymaking – a requirement that has long been recognised at the academic level. Finally, DIUS will be responsible for the production of a cross-Government Annual Innovation Report. Due to be published in autumn 2008, it will review progress across all aspects of government activity relevant to innovation.

At a general level, as identified in the *Sainsbury Review*, UK innovation (and research) policy appear to be achieving successful results although there are some remaining areas for further action. The subsequent policy document, *Innovation Nation*, took up the majority of the 70 or so recommendations of the *Sainsbury Review* and these are in varying stages of implementation by the Government. At this stage, their success can only be guessed.

3.4 Assessment of policy opportunities and risks

In the light of the Lisbon Strategy, the main opportunities and risks for knowledge demand in the UK arising from recent policy responses can be summarised as follows:

Main policy opportunities	Main policy-related risks
• Strategic identification of issues and challenges in a long term perspective • Role of Technology Strategy Board	• Significant minority of non-innovating businesses

As already noted, the UK innovation policy governance system is seen as a particular strength. As evidenced by the Government's response to the findings of the *Sainsbury Review*, there is a willingness to review and modify policy whilst maintaining a clear and long-term overall strategic approach which should maximise opportunities in the future. On a more practical level, the role of the TSB can also be seen to have potential in aligning research policy to the key needs of industry and society in general. However, despite major policy efforts, the persisting number of non-innovating businesses is a cause of long-term concern.

3.5 Summary of the role of the ERA dimension

It is difficult to assess the possible role of the ERA dimension in terms of knowledge demand in the UK context, except to note that all the relevant policies noted above are fully consistent with the Integrated Guidelines of the Lisbon Treaty, in particular, IGs 7, 8, 11, 14 and 15.

As also stated above, the UK fully supports the use of collaborative programmes such ERA-Nets, JTIs, Article169 actions and European Technology Platforms (ETPs), provided that these are fully responsive to the needs of industry and other end user demands. In particular, "the UK strongly supports the use of ETPs to identify industry relevant research priorities in FP7. At the same time, the role of ETPs following the launch of FP7 needs to be re-examined, and their interface with national programmes clarified"[10].

4 - Knowledge production

The purpose of this chapter is to analyse and assess how the research system fulfils its fundamental role to create and develop excellent and useful scientific and technological knowledge. A response to knowledge demand has to balance two main generic challenges:

[10] Proceedings from the UK Event on the European Research Area, 13 July, 2007

- On the one hand, ensuring knowledge quality and excellence is the basis for scientific and technological advance. It requires considerable prior knowledge accumulation and specialisation as well as openness to new scientific opportunities which often emerge at the frontiers of scientific disciplines. Quality assurance processes are here mainly the task of scientific actors due to the expertise required, but subject to corresponding institutional rigidities.
- On the other hand there is a high interest in producing new knowledge which is useful for economic and other problem solving purposes. Spillovers which are non-appropriable for economic knowledge producers as well as the lack of possibilities and incentives for scientific actors to link to societal demands lead to a corresponding exploitability challenge.

Both challenges are addressed in the research-related Integrated Guideline and in the ERA green paper.

4.1 Analysis of system characteristics

4.1.1 Improving quality and excellence of knowledge production

The UK Science base is generally viewed as one of the UK's strengths (Cunningham, 2007a). It continues to enjoy a good international reputation in terms of both the volume and quality of publications. There is a high level of participation in international cooperation activities, particularly the European Commission's Framework Programmes.

The dual support system of the UK Higher Education sector combines 'block grants' from the Higher Education Funding Councils made to individual universities and other higher education institutions with grants from the Research Councils paid to individual researchers, research groups or research centres within the institutions. Both mechanisms function on quality measures designed to ensure excellence in research.

The amounts of the 'block grants' are related to the quality of institutional research performance, formerly as determined by the Research Assessment Exercise (RAE); in future, the RAE will be replaced by a metrics-oriented Research Excellence Framework. Research Council funds are usually allocated on a competitive peer reviewed process and, due to recent Government efforts to provide a more balanced support for the actual costs of research, now provide 80% of the Full Economic Costs (FEC) of the research activities.

In terms of sustaining and improving the UK's scientific excellence, the 2007 annual report on the Science and Innovation Investment Framework notes progress in this direction with the UK having increased its share of highly cited papers to 13.3%, while the proportion of non-cited papers produced by the UK has continued to fall. It has also sustained a more consistent performance across the range of scientific disciplines than most other countries and retains its lead in the G8 on productivity measures.

In terms of the number and world share of citations, the UK is ranked second in biosciences, business studies, clinical medicine, environmental sciences, humanities, pre-clinical research, and social sciences, third in mathematics and fourth in the physical sciences and engineering. In terms of output of qualified scientists, the UK output of PhDs per unit HERD spend is above the EU average. While, in terms of disciplinary strength, PhD awards in the UK are concentrated in natural sciences.

In collaboration with the other UK Research Councils, the Engineering and Physical Sciences Research Council (EPSRC) uses a system of international reviews to benchmark the strength of UK research activity against world competitors and to highlight any gaps or missed opportunities. These reviews use international expert panels to examine ongoing research in specific disciplines in the UK. The results of these reviews provide the basis for future development of EPSRC plans.

In order to address the issue of strategically important research areas that have been identified as ‘at risk’, the Government has launched the Science and Innovation Awards scheme. This provides large, long-term grants (typically €5-8m over 5 years, with the first round launched in 2004) to support staff in research groups, on the condition that the host institute continues to provide support at the end of the grant. These awards are funded jointly by the EPSRC, and the Higher Education funding bodies in England, Wales, Northern Ireland and Scotland.

As a further element of its support for ‘strategic subjects’ (i.e. high cost subjects that are strategically important for the economy but subject to low student demand) the Higher Education Funding Council for England (HEFCE) is providing over €100m of extra resources over the next two years to prevent closures of vulnerable university departments. The extra funding will increase HEFCE teaching grants for the vulnerable subjects by 20% (equivalent to €1500 per student). HEFCE has also launched a Research Capability Fund, which supports research in emerging subject areas where the research base is currently not as strong as in more established subjects. The scheme will run until 2008-09, with an annual allocation of around €31m.

4.1.2 Improving exploitability of knowledge production

The UK has, for several years, prioritised the promotion of interaction between the business sector and the science base, through a range of linkage measures. Some of these, such as CASE awards, Collaborative R&D, KTPs, and LINK have been in existence, under various names, for decades. Thus, it is not possible to directly link the effectiveness of these measures to the overall level of performance. However, a range of non-attributable evidence is available.

For example, in order to assess, in both qualitative and quantitative terms, the degree of linkage between the business enterprise sector and the HE sector, and to provide reliable and relevant information to support the continued public funding of higher education institutions, the HEFCE commissions an annual survey of *Higher education-business and community interaction (HE-BCI)*. Data are gathered on a wide range of "third stream" activities (i.e. funding obtained in addition to funding obtained from the dual support system), reflecting the contribution of HEIs to the economy and society. These range from commercial and strategic interaction with businesses and public sector organisations to working with the local community.

The survey focuses both on strategic aims and on levels of infrastructure development in the institutions and on quantitative data, such as income from knowledge transfer activities and the number of external business partners/clients. It also provides indicators that inform subsequent funding decisions.

The 2007 HE-BCI survey, based on data from 2004-05, shows a continued significant improvement in the level and quality of various types of higher education-business and community interaction, with collaborative research income increasing by 12%, consultancy income by 19%, disclosures of potentially exploitable inventions by 11% and spin-off activity by 10%. Overall, UK HEIs received over €4b from business and community interaction in 2006-07, a 17% rise from the previous survey[11]. While not all institutions are active in all areas, a broad range of activities have been successfully developed that contribute to the economy and society including the exploitation of new knowledge under collaborative research projects, and the innovative application of existing knowledge. The latest survey also confirms the UK Higher Education sector's continued success in forming new companies from third stream activity. However, due to a lack of comparable data, it is not possible to judge whether there is a similar trend in business engagement among Public Sector Research Establishments.

The HE-BCI Stakeholders group, which includes representatives from government ministries, the UK higher education funding councils, the research councils, and the Confederation of British Industry has been working to improve the guidance and definitions in advance of the next survey to ensure that that it provides a robust and consistent view of the broad range of knowledge transfer and related activity in the UK without placing an undue burden on the HE sector.

Following the 2006 independent Leitch Review of the UK's long term skill needs, the DIUS responded in 2007 with the publication of its strategy to lead the UK into a so-called skills '"revolution" by 2020, *World Class Skills: implementing the Leitch Review of Skills in England* .

A comprehensive review of the intellectual property framework in the UK was conducted by Andrew Gowers. The resulting report, published in December 2006, made a number of recommendations across the spectrum of IP issues. In particular, it recommended reducing the costs and improving access to the IP system. It also stated its support for the establishment of a unitary Community Patent (COMPAT), with consequent reductions in the cost of patent applications in Europe.

4.2 Assessment of strengths and weaknesses

The 2007 annual report of the Science and Innovation Investment Framework notes progress in several measures related to knowledge production. For example, the UK is second to the US in terms of number of publications, with around 9% of the world total and is also second to the US with around 12% of world citations, and with 13% of the most highly cited papers. When measured relative to GDP, the UK is first in the G7, having maintained its lead from 1996 to the present. The UK has also led the G7 since 1996 in terms of the number of citations per researcher. This citation performance has been sustained across disciplines and the UK is in the top three in seven of nine fields (and in the top three of the humanities field, although the data for this field is less robust). While the gap between the UK and the US in the share of publications and citations is significant, the gap in research impact (as measured by citations per publication) is narrowing.

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[11] http://www.hefce.ac.uk/econsoc/buscom/hebci/

The UK has maintained a high level of productivity over the past decade, in terms of the number of citations per unit of R&D performed in the public sector while the US and Canada have declined. Very similar results are obtained when citations are scaled per unit of R&D performed in the higher education sector.

In September 2006, the DTI and the UK higher education funding bodies commissioned an independent study into the future need for infrastructure funding. The study found that the backlog in research infrastructure investment had halved since 2001 and was on course to reduce to a manageable level in the near future. The remaining backlogs were no longer barriers to necessary teaching and research, but were rather affecting efficiency, strategic positioning and potential for growth. SRIF was identified as a driving force in achieving this through a direct contribution to investment of over £3 billion, and by helping universities develop a more strategic approach to capital investment planning. Research Councils UK and Universities UK launched a review of the effects of FEC in May 2008, which will report at the end of the year.

The announcement of plans to strengthen the role of the Technology Strategy Board across Government has also been seen as a further positive development. These signs of progress have been endorsed by a review of the report by the UK Science Forum (a high-level industry led forum, established to support the UK's R&D and innovation goals and to inform future spending decisions).

In the same way that the previous weaknesses of the research infrastructure are being effectively addressed, new policy measures are geared towards weaknesses, such as improving the translation of knowledge production into competitive advantage.

The main strengths and weaknesses of the UK research system in terms of knowledge production can be summarised as follows:

Main strengths	Main weaknesses
• Scientific quality of science base high: strong performance and world ranking in research outputs (publications and citations) • Use of and competence in the evaluation and review, including excellence based funding allocation	• UK tends to have fewer number of researchers in workforce (UK is sixth in G7), with little change over the last decade • Significant minority of non-innovating businesses • Rate of business start-up and SME growth still lag behind US • Variability in innovation performance and capability across the UK regions

4.3 Analysis of recent policy changes

The UK is maintaining and enhancing its strong position in relative research excellence, particularly in terms of research outputs and their impact. However, it should be noted that given the time lags in publication and their subsequent citation, these are essentially historic measures and it will take time for any policies implemented under the Science and Innovation Framework to have effect. However, they are monitored and assessed on an annual basis.

The importance of scientific excellence is central to the Science and Innovation Investment Framework, with particular emphasis placed on further strengthening the UK science base and in promoting and supporting World-class research. This includes sustained increases in investment in the science base by the Research Councils and the Higher Education Funding Councils and with a particular focus on the UK's most research-intensive universities. This is coupled with the "performance management system" which is designed to ensure that the science budget is appropriately targeted and allocated in line with priorities.

Over the past three years, the Research Councils have been implementing a Performance Management System, whereby they publish delivery plans, scorecards and 'output 1 and 2 frameworks' related to the health of the research base and better exploitation of research. Indicators of success (now unified in an Economic Impact Reporting Framework or EIRF) have been developed and these *Research Council Output and Economic Impact Frameworks* now form the basis of annual report (DIUS, 2007).

As the Ten-Year Science and Innovation Investment Framework has been in place only since 2004, time is required to judge the impact and effectiveness of the policy measures that it has introduced. Nevertheless, the system of annual reporting on progress and the 2007 Annual Report has provided some preliminary insights into and quantitative assessment of developments so far.

The 10-year Framework sets the goal for GERD to reach 2.5% of GDP by 2014. In 2005, this ratio had reached 1.76%, an increase on the previous ratio of 1.72% for 2004. Some €33.5b was spent on GERD, a 5% increase in real terms from 2004 and a 7% increase in cash terms. However, for the past ten years, the proportion of R&D performed in the business enterprise sector has continued to exhibit a slight downward trend as a share of GDP. In 2005, BERD as a proportion of GDP was 1.08%, with no change from the revised ratio of 1.08% in 2004. In 2005 €20.6b was spent on total R&D performed in UK businesses, a 3% increase on 2004 and a 5% increase in cash terms. UK businesses fund around 42% of R&D performed in the UK, a proportion that is somewhat lower than other G7 countries and the OECD average, although the UK has a relatively high share of R&D funded from abroad (about 19%) (DIUS, 2007).

It is clear that significant progress has been achieved with regard to addressing the effects of chronic investment in the UK's research infrastructure, with the Science Research Investment Fund (SRIF), being recognised as a major component in achieving this success. SRIF is now to be replaced by a capital investment fund.

4.4 Assessment of policy opportunities and risks

In the light of the Lisbon Strategy, the main opportunities and risks for knowledge production in the UK arising from recent policy responses can be summarised as follows:

Main policy opportunities	**Main policy-related risks**
• Policy emphasis on the sustained renovation of research infrastructure • Close monitoring of the social and economic impacts of research • Development of innovation potential and scope to build on the strength of the science and engineering base	• Introduction of Full Economic Costs may discourage industry spending in higher education sector • Uncertainty over long-term supply of human resources for science and technology in key strategic areas

The effects arising from policy efforts to mitigate the chronic underfunding of research infrastructure appear to be substantial, with the UK research base now in a better position to support and benefit from its position of research strength, particularly in strategic areas of research and on the international arena. This is reinforced by the close integration of science and innovation policies which see S&T as a strong driver of UK innovation.

The UK's STI governance practices also seek to explore and monitor the linkage between the outcomes of research and their potential for socio-economic impacts. Developments such as the intended creation of an Innovation Index, by NESTA, and the setting up of an Innovation Research Centre, jointly funded by DIUS, BERR, TSB, ESRC and NESTA, which is intended to deliver more 'evidence' upon which policy may be formulated, also offer clear opportunities.

The introduction of full economic costs (FEC) in research funding, which seek to increase funding and to meet the associated costs of research such as infrastructure costs, is generally viewed as a positive step, although it has been suggested that it may also have the negative effect of discouraging funding from industry and the private, not-for-profit sector through raising the costs of research. It is yet to be seen if this potential threat is realised.

Lastly, the variability in the supply of qualified researchers in key strategic areas, coupled with the variation in demand from the research and private sectors, precludes the formulation of long-term sustainable strategies, although the problem is currently being addressed by short-term policy measures. Such uncertainty poses a potential long-term risk.

4.5 Summary of the role of the ERA dimension

Again it is difficult to assess the possible role of the ERA dimension in terms of knowledge production in the UK context, except to note that all the relevant policies noted above are also fully consistent with the Integrated Guidelines of the Lisbon Treaty, in particular, IGLs 7, 8, 10 and 23.

The White Paper, *Innovation Nation*, notes the influence of the UK Government in positioning research and innovation as core priorities of the revamped Lisbon growth and jobs agenda. This has involved negotiation of, for example, the launch of the Joint Technology Initiatives in areas of key UK strength (aerospace and pharmaceuticals) and in the creation of the European Institute for Innovation and Technology (EIT). It also notes that the UK has been "at the forefront of progress towards making the European Research Area (ERA) a reality, for example in developing a more strategic approach towards the establishment of new infrastructure facilities and mobility of researchers".

As noted in Section 2.5 above, the UK is also a major participant in a large number of European research initiatives, whilst on the policy side, it is extensively involved in various activities such as COST, CREST and the Open Method of Coordination, which are looking at areas of mutual interest and potential benefit.

5 - Knowledge circulation

The purpose of this chapter is to analyse and assess how the research system ensures appropriate flows and sharing of the knowledge produced. This is vital for its further use in economy and society or as the basis for subsequent advances in knowledge production. Knowledge circulation is expected to happen naturally to some extent, due to the mobility of knowledge holders, e.g. university graduates who continue working in industry, and the comparatively low cost of the reproduction of knowledge once it is codified. However, there remain three challenges related to specific barriers to this circulation which need to be addressed by the research system in this domain:

- Facilitating knowledge circulation between university, PRO and business sectors to overcome institutional barriers;
- Profiting from access to international knowledge by reducing barriers and increasing openness; and
- Enhancing absorptive capacity of knowledge users to mediate limited firm expertise and learning capabilities.

Effective knowledge sharing is one of the main axes of the ERA green paper and significant elements of IGL 7 relate to knowledge circulation. To be effectively addressed, these require a good knowledge of the system responses to these challenges.

5.1 Analysis of system characteristics

5.1.1 Facilitating knowledge circulation between university, PRO and business sectors

The issue of linkages between the business enterprise sector and the Science Base is a central aspect of UK innovation policy and a number of policy instruments are in place to encourage and improve knowledge transfer between the two sectors.

The Science and Innovation Investment Framework emphasises greater responsiveness from the publicly-funded research base towards the needs of the economy and public services. Research Councils, in particular, are orienting their programmes in closer cooperation with the end users of research (see Section 4.3). A further stated aim is to continue to improve UK performance in knowledge transfer and commercialisation from universities and public laboratories towards world leading benchmarks.

Launched in 2001, the Higher Education Innovation Fund (HEIF) is the core funding programme for the encouragement and support of knowledge transfer in HEIs in England (the devolved assemblies of Scotland, Wales and Northern Ireland have their own support mechanisms). The third round of the programme was launched in 2006 and includes a number of important changes, reflecting Government commitment to provide a permanent "third" stream of funding, In particular, the majority of HEIF third round funds were allocated using a funding formula to ensure that every English HEI receives some funding and a smaller competitive element has been introduced to support high impact innovative projects. HEIF is now operated by the RDAs in England, to tailor its delivery to more local needs. Following the 2007

CSR, and building on recommendations from the Sainsbury Review, it was announced that the fourth round (beginning 2008) would receive a budget increase to €230m by 2010/11. The scheme will also move to fully formulaic allocation, with further emphasis on performance, and aim to distribute funding more widely across the HE sector.

As noted above, the Government has established the TSB in order to enhance industry's efforts in knowledge circulation. The remit of the TSB includes strengthening the links with business and the research base, and the operation of the €260m Technology Programme, which funds research projects in firms and universities along a number of priority themes including low carbon energy technologies; biopharmaceuticals' manufacture; and sensors and imaging. TSB is run along similar lines to the research councils, to the extent of being co-located with their head offices in Swindon.

Under the technology programme, the TSB is responsible for a number of programmes aimed at facilitating the transfer of knowledge from the science base to the business sector. These include Knowledge Transfer Networks (KTNs), which are based on the long-term and highly successful Teaching Company Scheme. Based in specific fields of technology or business applications, KTNs bring together a variety of organisations (businesses, suppliers and customers, universities, RTOs, the finance community and other intermediaries) to enable the exchange of knowledge and stimulation of innovation. The TSB's Collaborative Research and Development scheme is designed to assist the industrial and research communities to work together on R&D projects in strategically important areas of science, engineering and technology. Knowledge Transfer Partnerships (KTPs) form another scheme that has exhibited long-term success. They allow companies to obtain knowledge, technology or skills, which they consider to be of strategic competitive importance, from the further/higher education sector or from RTOs.

In response to the Baker Report (August 1999) on realising the economic potential of public sector research establishments, the Government set up the Public Sector Research Establishments (PSRE) Fund to enable PSREs, both to develop their capacity to exploit their science and technology potential and to provide seed funding to support the very early stages of business formation from ideas emerging out of research in the public sector science base. The fourth round of awards, worth over €46m, was announced in June 2008. DIUS compiles an annual survey of knowledge transfer activities in PSREs.

In 2008, the UK had around 60 science parks in which businesses are located, usually on or near a university campus or research centre. More than 2,200 companies are based in science parks, employing over 47,000 scientists and engineers, 85% of these firms are small or medium sized with a technology base. Evidence (quoted in Cunningham, P., 2007) shows that companies based on UK science parks tend to grow more quickly, and have higher turnovers than similar companies based elsewhere off science parks. They are also more likely to gain access to finance for start up and business growth.

5.1.2 Profiting from access to international knowledge

DIUS, working in collaboration with a wide range government and non-government organisations, is responsible for the development and delivery of the UK's approach to international engagement in science and innovation. DIUS' Global Science &

Innovation Policy Directorate is responsible for managing inter-governmental science and technology relations with other countries and international organisations. With the support of the Global Science & Innovation Forum (GSIF - see below), it defines the UK's international strategy for science and innovation. International science and innovation activities include planning and managing UK involvement in the EU's science and technology activities, particularly the Framework Programmes.

Outside Europe, DIUS seeks to develop and strengthen links with major scientific partners across the world, on a bilateral and multilateral basis, where scientific, commercial or political returns to the UK are envisaged. The UK also has significant development objectives, which influence the decision making of the GSIF and other bodies.

DIUS has responsibility for GSIF. Operating across the UK government, and chaired by the Government's Chief Scientific Adviser, GSIF facilitates and promotes exchanges of information and ideas to improve co-ordination of the UK effort in international science and innovation collaboration. It also provides strategic guidance and systematically scans for new and emerging issues. The GSIF strategy is based on four priority areas:

- research excellence – through strengthened international collaborations and attracting the best researchers to the UK;
- excellence in innovation – through UK businesses accessing international science and by attracting international R&D investments to the UK;
- global influence – by using international science to underpin foreign policy and as a tool to promote bilateral partnerships; and
- development – using research and innovation to meet international development goals.

The Foreign and Commonwealth Office's (FCO) Science and Innovation Network (SIN)[12] is based in 30 countries and territories around the world. Its purpose is to strengthen the UK's long-term prosperity, sustainability and security. The 2008 White Paper *Innovation Nation* announced that DIUS will now assume responsibility for leading and managing the FCO SIN and that, in the future, DIUS and FCO will co-fund this network and DIUS will host a management team of DIUS and FCO staff to oversee the network's operation (DIUS 2008b).

Working in collaboration with BERR, the FCO also has responsibility for UK Trade & Investment[13] (UKTI), the government organisation supporting overseas R&D investments in the UK. UKTI is responsible for rolling out business-led UK marketing strategies aimed at overseas buyers and potential investors in sectors of high business innovation (Financial Services, ICT, Life Sciences, Creative and Energy). The strategies represent a new form of partnership between business and Government for the delivery of a collective marketing effort. During 2008, new strategies will be developed in the areas of Climate Change and Advanced Engineering (DIUS, 2008b).

On the academic side, the British Council, the Royal Society and the Research Councils all provide support for UK researchers, postgraduates and international

12 http://www.fco.gov.uk/en/fco-in-action/global-network/science/
13 http://www.uktradeinvest.gov.uk/

students who are seeking funding for international collaboration in science and technology.

5.1.3 Absorptive capacity of knowledge users

The UK Government has identified the issue of skills and training as a challenge, particularly within the SME sector, and has introduced measures to address this as part of a wider policy mix. UK performance on workforce skills levels is mixed, but with relatively good performance in terms of higher-level skills (university degree or other higher-level qualifications), UK participation rates in higher education now exceed 30%, having improved significantly since the early 1990s, with a large proportion of this expansion in higher education in Science, Engineering and Technology (SET). However, there may be problems with specific subjects, particularly physics and chemistry. Some UK universities have met with difficulties in attracting sufficient numbers of students in these subjects, have been forced to merge, and even close, relevant departments.

The Leitch Review of Skills, published in 2006, set out the skills challenges faced by the UK and the Government implemented a number of measures to address these. Figures indicate that, since 2001, over 1.75 million people have improved their functional literacy and numeracy skills and around 100,000 apprentices now complete their apprenticeships each year in England compared to 40,000 in 2001/02. From 1999 to 2006, participation in higher education amongst 18-30 year olds rose from 39.3% to 42.8%. However, the Leitch report concluded that more needed to be done for the UK to achieve the goal of becoming a world leader on skills by 2020, benchmarked against the upper quartile of OECD countries. In July 2007, the Government published its response to the Leitch Report[14] and set out how it would take forward the report's recommendations. This involved the establishment of a public service agreement for skills.

Another weakness concerns management; average management practices in the UK are often below best practice, although good UK managers match the best in the world. This affects company performance, particularly compared to the US and differences in management practices between the two countries are estimated to account for 10-15% of the productivity gap. A possible consequence is that less-skilled managers place less emphasis on innovation and raising value-added than more skilled ones. In turn, this can affect the supply and demand of skills – a vicious circle in which managers do not demand higher skills as their products have low specifications, while workers have few incentives to obtain high skills due to the lack of demand by managers (DIUS, 2008b).

Just over a quarter (27%) of UK firms view the lack of qualified personnel as a factor of medium to high importance in constraining innovation. The greatest proportion of employment with graduate level qualifications in science and engineering is found in knowledge-intensive services. On a positive side, most UK sectors have exhibited a slight increase over time in the proportion of employees educated to degree level in SET subjects.

[14] DIUS (2007) World Class Skills: Implementing the Leitch Review of Skills in England

5.2 Assessment of strengths and weaknesses

In the private sector, the significant international input to business research funding has already been noted. While this underlines the perceived attractiveness of the UK as a location for corporate R&D activities, the impacts on wider knowledge circulation within the UK maybe more diffuse. Likewise, the international attractiveness of the UK HE system seems mainly to benefit outward knowledge flows. The perceived challenge is thus one of absorption capacity.

Investment in training by employers does not match the levels of the highest skilled economies. Although Labour Force Survey data indicate a relatively high incidence of job related training in the UK compared to other countries, other surveys suggest that employer-provided training in the UK is often of relatively short duration and may not be of the intensity required to upgrade workforce competencies in line with the goals of the Leitch Review (DIUS, 2008a). The most recent data suggest a third of employers provided no training at all over the course of a year. These may suggest a demand weakness: skills are a derived demand and this may relate to more general issues concerned with business and innovation strategies. It has been suggested that, in some parts of the economy, a low demand for skills is related to low ambitions for the business and business strategies of cost-based competition in low value segments of product markets. Such firms may also not seek to innovate and may be trapped in a low skills equilibrium due to the problem of their inability to change their business model. With increasing global competition, such strategies may become unsustainable.

Between the public and private sectors, there are good examples of mechanisms in operation to promote knowledge circulation. UK science parks are seen as one example with several success stories. Nevertheless, this remains a key policy challenge in the UK.

Around a quarter of UK innovative enterprises source information from HEIs, and a similar proportion source information from government or public research institutes. Moreover, the proportion of all firms sourcing information from government or public research establishments has been increasing over time. On the other hand, only 1% of businesses noted that HEIs were of high importance as an information source in 2007 (cf. 27% that rated clients or customers of high importance). However, similar patterns can be seen in data from several other European countries, with the exception of Finland (DIUS, 2008a). From the HEI perspective, recent figures show a range of positive trends in knowledge transfer activities reported by HEIs. Business-derived income for UK HEIs rose to about €710m in 2005-06. There has also been growth in the number of licenses and licensing income from business which has exceeded that in the US over the last few years.

The UK is an attractive place for foreign owned firms to perform R&D. The share of total R&D funded from abroad is relatively high (19%) compared to other G7 countries and some 27% of R&D performed in the UK's business sector is funded from abroad. Over the last decade, the UK has also shown a strong positive balance in its technology balance of payments and is a net technology exporter. Total R&D expenditure by affiliates of foreign companies increased by more than 40% in the UK between 1994 and 2004. In 2004, this foreign investment accounted for 40% of the total R&D expenditure performed in the business sector, much higher than in many European countries (DIUS 2008b).

For its size and stage of development, the UK is a relatively open economy. It has the largest FDI inflow of any OECD economy, a pattern accentuated in technology-based markets and for knowledge flows. Data also suggest that UK-based companies are prominent investors in R&D overseas. For example, UK firms patenting pharmaceuticals and chemicals were more likely to be exploiting inventions developed overseas than similar firms in France or the US.

The strengths of the UK lie in its combination of positive experiences in identifying the benefits of and supporting knowledge circulation. These include both policy measures and initiatives from the actors themselves. The strength and international reputation of the UK science base makes it an attractive source of knowledge to investors.

Main strengths	Main weaknesses
• Comprehensive and long-term policy mix to stimulate knowledge transfer • Positive trends in knowledge transfer indicators from science base to private sector • Successful role of UK science parks • Strong, central strategy for international R&D activities • Open economy, attractive to FDI and high level of foreign participation by UK researchers	• There is still a gap between research performance and its translation into commercially competitive products, processes and services • Persistent shortcomings in business skills base and general poor demand for skills • Poor innovation management skills in majority of business sector

5.3 Analysis of recent policy changes

Important developments are occurring in terms of both intersectoral and international knowledge circulation. These are clearly taken on board in recent policy developments, with measures implemented in both domains. Indeed, the issue of linkages between the business enterprise sector and the Science Base forms a longstanding element of UK innovation policy. It has been given a further boost under the Science and Innovation Investment Framework, with the explicit aim of improving UK performance in knowledge transfer and commercialisation from public sector research. Available indications are that these policies may be having an influence on trends, which seem to be generally positive. Likewise, recent policy efforts seek to improve co-ordination of the UK effort in international science and innovation collaboration in a more systematic manner.

Recently, recommendations to continue to build on the UK's successes in knowledge transfer have been followed up by the development of an entirely formulaic approach to the HEIF and plans to expand Knowledge Transfer Partnerships. This again seems to provide evidence of the UK's successful use of a process of review and evaluation in its innovation policy governance system. Moreover, the continued development of Innovation Platforms, by the Technology Strategy Board, also appear to offer a means of driving the uptake of research by industry and of creating closer links between user demand and research,

5.4 Assessment of policy opportunities and risks

A strength and clear opportunity provided by the policy context is the priority given to knowledge circulation issues at both intersectoral and international levels. In particular, the establishment of the TSB is a significant step towards improving and expanding these linkages on a larger scale. However, the policy emphasis on the UK's attractiveness as a location for inward investment, could, paradoxically entail the risk that this would lead to a degree of dependence on, potentially foot-loose or ephemeral, foreign investment, who could relocate elsewhere in the face of changing economic circumstances (Cunningham, 2007a).

The well-established (and closely monitored) policy mix in support of knowledge circulation provides opportunities for the identification of longer-term trends and for valuable lessons to be drawn regarding the effectiveness of such policies. Moreover, the proposed changes to the Research Assessment Exercise (now known as the Research Evaluation Framework - REF) and the possible incorporation of business interaction metrics could lead to the removal of the inherent policy inconsistencies found between the former RAE (with its emphasis on academic quality expressed through scientific publication) and schemes to promote knowledge transfer).

Main policy opportunities	Main policy-related risks
• Establishment of and enhanced role for Technology Strategy Board • Rationalisation of REF metrics to include knowledge transfer objectives	• Policy focus on UK attractiveness could lead to dependence on high level of (potentially ephemeral) FDI

5.5 Summary of the role of the ERA dimension

The UK performs highly in terms of the participation of its researchers in international science ands technology-related activities. A range of support mechanisms is in place to assist UK researchers, individually and collectively, in their participation in bilateral and multi-lateral internationally collaborative activities. However, there have been widespread concerns over the relatively low level of UK business participation in the Framework Programmes. For example, the results for UK participation in FP6 raise significant concerns when compared to those for other large Member States. Although the UK scores high in terms of percentage of Higher Education participation (56% compared to 32% and 19 % for Germany and France, respectively), the picture is reversed for participation by industry (19% for the UK, compared to 26% and 24% for Germany and France, respectively) (DIUS, 2008b).

This is an issue addressed by the Technology Strategy Board, which, in collaboration with other key actors such as the RDAs, Devolved Administrations and the Knowledge Transfer Networks, is “to develop a marketing plan to help deliver a step change in the level of UK business participation in consortia competing successfully for grants in FP7”, as part of its international strategy.

Domestically, the UK has made significant advances in knowledge transfer in recent years, with UK universities and public research institutes developing knowledge transfer systems, especially following the Lambert Review in 2003. The UK position is that voluntary guidelines are more welcome than legislative solutions, such as a

Bayh-Dole Act. During its presidency of the EU the UK initiated a CREST project[15] which produced an IP tool kit for "European cross-border collaborations between industry and public sector research organisations and training of technology transfer professionals", based on the Lambert principles. The UK is aware of the need to carefully balance rapid and effective access and delivery of the outcomes of scientific research and the need to capture and protect intellectual property. Also relevant is the debate between open access and subscription-based models for scientific publication, where the UK favours the use of equitable, but different and innovative business models for scientific publications.[16]

6 - Overall assessment and conclusions

6.1 Strengths and weaknesses of research system and governance

A recent Commission-sponsored peer review of the UK research and innovation system concluded that the main strengths of the UK system were in its capacity for R&D, both within the Science Base and its industrial R&D, as well as its system of innovation policy governance, and, in particular the attention to quality and the measures in place to help achieve this (Cunningham, 2007a). This resonates with the analysis presented in the current report, the results of which are summarised in table 3 below. More recent reviews of the UK research and innovation system (notably the *Sainsbury Review*, the White Paper *Innovation Nation* and its background analysis report (DIUS 2008a)) also support these broad conclusions.

In terms of resource mobilisation, a key strength in UK resource mobilisation is the core policy emphasis on maintaining and enhancing the high quality of the UK science base, as well as promoting its role in providing both a rich source of innovation potential and the supply of human resources. The UK's system of funding research at universities, based on the dual support system with the competitive allocation of funds and emphasis on excellence, can also be highlighted as a strength, provided long-term infrastructure needs are also adequately met (which should also be addressed by recent policy developments). This is in a general policy context of long term policy planning, backed up by long term funding commitments.

In the private sector, particular areas of strength include high levels of R&D in pharmaceuticals and aerospace, and, more generally, the mobilisation of foreign research investments. Overall, however, the relatively low research intensity of business R&D is a perceived weakness. In connection with this, the contribution of R&D in service industries is the subject of some debate. Direct grant support to firms also has a low priority in UK policy, except for the targeted support of SMEs, with a general preference for indirect measures of support and the development of stable and supportive framework conditions.

The proportion of R&D personnel in the UK, in both public and private sectors is also low compared to other EU Member States (0.45% of population).

[15] http://ec.europa.eu/invest-in-research/pdf/download_en/crestreport.pdf
[16] Proceedings from the UK Event on the European Research Area, 13 July, 2007

In the articulation of demand, the comprehensive process of review, monitoring progress and the role and value of evaluation contribute to long term policy planning. While complex, the incorporation of stakeholder views across government, industry and academia, as well a commitment to stronger public engagement all provide a sound basis for policy decisions.

The quality of knowledge production by the UK science base is an evident strength, as is the Government's commitment to build on these strengths. Despite a long-term policy focus, the UK remains relatively weak at translating this potential into the market.

Transfer of knowledge from the science base, however, does benefit from a high position on the policy agenda and from increasing orientation towards collaborative R&D and innovation. This builds on the generally strong international outlook of the UK science base, both in terms of collaboration and education and research training. The attractiveness for "inward investment" in UK higher education, in terms of the large number of fee paying overseas students, also reflects the general attractiveness of the UK for overseas research investments.

Within the UK, the science base contributes in a more focused way to economic prosperity at regional level through facilitating and contributing directly to knowledge circulation, such as through science parks.

The main lessons that may be drawn from the recent peer review of the UK’s research and innovation policy system can be summarised as follows:

- The current coordinated approach to policy formulation plays a critical role, although the recent split in responsibilities between the DIUS and BERR may impact upon coordination;
- Clear and realistic long-term targets and goals, together with the production of strategies to reach them clearly communicate the Government’s intentions to all actors in the research system.
- There is an open and transparent process of policy making and implementation.
- A strong governance regime, which gives a prominent role to the processes of review (at the system and sub-system levels), monitoring and evaluation, coupled with good feedback mechanisms for the future implementation of policies.

Domain	Challenge	Assessment of strengths and weaknesses
Resource mobilisation	Justifying resource provision for research activities	Coordinated long term S&T policy framework with associated budgetary process
	Securing long term investment in research	Public sector spending on R&D has generally increased over last decade but still relatively low business investment in R&D relative to GDP
	Dealing with barriers to private R&D investment	Range of policy measures in place, coordinated and led by new Technology Strategy Board
	Providing qualified human resources	Increasing overall supply of STEM skills although overall skill levels of population exhibit lags compared to international leaders and there are concerns over numbers of graduates in certain key disciplines
Knowledge demand	Identifying the drivers of knowledge demand	Variety of sources used to assess and address the demand for knowledge
	Co-ordination and channelling knowledge demands	Coordinated long term S&T policy framework and strengthened public engagement
	Monitoring of demand fulfilment	Increased exploitation of publicly funded research, some successful high tech sectors and a sizeable population of high tech SMEs; Strong non technology based innovation in high value added sectors but low demand for university-industry interactions in knowledge transfer and exploitation (cf. competitors) and limited technology diffusion from the research base
Knowledge production	Ensuring quality and excellence of knowledge production	Scientific quality of science base high: strong performance and world ranking in research outputs (publications and citations) UK tends to have fewer number of researchers in workforce (UK is sixth in G7), with little change over the last decade Significant minority of non-innovating businesses
	Ensuring exploitability of knowledge	Use of and competence in the evaluation and review, including excellence based funding allocation Rate of business start-up and SME growth still lag behind US Variability in innovation performance and capability across the UK regions
Knowledge circulation	Facilitating circulation between university, PRO and business sectors	Comprehensive and long-term policy mix to stimulate knowledge transfer Positive trends in knowledge transfer indicators from science base to private sector Success story of UK science parks
	Profiting from international knowledge	Strong, central strategy for international R&D activities Open economy, attractive to FDI and high level of foreign participation by UK researchers
	Enhancing absorptive capacity of knowledge users	Persistent shortcomings in business skills base and general poor demand for skills Poor innovation management skills in majority of business sector There is still a gap between research performance and its translation into commercially competitive products, processes and services

6.2 Policy dynamics, opportunities and risks from the perspective of the Lisbon agenda and the ERA

The peer review of the UK's research and innovation policy system noted the opportunity for cross-fertilisation between the Science and Innovation Investment Framework 2004 – 2014 and the National Reform Programme in the context of the Lisbon Strategy.

While aspects of the UK system have already been highlighted above as strengths, the long-term policy framework can also be seen as providing opportunities across all four domains of the current report's analytical framework, identifying and addressing challenges. In addition, more specific opportunities and risks in the policy context have been described above and are summarised below.

The Science and Innovation Investment Framework has clearly identified the issues and challenges for resource mobilisation in both the short and long term. These provisions and their envisaged effects on the UK science base represent a wealth of opportunities, for the further development and exploitation of the UK science base, both within the UK, and to further attract both foreign researchers and foreign corporate investment. More recent analyses, presented in the *Sainsbury Review* and in the White Paper *Innovation Nation*, confirm these issues and challenges, while highlighting areas of success since the instigation of the 10-year Framework.

The identification of issues and challenges in a long term perspective is now an established aspect of the UK system, not only embodied in the framework, but also building the UK's strong experience in Foresight, and more recent "horizon scanning." exercises The TSB is another example of the potential for capturing and reacting to knowledge demand.

In terms of opportunities for enhanced knowledge production, the recent policy support for the renewal and enhancement of the UK's research infrastructure is a leading example, although this was a consequence of the identification of the effects of a chronic underfunding.

The establishment of the TSB has also been seen to provide opportunities to contribute to better capturing and channelling knowledge demand. However, it is also set to play a potentially key role in knowledge circulation, most notably between the public and private sectors in the UK. This can build on the existing set of policy instruments to support industry-university partnerships.

As for risks, the identified supply problems in domestic human resources in S&T, with a decrease in the capacity for rapid 'renewal and growth' of the population of researchers are clearly a concern. While policy seeks to address this, the acknowledged strengths of the UK science base, including the attractiveness of the UK higher education system, in certain ways contribute to the threat, with UK S&T graduates and researchers attractive as employees in the US or outside the S&T domain, such as in the financial services sector.

Although some initial results are promising, the strong dependence on indirect measures in private sector R&D has been questioned (Cunningham, 2007a), particularly the impact on SMEs, where other more direct Government support measures might be appropriate. For example, the impacts of tax credits are a very significant support measure, which should be taken into account.

In providing increased support for knowledge production in the UK, the introduction of Full Economic Costs in research grants may discourage industry spending in the higher education sector, although their strong positive effects, should easily outweigh the potential negative impacts. Furthermore, despite the strong recent efforts towards the renovation and enhancement of the UK research infrastructure, there is a need to maintain the provision of leading edge infrastructure in order to meet the demands of continued research investment. Finally, risks related to knowledge circulation in the UK policy context, such as the relatively high dependence on FDI in research in the UK, may have an erosive effect on the UK's domestic competences and identity.

Domain	Main policy opportunities	Main policy-related risks
Resource mobilisation	Good identification of resource mobilisation issues and challenges Promoting attractiveness of UK to foreign researchers and foreign corporate investors	Unstable global macro-economic conditions which may impact research and innovation budgets
Knowledge demand	Strategic identification of issues and challenges in a long term perspective Role of Technology Strategy Board	Significant minority of non-innovating businesses
Knowledge production	Policy emphasis on the renovation of research infrastructure Close monitoring of the social and economic impacts of research Development of innovation potential and scope to build on the strength of the science and engineering base	Introduction of Full Economic Costs may discourage industry spending in higher education sector Uncertainty over long-term supply of human resources for science and technology in key strategic areas
Knowledge circulation	Establishment of and enhanced role for Technology Strategy Board Rationalisation of REF metrics to include knowledge transfer objectives	Policy focus on UK attractiveness could lead to dependence on high level of (potentially ephemeral) FDI

6.3 System and policy dynamics from the perspective of the ERA

In general policy terms, the UK is supportive of various EU research developments, including the development of the ERA, whilst also seeking to direct these in order to ensure their optimal performance. The UK Government strongly encourages UK participation in all the EU research funding frameworks, on the basis of obtaining a maximal return on its EU payments and in order to ensure that the UK has a lead role, or at least a strong presence, in the governance of these initiatives. UK researchers are active (and frequently leading) participants in a range of European research programmes and initiatives, notably the Framework Programmes and EUREKA. In these contexts, UK researchers have indeed played a major role in European research programmes, both from the perspective of overall participation and also in terms of the number of projects coordinated by UK teams. However, this level of performance is not matched by UK business participation rates.

Although it is difficult to assess the possible role of the ERA dimension in terms of knowledge demand in the UK context, it is clear that, overall UK policies in this area are fully consistent with the Integrated Guidelines of the Lisbon Treaty, in particular, 7, 8, 11, 14 and 15. Similarly, in terms of policies aimed at knowledge production, UK policies are also fully consistent with the Integrated Guidelines 7, 8, 10 and 23.

References

Boden, M (2008): ERAWATCH Analytical Country Report 2007: United Kingdom. JRC Scientific and Technical Report, European Commission Joint Research Centre, Institute for Prospective Technological Studies and Directorate General for Research, EUR 23389 EN/6

Bulli, S. Business Innovation Investment in the UK, Department for Innovation, Universities and Skills, 2008.

Cunningham, P. (2007a): CREST 3% OMC Science & Innovation Policy Mix Peer Review United Kingdom: Background and Visit Follow-up Reports

Cunningham, P. (2007b): Monitoring and analysis of policies and public financing instruments conducive to higher levels of R&D investments - Country Review United Kingdom.

Department for Innovation, Universities and Skills (2008a). Implementing 'The Race to the Top': the response to Lord Sainsbury's Review of Government's Science and Innovation Policies: http://www.dius.gov.uk/publications/SainsburyReview-v12.pdf

Department for Innovation, Universities & Skills (2008b): Innovation Nation, March 2008. Available at: http://www.dius.gov.uk/publications/ScienceInnovation.pdf

Department for Innovation, Universities & Skills (2008a): Background analysis: strengths and weaknesses of the UK innovation system. Available at: http://www.dius.gov.uk/publications/innovation_nation_docs/Background_analysis.pdf

Department for Innovation, Universities and Skills (2007), Science and Innovation Investment Framework 2004-14: Economic Impacts of Investment in Research & Innovation, URN 07/1146

Department for Innovation, Universities and Skills, Science and Innovation Investment Framework 2004-14 (2007): Annual Report on Research Council Output and Economic Impact Frameworks, URN 07/466

Department of Business Enterprise and Regulatory Reform, and Office for National Statistics (2005): SET Statistics 2005: http://www.dti.gov.uk/science/science-funding/set-stats/index.html

Department of Business Enterprise and Regulatory Reform (2007), Proceedings from the UK Event on the European Research Area, 13 July, 2007. http://www.berr.gov.uk/dius/science/int/euro-programmes/era/page42215.html

Department of Trade and Industry (2003): Competing in the global economy: the innovation challenge, DTI Innovation Report, December 2003. http://www.dti.gov.uk/innovationreport/innovation-report-full.pdf

Department of Trade and Industry (2004): DTI Five Year Programme, Creating Wealth from Knowledge: http://www.dti.gov.uk/about/fiveyearprogramme.pdf

Department of Trade and Industry (2006): R&D Scoreboard. Available at: http://www.innovation.gov.uk/rd_scoreboard/

Department of Trade and Industry, The Government's Productivity and Competitiveness Indicators, http://www.dti.gov.uk/about/economics-statistics/economics-directorate/page21913.html

ERAWATCH Research Inventory (2007), UK country information (EWN country correspondent, P. Cunningham et al.): http://cordis.europa.eu/erawatch/index.cfm?fuseaction=ri.content&countryCode=GB&topicID=4

European Trend Chart on Innovation (2006): Annual Innovation Policy Trends and Appraisal Report: UK 2006. European Commission, Enterprise Directorate-General prepared by P. Cunningham et al.

Funders Forum:http://www.dti.gov.uk/science/science-funding/Funders_Forum/index.html

Global Science and Innovation Forum (2006): A Strategy for International Engagement in Research and Development

Higher Education Funding Council for England (2005): Guide to Higher Education in the UK, HEFCE, April 2005.

Higher Education Funding Council for England (2006): Higher Education-Business and Community Interaction Survey: http://www.hefce.ac.uk/pubs/hefce/2006/06_25/

Home Office (2005): Science and Innovation Strategy 2005-08, 22 November 2005. Available at: http://www.scienceandresearch.homeoffice.gov.uk/

HM Treasury and BERR (2008): 'Enterprise: unlocking the UK's talent', March 2008. http://www.berr.gov.uk/files/file44992.pdf

HM Treasury (2007): 'The Race to the Top' - Sainsbury Review of Science and Innovation: http://www.hm-treasury.gov.uk/d/sainsbury_review051007.pdf

HM Treasury and DIUS (2007): 'Science and Innovation Investment Framework 2004-2014: Annual Report 2007: http://www.berr.gov.uk/files/file40538.pdf

HM Treasury (2007): Lisbon Strategy for Jobs and Growth UK National Reform Programme: Update on progress. http://www.hm-treasury.gov.uk/d/lisbon_nationalreformprogramme210907.pdf

HM Treasury (2006): Lisbon Strategy for Jobs and Growth UK National Reform Programme: Update on progress: http://www.hm-treasury.gov.uk/d/lisbon_natreform151006.pdf

HM Treasury (2006): Gowers Report on Intellectual Property

HM Treasury (2005): Lisbon Strategy for Jobs and Growth UK National Reform Programme: http://www.hm-treasury.gov.uk/d/lisbon_jobs131005.pdf

HM Treasury, The Lambert Review of Business-University Collaboration, HM Treasury Consultation Review, 2003.

Malik, K., Gagliardi, D. and Cunningham, P. INNO-Policy TrendChart - Policy Trends and Appraisal Report, United Kingdom 2008, August 2008

Ministry of Defence (2005): Defence Industrial Strategy – Defence White Paper, December 2005: http://merln.ndu.edu/whitepapers/UnitedKingdom-2005.pdf

National Audit Office (2007): Big Science: Public investment in large scientific facilities HMSO

OECD (2006a): Going for Growth. OECD, Paris

OECD (2006b): Education at a Glance, OECD, Paris http://www.oecd.org/edu/eag2006

Office of National Statistics (2007): Business Enterprise Research and Development 2006, National Statistics: http://www.statistics.gov.uk/pdfdir/berd1104.pdf

Office of National Statistics (2006b): Economic Trends 628, March 2006, ONS, pp. 58-64: March: http://www.statistics.gov.uk/articles/economic_trends/ET628.pdf

OSI – Office for Science and Innovation (2007): Measuring economic impacts of investment in the research base and innovation: a new framework for measurement

Royal Society (2008), A Higher Degree of Concern? January 2008.

The Patent Office, "Innovation Support Strategy": http://www.patent.gov.uk/innovationstrategy.pdf

Technology Strategy Board. http://www.dti.gov.uk/innovation/technologystrategy/innovation_platforms/index.html

List of Abbreviations

AHRC	Arts and Humanities Research Council
BBSRC	Biotechnology and Biological Sciences Research Council
BERD	Business Enterprise Expenditure on R&D
BERR	Department for Business, Enterprise and Regulatory Reform
BSSP	Business Support Simplification Programme
CBI	Confederation of British Industry
CCLRC	Council for the Central laboratory of the Research Councils
CIHE	Council for Industry and Higher Education
CSA	Chief Scientific Adviser
CSR	Comprehensive Spending Review
CST	Council for Science and Technology
DAs	Devolved Administrations
DIUS	Department for Innovation, Universities and Skills
DEFRA	Department for Environment, Food and Rural Affairs
DH	Department of Health
DCLG	Department for Communities and Local Government
DCMS	Department for Culture, Media and Sport
DELNI	Department of Education and Learning Northern Ireland
DFID	Department for International Development
DGSI	Director General, Science and Innovation
DTI	Department of Trade and Industry
EIRF	Economic Impact Reporting Framework
EIS	European Innovation Scoreboard
EPSRC	Engineering and Physical Sciences Research Council
ERA	European Research Area
ERP	Energy Research Partnership
ESRC	Economic and Social Research Council
ETI	Energy Technologies Institute
EU	European Union

FCO-SIN	Foreign & Commonwealth Office – Science and Innovation Network
FDI	Foreign Direct Investment
FEC	Full Economic Costing
FE	Further Education
FP	Framework Programme
G7	Group of seven industrialised nations
GBAORD	Government Budget Appropriations or Outlays for R&D
GDP	Gross Domestic Product
GERD	Gross Expenditure on R&D
GO-Science	Government Office for Science
GOVERD	Government Expenditure on R&D
GSIF	Global Science and Innovation Forum
HE-BCI	Higher Education-Business and Community Interaction
HEFCE	Higher Education Funding Council for England
HEI	Higher Education Institutions
HEIF	Higher Education Innovation Fund
HERD	Higher Education Expenditure on R&D
HMT	Her Majesty's Treasury
IPTS	Institute for Prospective Technology Studies
JRC	Joint Research Centre
KTN	Knowledge Transfer Network
KTP	Knowledge Transfer Partnership
MoD	Ministry of Defence
MRC	Medical Research Council
NCGE	National Council for Graduate Education
NERC	Natural Environment Research Council
NESTA	National Endowment of Science Technology and the Arts
NRP	National Reform Programme
NSA	National Skills Academy
OECD	Organisation for Economic Co-operation & Development
ONS	Office for National Statistics
OSI	Office for Science and Innovation
PRO	Public Research Organisation
PSA	Public Service Agreement
PSRE	Public Sector Research Establishment
R&D	Research and Development
RAE	Research Assessment Exercise
RDA	Regional Development Agency
REF	Research Excellence Framework
RIS	Regional Innovation Strategy
RTO	Research Technology Organisations
S&T	Science and Technology
SBRI	Small Business Research Initiative
SBS	Small Business Service

SET	Science, Engineering and Technology
SFLG	Small Firms Loan Guarantee
SME	Small and Medium-sized Enterprise
SRIF	Science Research Investment Fund
STEM	Science, Technology, Engineering & Mathematics
STFC	Science and Technology Facilities Council
TSB	Technology Strategy Board
UKTI	UK Trade and Investment

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Abstract

The main objective of ERAWATCH country reports 2008 is to characterise and assess the performance of national research systems and related policies in a structured manner that is comparable across countries. The reports are produced for each EU Member State to support the mutual learning process and the monitoring of Member States' efforts by DG Research in the context of the Lisbon Strategy and the European Research Area. In order to do so, the system analysis focuses on key processes relevant for system performance. Four policy-relevant domains of the research system are distinguished, namely resource mobilisation, knowledge demand, knowledge production and knowledge circulation. The reports are based on a synthesis of information from the ERAWATCH Research Inventory and other important available information sources.
This report encompasses an analysis of the research system and policies in United Kingdom.

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