CREST 3% OMC Third Cycle Policy Mix Peer Review

Country Report United Kingdom

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List of acronyms

BBSRC	Biotechnology and Biological Sciences Research Council
BERD	Business Enterprise Expenditure on Research and Development
CIS	Community Innovation Survey
CREST	European Union Scientific and Technical Research Committee
CSA	Chief Scientific Adviser
DGRI	Director General for Research and Innovation
DTI	Department of Trade and Industry
EPSRC	Engineering and Physical Sciences Research Council
ESFRI	European Strategy Forum on Research Infrastructures
ESRC	Economic and Social Sciences Research Council
FDI	Foreign Direct Investment
FEC	Full Economic Costing
GERD	Gross Expenditure on Research and Development
GDP	Gross Domestic Product
GSIF	Global Science and Innovation Forum
HE	Higher Education
HEI	Higher Education Institute
HEIF	Higher Education Innovation Fund
HERD	Higher Education Expenditure on Research and Development
IP	Intellectual Property
MRC	Medical Research Council
NAO	National Audit Office
NERC	Natural Environment Research Council
NIS	National Innovation System
OMC	Open Method of Coordination
OSI	Office of Science and Innovation
PPARC	Particle Physics and Astronomy Research Council
PSRE	Public Sector Research Establishment
R&D	Research and Development
RAE	Research Assessment Exercise
RC	Research Council
RDA	Regional Development Agency
SEEDA	South East England Development Agency
SET	Science, Engineering and Technology
SIIF	Science and Innovation Investment Framework 2004-2014
SME	Small and Medium-sized Enterprise
SRIF	Science Research Investment Fund
S&T	Science and Technology
STEM	Science, Technology, Engineering and Mathematics
ST&I	Science, Technology and Innovation
SWOT	Strengths, Weaknesses, Opportunities, Threats
TSB	Technology Strategy Board
TT	Technology Transfer

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1 Introduction

As part of the policy mix peer review process instigated by CREST during the third cycle of the Open Method of Coordination, a review team comprised of representatives of EU Member States, the European Commission and an independent consultant visited the UK in January 2007.

This document is the report of the review team to the CREST 3% OMC Policy Mix Group. It presents a synthesis of the views of all the experts who took part in the review of UK R&D and innovation-related policies. The team was comprised of the following experts:

- **Thomas Alslev Christensen**: Danish Agency for Science Technology and Innovation, Denmark
- **Christian Seiser**: Federal Ministry for Education, Science and Culture, Austria
- **Laurent Buisson**: Service de l'innovation et de l'action régionale, Direction générale de la recherche et de l'innovation, Ministère délégué à l'enseignement supérieur et à la recherche, France
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To prepare for their visit to the UK, the experts were provided with a background report written explicitly for the purpose of this policy review. The OMC Policy Review Background Report on the UK (separate Annex A) provides information on the Science Base, Business R&D and Innovation, Economic and Market Development, Human Resources and the overall Innovation System.

On 22-24 January 2007, the Peer Review Team visited the UK and held a series of interviews with senior officials from Government, Research Councils, business, universities, agencies and representative bodies in the UK. These visits were hosted by the Department of Trade and Industry in London. The interview programme, organisational arrangements and details of the key stakeholders interviewed are presented in Annex 1. The key issues addressed by the review team are presented in Annex 2.

The following report commences with a very brief overview of the UK ST&I system (in the form of a summarised SWOT analysis covering the five sections used to structure the background report (see separate Annex A): Science Base (R&D capacity); Business R&D and Innovation; Economic and Market Development (absorptive capacity); Human Resources (human and social capacity); and the Overall

Innovation System). This is followed by a synthesis of the experts' observations, organised on the basis of the key issues identified during the interview process. The final sections provide recommendations for the UK and report on some lessons learnt by the reviewers to disseminate in their own countries and organisations.

2 The United Kingdom R&D and Innovation System

This section uses a basic SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis format to summarise the contents of the background report prepared for the review team (see separate Annex A). In this background report, the National Innovation System was broken down into four domains relating to: the Science Base; Business R&D and Innovation; Economic and Market Development; and Human Resources. SWOT tables are presented for each of these domains. A final section of the background report offered some perspectives on the innovation system as a whole, looking at the challenges it faces and the lessons to emerge from an overview of policy developments in the UK.

2.1 The Science Base

The UK Science Base: SWOT analysis

Strengths

- Public sector spending on R&D (PUBERD) has generally increased over the last decade
- Strong performance and world ranking in research outputs (publications and citations); second to USA in most metrics
- Very strong in terms of research outputs per researcher, with balanced strengths across all fields
- UK has 2nd largest (and growing) share of the world's most highly cited papers
- UK has above EU average output of PhDs per unit HERD spend
- UK PhD awards concentrated in natural sciences, where the UK has relative research strength

Weaknesses

- UK is spending less on research as proportion of GDP than its competitors and EU15
- Gap between research performance and translation into commercially competitive products, processes and services
- Frequency of R&D personnel is also low (0.45% of population); UK is below EU average and below all except Italy in G8
- Falling percentage of HERD funded by Business Enterprise sector
- UK is weak in provision of basic and intermediate skills in the workforce

Opportunities

- Translation of research excellence into competitive performance

Threats

- GERD as % of GDP has declined recently
- Public sector spending on R&D (PUBERD) has recently dropped
- Numbers of UK PhD awards are average but smaller (EU and SE Asian) countries are increasing their shares
- Uptake of some science degrees (physics, chemistry) are dropping – some university departments face closure
- Below comparator group average productivity of medical sciences PhDs and falling outputs of PhDs in engineering.
- Introduction of FEC may discourage industry spending in HE sector

2.2 Business Enterprise R&D and Innovation

UK Business Enterprise R&D and Innovation: SWOT analysis

Strengths	Weaknesses
• Above EU average for total innovation expenditure • Above EU average for employment in high-tech services • Above EU average in triadic patents • Strongly performing pharmaceuticals and aerospace sectors with strong R&D capabilities	• Consistent relatively low levels of innovation activity and BERD, with recent further decline • Low share of firms that receive public funding for innovation (46% of EU average) – although CIS omits tax incentives (favoured in UK policy) and focuses on direct support (discouraged in UK policy) • UK performs at 33% of EU average for new-to-market product sales • Weak on innovation demand due to very low levels of capital investment (and poor customer responsiveness) • Scores poorly on innovation governance (but due entirely to low score for e-governance)
Opportunities	**Threats**
• Strengthening the linkages between the business enterprise sector and the science base would improve the capture of the latter's outputs and capabilities and enhance productivity and competitiveness • Strengths in services sector could benefit from targeted innovation policies	• Long term effects of deficiencies in skills base and declining interest in physics, chemistry and engineering may negatively affect industrial R&D capacity

2.3 Economic and Market Development

UK Economic and Market Development: SWOT analysis

Strengths	Weaknesses
• UK has experienced period of relative macroeconomic stability • Strongly performing science and engineering base • Relatively strong in innovation cooperation • Positive attitudes to enterprise • Good access to finance for start-ups • Indicators of healthy enterprise activity by SMEs • Openness to foreign competition, light touch product market regulation and highly regarded competition regime • High stock of inward investment	• Long-standing productivity gap (output/hr and output/worker) with main competitors • Low business and government investment levels resulting in comparatively poor infrastructure • Low total and business investment in R&D relative to GDP • Generally poor performance in patenting (but tendency to use design complexity and copyright as alternatives)
Opportunities	**Threats**
• Productivity gap is closing • Increasing levels of government investment • Scope to build on the strength of the science and engineering base • Low start-up costs and administrative burdens • Light touch product market regulation and highly regarded competition regime	• Aversion to risk may prevent uptake of opportunities for enterprise • Firms report low customer demand for innovation

2.4 Human Resources

UK Human Resources: SWOT analysis

Strengths	Weaknesses
• High output of S&E graduates (172% of EU average) • High participation levels in lifelong learning (215% of EU average) • Above EU average in terms of working population with tertiary education • Relatively high proportion of workforce with SET degrees • High level of student mobility as measured by foreign students studying in UK	• UK has lower availability of highly skilled people with research training than its competitors (only 0.3% of population; 0.6% of labour force). UK ranks lowest in G8. • Poor performance in basic literacy and numeracy skills in workforce • Perception of poor management skills levels in some areas • Low proportion of its population qualified at the intermediate level, with concerns about the quality of vocational qualifications at the intermediate level.
Opportunities	**Threats**
• Scope for improvement of average performance in terms of % of population (aged 20-24) having completed at least upper secondary education • Improving entrance to and retention of S&E graduate output in innovation-relevant workforce could benefit overall industrial innovation performance	• Large proportion of population with low-level skills • Risk of loss of university departments teaching of S&E subjects in strategically critical areas of the economy (e.g. physics, chemistry, engineering) due to low student uptake of these subjects.

2.5 Overall Innovation System

Looking across the UK Innovation System as whole, the background report identified three major **challenges** faced by the UK. These are to:

- Increase the intensity of innovation activity in enterprises;
- Strengthen linkages between the public research base and business;
- Match future skills needs and improve the supply of high quality labour.

The background report also reviewed the UK's R&D and innovation policies and identified a number of **lessons** relevant to the attainment of the Lisbon objectives. These may be summarised as follows:

- Coordinated approaches to policy formulation play a critical role in the formulation and implementation of the UK policy mix, with a clearly identifiable lead agency taking responsibility for innovation, and good coordination links with all other relevant policy actors;
- Policymakers in the UK aim to set clear and realistic long-term targets and goals, together with the production of strategies which clearly communicate Government's intentions to all actors in the innovation system;
- The UK benefits from an open and transparent process of policy making and implementation;
- The UK has a strong governance regime in which a prominent role is given to the processes of monitoring, evaluation and review (at the system and sub-system levels), coupled with good feedback mechanisms influencing future policy formulation and implementation.

3 Commentary by the Review Team

This Section contains a synthesis of the views of the Peer Review Team members after the review visit in January 2007. Overall, the Review Team was positive in its opinion of the UK's ST&I system and the mix of relevant policies in place. The team highlighted the following areas where the UK system of innovation was able to demonstrate specific strengths:

- Its **capacity for R&D**, both within the Science Base and industry;
- Its system of **innovation policy governance**; and, in particular,
- The general **attention to quality** and the measures in place to help achieve this.

3.1 Science Base Capacity and Performance

In terms of capacity, the Science Base**,** comprising over 140 universities with around 300,000 teaching staff, together with Government laboratories and a large number of Research Council institutes and centres, was thought to offer a very rich source of innovation potential. It was noted that the UK has been able to create a system of innovation that focuses and capitalises on the strengths of its research base, its world-class universities and its excellent research institutions.

The peer reviewers commented on the **excellence of UK universities**, **research institutions and personnel** and the extremely **high quality of R&D** and educational activities. For example:

- The UK ranks second in the world in seven out of ten broad disciplines;
- It has the second largest (and growing) share of the world's most highly cited papers;
- It has above the EU average output of PhDs per unit of HERD spent.

The reviewers also looked favourably upon attempts to **strengthen the second and third functions of universities** (i.e. research and linkage with the business sector)[1], through:

- An increasing interest and commitment to developing:
  - collaborative R&D and innovation-oriented activities;
  - the supply of specialised courses and services in support of businesses and the entrepreneurial environment;
- The contribution to economic prosperity of the region, through the wide variety of services for S&T knowledge dissemination and transfer, and the accelerated pace of creation and evolution of spin-offs and science parks/incubators.

The UK's system of **funding research at universities**, primarily based on a competitive allocation process overseen by the Research Councils, was also highlighted as a strength, whilst a further strength of UK universities themselves was their orientation towards the international scene in terms of:

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[1] In this perspective, teaching is the first function.

- The supply of educational and training services (through both seeking additional sources of interested clients and expanding their educational markets world-wide and also by attracting more foreign students to the UK;
- Their R&D activities (notably the level of participation in international R&D projects at both European and global levels, many of them coordinated by UK participants).

The peer reviewers also noted that UK universities provide a best practice system for the provision of research-based technological services and that there was a high degree of collaboration between universities and large private enterprises.

However, the review team expressed some concern over the low proportion of R&D personnel as a percentage of the overall population (0.45%), with the UK lying below the EU average and below all G8 countries with the exception of Italy in terms of this indicator. In addition, although the UK seems to focus on world-class academic research, and despite the existence of a number of key policy initiatives[2], it appears to pay less attention to research dedicated to key non-military technologies (in fields such as energy, microelectronics, computational infrastructures, etc.) than it does to defence-related research.

It was also noted that, although the UK boasts a world class science base, the quantity and quality of the people leaving the primary and secondary education systems and continuing SET activities in the tertiary sector and beyond were inconsistent with the expectation that the tertiary system will be able to sustain and further enhance its world-class status. In turn, this prompted the opinion that a more 'joined-up' education and innovation policy perspective was probably required.

Moreover, whilst UK policy exhibits a strong focus on support for world-class academic research projects through competitive funding schemes, the future provision of the scientific infrastructures needed to support such research is open to question. Even the introduction of Full Economic Costing for research projects may not provide the all the necessary finance needed to replenish infrastructures, as such facilities are difficult to sustain through competitive schemes alone.

3.2 Business Enterprise R&D and Innovation Performance

The peer reviewers noted that a number of indicators reflected positively on the current UK situation, including:

- The proportion of UK companies with R&D above £2.9 million and with high R&D intensity (over 10%) is rising and is significantly above that of the rest of the EU (although still below the USA);

[2] The Background Report noted a number of large–scale research programmes in the UK. These included the cross-Research Council programmes in: stem cell research; sustainable energy economy; rural economy and land use; e-science; post-genomics and proteomics; and basic science (including grid computing). The ongoing establishment of the new Energy Technology Institute was also mentioned during the interview programme, as were the technology priorities of the Technology Strategy Board.

- UK R&D is particularly strong in pharmaceuticals and aerospace and contains a growing software sector (119 companies in 2006);
- There are 72 UK–owned companies in the Global 1250, making it the third largest country group (equal to Germany). These companies have a total R&D expenditure of £13.1 billion, an increase of over 8% over the previous year[3]. However, of the top 50 companies in the Global 1250, only three (GlaxoSmithKline, AstraZeneca and BAE Systems) are UK-owned.
- Private sector investment in R&D accounts for approximately 47% of civil GERD (2003);
- The comparative level of support from large enterprises for research performed in the public sector is impressive, even though the percentage of HERD funded by the business sector is falling;
- In performance terms, the UK has a strong financial services sector, which also makes a significant contribution to the economy.

On the negative side, the UK displays a **low level of total and business investment in R&D relative to GDP**. In addition, direct grant support to single firms for R&D and innovation is given a lower policy priority in UK policy than elsewhere, and a relatively low share of firms receive public funding for innovation (46% of the EU average)[4]. On the other hand, collaborative R&D schemes are favoured over single firm support instruments, and indirect support for R&D through tax incentives constitutes the central plank of support for R&D in the business sector [5]. This reflects the broad 'non-interventionist' character of UK innovation policy.

In terms of the structure of the UK economy, it was noted that the relative importance of the more traditional manufacturing industries is declining, whilst the service industry is well developed, especially the financial sector. This raises issues for the formulation of innovation policy, in particular for the formulation of policy catering for the specific needs of service sector companies. For example, the definition of research in the service sector and an understanding of its role need better clarification. One consequence of the large share of the services industry in the economy is that the UK's overall business R&D contribution is less apparent than in countries that have a larger manufacturing base. There are, for example, only 6 companies in the UK with R&D spends above €500 million and 12 with R&D spends higher than €250 million, as opposed to 10 and 21 respectively in France; and 15 and 20 respectively in Germany[6]. However, the most recent edition of the UK's R&D Scoreboard includes, for the first time, R&D expenditure data on companies from the service sector (namely banking and retail), where the contribution of service sector R&D expenditure is more apparent.

In terms of the overall sectoral mix of R&D performed in the UK, the privatisation of utilities companies and national research laboratories has led to a loss of capacity for

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[3] R&D Scoreboard, 2006: http://www.innovation.gov.uk/rd_scoreboard/highlights.asp

[4] This, however, is a function of the UK's industrial structure.

[5] A high percentage of businesses needing support could also be seen as a weakness of either the companies themselves or the innovation support system more generally.

[6] While this suggests that the UK may be over-concentrated in certain sectors, the new Value-Added Scoreboard (http://www.innovation.gov.uk/value_added/default.asp?p=home) presents some analyses that suggest it shows greater diversification than in France or Germany.

research in some areas of the economy and this was seen by the peer reviewers as a negative development with potentially adverse consequences for the UK's research portfolio.

A further concern was that continued low levels of private sector R&D as a proportion of GDP might threaten the overall performance of the UK R&D and innovation system.

3.3 Innovation Governance

3.3.1 Innovation governance strengths

The review team noted that the UK had some **particular strengths** with regard to the governance of its system of innovation, including:

- The use of thorough and consistent long-term, strategic policy planning (backed up by long-term funding commitments). One example is the Science and Innovation Investment Framework 2004-2014, which entails:
  - Multi-annual (3 year) delivery plans and annual reporting of achievements, which confer a degree of strategic stability and offer time for reflection on policy impacts;
  - A strong and permanent cooperation between Government Departments in order to ensure the proper achievement and delivery of planned results;
  - Strong leadership by the DTI in innovation policy matters, with equally strong efforts to coordinate innovation policy-making at the inter-ministerial level. Concentrating leadership for innovation policies in a single ministry, backed up by strategic intelligence, was felt to offer a major opportunity to fuse the 'R' and the 'D' in R&D policies into innovation policies;
  - The co-location of the Chief Scientific Advisor (broadly responsible for government policy on science) and the Director General for Research and Innovation (broadly responsible for innovation policy) within DTI was also viewed positively. Similarly, the division of responsibilities between other government actors is clear and well understood;
  - Although the DTI is still involved in some direct allocation of resources to innovation actors, the creation of the new Technology Strategy Board, which will distance the DTI from this responsibility, was seen a positive step;
  - The involvement of the Treasury in discussions on science and innovation policy, given its authoritative position in the UK system of governance, was viewed as a positive feature;
- The use of complex but inclusive policy making processes, based on large-scale reviews, consultations and debates designed to engage the public and key stakeholders in support of science (for example, the UK Science Forum);
- The use of in-depth analyses of different policy sectors to provide a sound basis for innovation policy development;
- A focus on developing a strongly output-oriented innovation policy;
- Engagement in world-wide efforts aimed at solving major S&T issues on the global agenda (for example, the Global Science and Innovation Forum and its associated strategy);

- A strong commitment towards the development of an appropriate framework for the formulation and implementation of technology and innovation policy. This includes:
    - the setting-up of the Technology Strategy Board;
    - the elaboration of the Technology Programme, which promotes industry-led R&D and innovation, in seven technology areas considered to be key priorities, each identified on the basis of a large-scale Foresight exercise (involving also more distant 'horizon scanning').

The Government's strong emphasis on **quality assurance** was also noted by the review team, in particular the strong interest to ensure and permanently increase the quality of R&D activities. In this respect, the most outstanding feature is the **strong and elaborate UK evaluation culture** and a well-established tradition of economic analysis. The commensurate level of resources allocated to evaluation of research in the public sector, through the Research Assessment Exercise (RAE), and to the evaluation of other public spending on research also impressed the review team.

On the other hand, the reviewers highlighted a number of possible weaknesses in the UK's governance of innovation policy, such as:

- The selection of a target of 2.5 % investment in terms of GDP, instead of a 3% target, was perceived as an apparent lack of ambition in terms of goal setting. However, it was accepted that this target was based on a pragmatic assessment of the UK's capacity for innovation and growth and offered a realistic goal, especially if becomes possible to capture R&D performed by the service sector in official statistics;
- The reluctance of the UK to take a more proactive stance on the provision of direct support for companies was also questioned. While the need to avoid market distortion was recognised, the case was made that direct support measures might be needed to rectify market failures and stimulate the demand for innovation.

It was suggested that more proactive industry-related strategies should be strengthened and could perhaps exhibit a greater focus on growth-company policies. Related to this point, the reviewers highlighted the potential of the new Technology Strategy Board as a strong advocate of cooperation between academia and industry.

3.3.2 Development of the ten-year investment framework for Science and Innovation

The Review Team noted that, building on the UK's strong progress in this area, opportunities could be developed from the further integration of R&D policy into a wider innovation policy framework, together with development of a continuous dialogue with universities, business associations and trade unions with the aim of developing the innovation system and ensuring an effective implementation of the Science and Innovation Investment Framework 2004-2014. Towards this goal, it would also be desirable to undertake an evaluation and midterm revision of the Science and Innovation Investment Framework 2004-2014. In this context, the review team welcomed the on-going review by Lord Sainsbury of the Government's innovation policy initiatives.

It was also felt that there was opportunity for cross-fertilisation between the Science and Innovation Investment Framework 2004-2014 and the National Reform Programme developed in the context of the Lisbon strategy.

3.3.3 Other governance issues

The UK Government should continue its strategic use of Foresight, an area in which it has established considerable strengths, and other strategic intelligence instruments (such as its increasing use of 'horizon scanning' exercises) to promote 'front-runner' entrepreneurship and new market opportunities, as exemplified by the initial efforts of the Technology Strategy Board.

In terms of the dominant role played by the service sector within the UK economy, the team felt that efforts should be made to develop a better understanding of the role played by R&D in this sector and the ways in which it could be supported. This would allow the existing suite of innovation support schemes to be adapted to meet the specific needs of the service sector.

3.4 Policy Interventions

3.4.1 Breadth of coverage

The UK deploys a comparatively broad range of policy instruments in the overall policy mix affecting R&D and innovation activities. In particular, the peer reviewers highlighted the wide and complex set of instruments addressing:

- The development of R&D activities and infrastructures in universities and the research institutions of the public sector. These include:
    - Competitive funding, through the R&D programmes financed by the Research Councils (with the introduction of Full Economic Costs for R&D activities conducted by universities);
    - Allocation-based funding (on the basis of the Research Assessment Exercise);
    - A range of measures for stimulating infrastructure development, knowledge transfer and innovation-oriented activities, including: the Science Research Investment Fund (SRIF), Knowledge Transfer Partnerships, Higher Education Innovation Fund, and the Public Sector Research Establishments Fund, etc;
- Interventions for stimulating R&D and innovation activities in the private sector. These include R&D grants and innovation support measures appropriate to the various stages of R&D and innovation activities, including:
    - Promotion of Collaborative R&D, Knowledge Transfer Networks and UK-specific Technology and Innovation Platforms, through the new Technology Programme;
    - Measures delivered via the RDAs, such as Knowledge Transfer Partnerships and the Higher Education Innovation Fund;
    - Tax incentives for business investment in R&D (with separate tax credit regimes for Large Enterprises and SMEs), and tax incentives for the Venture Capital funding of innovation (which was seen as an interesting approach);
    - Support for capital investments via Regional Venture Capital funds, Early Growth funds, the Venture Capital Trust etc;

- Improved procedures and practices for the management of IPR, including the use of the contract models suggested by the Lambert Report.

In terms of the broader policy mix, the review team felt there was a well-placed and commendable focus on deregulation and the development and enhancement of well-functioning goods and service markets, whilst open borders (the UK has a very open economy with few tariff and trade barriers) and a progressive immigration policy promote imports of high skilled workers. The low use of state aids was also noted as a positive factor.

One of the general observations made by the team concerned the broad definition of innovation employed by the UK Government. This covers not only technology-based innovation, but also innovation in terms of management practices, service provision, business models etc. Such a definition covers many of the innovations that occur in the service sector and does not restrict itself to the more usual technology-based innovations found in the manufacturing sector. It was felt that this openness to other forms of innovation places the country in a favourable position in terms of being able to stimulate, develop and capitalise upon innovation in its broadest sense.

3.4.2 R&D tax credits

The R&D-related tax credit regime, which forms the largest single measure of UK innovation support, was of particular interest to the review team. It was seen as potentially very supportive for stimulating business R&D and innovation nationally, but it could, perhaps, be further refined in the light of assessments of its operation, in order to encourage the more specific growth and development of certain types of company or particular sectors.

Several members of the peer review team felt that too much emphasis has been placed on the use of R&D Tax Credits as a stimulus for research and innovation in the absence of evidence to support the impact of this scheme[7]. In particular, the incentives for SMEs to increase their levels of R&D and innovation currently appear to be uncertain and may be insufficient to boost innovation in SMEs.

More generally, even though the UK has an extensive range of innovation support mechanisms for SMES (which encompass R&D grants, proof of concept support, collaborative R&D, targeted tax incentives for R&D, venture and seed capital accessibility and dissemination of best practice), the review team felt that the modest funding available for industrial research projects offered only low levels of support to SMEs, particularly in comparison to the levels of support for larger companies.

3.5 Regional Policies

One of the key achievements of the UK has been the phenomenal explosion of Science and Technology parks around universities (about 60). This has resulted in a number of major structural changes, such as:

[7] During the interviews, it was noted that the tax credits system was in its early stages and some preliminary figures were quoted. In addition, the Treasury undertook a thorough and wide ranging review of tax credit systems for the promotion of R&D prior to introducing the UK tax credit in a step-wise fashion.

- Localised changes to the general structure of the population of UK-based SMEs due to the comparatively large number of high technology start-ups and spin-offs evolving in proximity to the science parks;
- The resultant structural changes to local and regional economies, due to:
  - the emergence of new dominant technology profiles;
  - better economic performance recorded by companies based in the science parks;
  - the symbiotic relationships that have developed between S&T parks and host localities.

This latter point was thought to offer an opportunity for the UK, and in particular for the Regional Development Agencies, to enhance their impact on the innovation activities of SMEs in their regions, particularly if policies are focused on knowledge intensive SMEs. RDAs are already lead players in terms of their engagement with science parks and similar initiatives within their regions, implementing an extensive range of targeted policies for SMEs and cluster policies. Nevertheless, opportunities exist to further enhance and complement the already diverse set of existing instruments in place to support industry-university partnerships.

3.6 Technology and Knowledge Transfer

The review team felt that one of the main weaknesses of the UK NIS concerned the gap between its extremely high level of research performance and its (lower) capacity to translate this into commercially competitive products, processes and services (see the Background Report in Annex A for further details). A contributory factor was felt to be the low absorptive capacity within the UK for research-intensive developments (despite the UK possessing a large number of small high-tech companies). Accompanying this was a lack of technological services promoting research, development and innovation in small and medium-sized enterprises and an insufficient focus on the issue of knowledge exchange with SMEs.

Also it was noted that the UK's range of intermediary organisations engaged in the provision or facilitation of technology transfer to SMEs (which includes Industrial Liaison Offices and similar activities within universities, Business Links offices, specific activities within the RDAs, etc.) presented a complex picture for which it was difficult to obtain a policy overview.

3.7 Globalisation and Internationalisation

For the UK, it was felt that some of the greatest opportunities and, of course, challenges, seem to be those generated by the internationalisation of R&D in the context of economic globalisation. These opportunities and challenges cover both capacity and performance aspects and are primarily related, to a very significant extent, to Business Enterprise R&D and innovation (and not so much to the Higher Education sector, which already contains some highly visible and powerful international players).

3.7.1 Exploiting opportunities

Overall, due both to the **quality of its research** and the prevalence of the **English language,** the UK is well placed in the global competition for talent (in terms of students, scientists, etc.), and as a location for business-sponsored research or direct investment in R&D centres.

Thus, in order to make these opportunities produce full-scale results, there seems to be a need for even stronger policy measures, perhaps deriving from the GSIF[8] Strategy, related to the following complementary aspects:

- Facilitating the transformation of (the larger) UK 'national companies' (i.e. domestic firms) into international R&D players, by encouraging the expansion of their R&D centres and activities (and not only production capacity) to other countries, with a view to better adapt the new technologies and/or products to the envisaged clients/ markets;
- Supporting the evolving perspective of:
    - the UK becoming a major (European) attractor for the location of R&D activities belonging to large (mainly US-based) multinational companies. The goal would be to attract investment for new UK-based R&D centres. This observation was based primarily on the experience of the Medical Research Council in partnership with the medical research charity the Wellcome Trust, which presented a rather 'acquisition-oriented' picture of multi-national companies targeting either research activities in the public sector or outstanding research capacities in the private sector;
    - developing closer and longer term links and joint R&D activities between UK 'nationals' and multi-national companies, with a view towards a more equal relationship in R&D collaboration and the distribution of IPRs.

In essence, these measures could promote:

- Technologies that could provide the stimulus for conditions that might lead to the development of future specific lead markets[9];
- The attraction and retention of more, high-level, young UK graduates towards business R&D, which would capitalise on the UK's strengths in the production of such graduates.

3.7.2 Business Enterprise R&D and innovation challenges

Conversely, the increasing internationalisation of R&D brings with it several threats and associated challenges for the UK innovation system. There were felt to be two major threats or challenges in this area. Firstly, the apparent absence in the UK of 'critical mass' in certain key technology areas, i.e. the relative lack of technology clusters or competence centres, may imply that newly created or growing high-technology companies (possibly developed with substantial public support) could be vulnerable to the 'acquisition'-oriented behaviour of multi-national (non-UK owned) companies. Thus, UK investment in the development of such leading edge companies would be transferred abroad.

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[8] Global Science and Innovation Forum – an OSI strategic advisory body chaired by the UK Chief Scientific Advisor.

[9] Perhaps developing ideas emerging through the Innovation Platforms operated under the Technology Strategy Board.

Secondly, in a more and more globalised economy (particularly with reference to the high level of Foreign Direct Investment in research in the UK) the national innovation system runs the risk of losing its genuine UK context (with the NIS becoming the host of innovation rather than the driver or owner of innovation in the UK). Moreover, a substantial proportion of R&D in the UK is sponsored by foreign companies, which could become an issue if these decided to shift their investments to other locations.

These threats, however, are simply the obverse side of the opportunities already discussed. The UK stance is that an open economy is a strength and that more benefits are likely to be derived from it than from vain attempts to isolate the UK from international developments.

3.8 Human Resource Issues

The long-term availability of highly qualified human resources for research, in particular the issue of 'brain drain', appears to pose a long-term threat to the maintenance of the UK's strength in research and is a concern for the future policy mix.

For example, one potential threat facing the UK Science Base is a possible long-term decrease in the capacity for rapid 'renewal and growth' of the population of researchers, due to:

- An apparently decreasing proportion of students undertaking STEM-related studies, in spite of the increasing economic demand for this category of highly skilled personnel[10];
- The high proportion of foreign students participating in advanced research programmes (who may leave the UK on completion of their studies);
- The attraction of highly qualified UK university staff and researchers to (notably) US universities, largely due to the relatively greater opportunities to acquire and maintain scientific prestige, including apparently 'easier' research assessment processes; the higher financial attractions offered; and the highly competitive and challenging working environment, including the quality of laboratories and research facilities.

Similarly, in the area of Business Enterprise R&D and innovation, the UK faces a possible long-term decrease in the number of S&T specialists and engineers available for employment in technology-oriented companies due, in part, to the significantly increasing number of exceptional graduates absorbed by the (financial) services sector.

3.9 Sectoral Disparities and Policies

A further threat is the risk of the erosion of existing competitive advantages in some areas of business R&D, due to the UK's apparent low policy interest in concentrating its R&D potential at the sectoral level (for example, through developing even closer linkages between the science base and industry in key industrial sectors and by further stimulating stronger inter-firm cooperation/clustering).

[10] There are conflicting views on the available evidence for these trends (see DTI Economics Paper 16). Indeed, the most recent figures indicate an up-turn in student enrolments in this area.

On a broader level, there seems to be a disproportionate reliance on large enterprises and defence research. According to OECD statistics, the UK exhibits a relatively large public funding of industrial R&D, but this is focused, to a large extent, on large companies and military/defence applications. Thus, the externalities to the general innovation environment are unclear.

4 Main Lessons for the UK

4.1 Key Technological Research Needs

The existence of a gap between the science base and the R&D and innovation needs of the business sector, especially in relation to the development and demonstration end of the R&D spectrum, was clearly identified by representatives of both large and small scale businesses (the so-called “gap in the middle”). This seems to reflect a pressing need to reconsider the role of dedicated technological research institutes as public platforms for high-level technological services (thus complementing the ‘third mission’ of universities). It appears that, at present in the UK, such institutes are expected to evolve mainly in ‘critical’ areas (for example, energy or sustainable production and consumption, and also in areas such as measurement and standardisation in various technical domains).

There was some feeling that the research centres associated with former nationalised industrial sectors (such as energy, transport, telecommunications, etc.) had been lost with the privatisation of these industries and the parallel privatisation of some of the public sector research laboratories in these areas. There may thus be a need to (re)consolidate the UK’s network of technological research institutes in order to bridge the gap that seems to affect the business sector. This should be done in direct consultation with stakeholders from the UK’s dominant and emerging industries, particularly the UK’s industrial associations. It should also take into account relevant infrastructures of European interest (included in the ESFRI roadmap).

It was also pointed out that several countries on the continent have a long tradition of supporting innovation in business either directly, through the funding of public/private joint R&D projects, or through the development of research institutions dedicated to applied research. Large companies as well as small and medium-size businesses take advantage of this support, which is provided, for example, in Germany through the Fraunhofer Gesellschaft and in Sweden through Vinnova.

However, the transformation of the Technology Strategy Board into a new self-standing agency may offer an opportunity to take advantage of this experience, perhaps by benchmarking some of the present practices in other European technology agencies. Furthermore, the new Energy Technology Institute could examine the experiences of similar agencies on the Continent (for example, the Commissariat à l’énergie atomique in France), or even the experiences of ‘lead’ institutions in other technological areas (e.g. institutions effectively in charge of the R&D ‘roadmap’ in their respective fields or sectors).

4.2 Bridging Agencies/Instruments

The separation of ‘science’ and ‘innovation’ and the increasing variety of programmes and instruments for implementing technology and innovation policies leading to ‘knowledge-driven industries’ often require the creation of a special, dedicated agency, which usually operates in close connection with those ministries responsible for industry and economic competitiveness. Accordingly, the same type of agency, separated but closely connected to the DTI, might well be needed for the management of programmes supporting the implementation of the Technology Strategy.

Relevant examples from other countries include: Tekes (Finland); Vinnova (Sweden); and the more recent *Agence de l'Innovation Industrielle* (France). These could serve as useful models against which to benchmark the activities of the Technology Strategy Board.

4.3 Regional Innovation and the Role of the Technology Strategy Board

In the same context as above, while the RDAs provide a wide range of moderate scale instruments to support all forms of R&D and innovation activities at the level of individual (mostly small or medium size) businesses (performed either on their own or in collaboration with R&D organisations), the technology programmes associated with the Technology Strategy Board could potentially become highly appropriate platforms for developing multiple-actor collaborations and for instigating structural changes in the industrial fabric, through the strategic concentration of technological potential around the following areas:

- *Technology areas of high competitive interest*, in which the DTI could promote the creation of specific lead markets (in Europe) for new or highly innovative technologies, with a clear and strategic focus on long-term sustainability, such as energy, health, transportation (including public transport and automotives), etc. These could be developed through targeted public technology procurement policies and tailored public-private partnership instruments[11];

- *Strongly and visibly integrated sectoral or regional clusters*, which would promote the technology profiles and the associated R&D agendas that are expected to have a major impact on the long-term development of the respective sectors/regions. These could be delivered through competitions between technology programmes developed by the regions, tailored according to their specific needs, and identified on the basis of regional foresight studies. Relevant examples from other countries include: the Finnish centres of excellence programme in science, technology and innovation; the Swedish Competence Centres; and the German Inno-Regio Programme.

4.4 Tax incentives for R&D: Further Diversification

Despite the UK's large number of financial and fiscal instruments for stimulating R&D and innovation activities in the business sector, in particular in SMEs (with special emphasis on the Grants for R&D and the R&D tax credits schemes), it might be useful to have an even further diversification of instruments, through complementary alternatives, such as:

- Tax incentives related to R&D incomes (for further promotion of the development of demand-driven, industry-led, R&D activities);
- The wider and more popular use of both loan and capital instruments, including venture capital specifically for R&D and R&D-related activities;
- Tax incentives to attract major foreign R&D centres/activities.

[11] The pilot Innovation Platforms operated by the Technology Strategy Board perhaps address this issue and may offer an appropriate example.

4.5 Evidence of the Impact of the R&D Tax Credit

The impact of the – relatively new – R&D Tax Credit will have to be assessed as soon as enough data is available. Two years ago, France started to assess the impact of its own research tax credit system, which was introduced at the beginning of the 1980s. In its methodology, an attempt is made to make comparisons between the performance of two populations of companies: one in which companies have taken advantage of the tax credit; and the other in which companies have not taken advantage of it.

4.6 Broader Lessons/Suggestions

- Provide resources (through the Research Councils?) for curiosity-driven, high-risk ideas which are neither goal-oriented not immediately exploitable and which reach beyond impact assessments and the output-driven evaluation culture (while the latter should of course remain a main pillar of the NIS);
- Provide visible support to those players of the NIS that help the take-up of new knowledge (with particular emphasis on strong collaboration schemes between industry and universities);
- HM Treasury should consider adopting an even broader view of the NIS with regard to the policy mix in order to help avoid long-term harm to the NIS if indirect support measures prove less effective than postulated;
- Put more focus on increasing the numbers of academics employed in private enterprises and the business sector by providing support for mobility schemes.

5 Main Lessons for Other Countries

Each member of the peer review team highlighted the most pertinent lessons for R&D and innovation-related policies in their own country. These are summarised below.

5.1 Innovation Governance

The overall governance of the UK national innovation system was appreciated by all the reviewers. For the Austrian representative, the co-ordination mechanisms under the remit of the UK's Chief Scientific Advisor were a particular example of good practice. There is strong political leadership and a clearly identified leadership role through the DTI. Similarly, there is strong coordination of innovation policies across ministries (both lessons for Denmark and Finland). Likewise, the DTI and, especially, the Office for Science and Innovation since April 2006, have assumed a specific role in the coordination of scientific and technology policies in other government departments. The UK's Chief Scientific Advisor oversees this coordination with the support of a dedicated team. Although the OSI is a rather recent institution, France may take this experience into account when adapting its own procedures to coordinate the actions of the different ministries.

5.2 Evaluation Culture

The integrated approach demonstrated by the UK in using strategic intelligence for the development of new R&D activities was considered highly impressive. France, which is in the process of setting up a Directorate for strategy within the Ministry for Research, with a department dedicated to the analysis of science and innovation policies, was particularly impressed by the culture of evaluation and foresight in the UK.

5.3 Stakeholder Engagement in Policy Formulation

The UK's distinctive approach to technology and innovation policy, which clearly relies on the initiative and contribution (advisory and financial) of the private sector, forms a lesson for Romania. In order to translate this message, it may be necessary to emulate:

- Agencies and dedicated programmes, such as the Technology Strategy Board and the Technology Programme, ensuring that there is a strong and systematic involvement from the private sector from the very early elaboration phases;
- The development of associated firms, highly specialised in proof of concept[12] and knowledge transfer operations in order to strengthen the knowledge transfer capacity in universities and research institutions in the public sector.

5.4 Breadth of Policy Mix

The UK exhibits a broad policy mix with a highly diverse and complex set of policies in place to stimulate R&D and innovation activities in the business sector. For Romania, the main lesson was the need to establish a wide range of financial and fiscal instruments, through various direct and indirect state aid means, to complement collaborative R&D measures.

[12] It should be noted that 'proof of concept' funding has been introduced by the UK Research Councils, with Scottish Enterprise and the Welsh Assembly also introducing similar instruments.

5.5 Regional and Local Innovation Needs

From the UK's example, one lesson for Romania was the need to transform the way R&D and innovation is supported by the major promoters of regional and local development, mainly by:

- Giving Regional Development Agencies a key role as facilitators of the development of R&D and innovation activities in the business sector;
- Giving strong support to the development of science parks, as key determinants of structural economic change.

5.6 Funding Structure for HEIs

The use, in the UK, of a three-way funding system – which supports world-class research, academic research and innovation in universities via the Research Councils, the Higher Education Funding Councils and the Higher Education Innovation Fund – was of particular interest to France, which is contemplating a redefinition of its public support to higher education institutions.

5.7 Strengths of HEIs

The strong position of UK universities, in terms of their autonomy and high levels of performance, was seen as a lesson for the Danish context.

5.8 The Role of Services in the Economy

The UK's interest in the role and extent of R&D in the service sector and the implications for the measurement of R&D, together with the need to capture and understand this sector's specific requirements and the opportunities and threats it faces, was of particular interest to Austria.

5.9 Venture Capital Schemes

Finland might be able to learn from the experience of the UK in terms of its incentives to increase the level and availability of Venture Capital funding.

ANNEX 1

Interview Programme

On 22-24 January 2007, the Peer Review Team visited the UK and held a series of interviews (hosted by the Department of Trade and Industry in London) with senior officials from Government, Research Councils, business, universities, agencies and representative bodies in the UK.

The team comprised:

- **Thomas Alslev Christensen**: Danish Agency for Science Technology and Innovation, Denmark
- **Christian Seiser**: Federal Ministry for Education, Science and Culture, Austria
- **Laurent Buisson**: Service de l'innovation et de l'action régionale Direction générale de la recherche et de l'innovation Ministère délégué à l'enseignement supérieur et à la recherche
- **Rolanda Predescu**: Ministry of Education and Research, Romania National Authority for Scientific Research, Romania
- **Markus Koskenlinna**: Executive Director, Impact Analysis Tekes (Finnish Funding Agency for Technology and Innovations), Finland

They were accompanied by:

- Marnix Surgeon: DG RTD, European Commission
- Mark Boden: IPTS, European Commission

The lead consultant for the UK Review, Dr Paul Cunningham of PREST, University of Manchester, was also present and acted as facilitator for the meetings.

Organisational arrangements were handled by Caroline Jacobs and Brian Ditcham from the Office for Science and Innovation, Department of Trade and Industry. The UK representative on the CREST Policy Mix Group, Chris North, from the OSI/DTI, also attended as an observer.

The interviews were arranged into a number of issue-specific meetings. These, and the UK representatives interviewed are presented in the table on the following page:

Interview No.	Issues	Interviewees
1.	Finance and fiscal innovation issues	**Caroline Barr**: HM Treasury, Head of Science and Industry Team **Chris Stark**: HM Treasury, Budget, Tax and Welfare Directorate **Nick Munn**: DTI, Head of Business Finance and Investment Unit
2.	UK innovation system – impact assessment	**Mark Beatson**: DTI, Director, Science and Innovation Analysis
3.	Coordination and Governance of UK science	**Sir David King**: Government Chief Scientific Advisor, OSI
4.	Innovation budget and Science Budget	**Sir Keith O'Nions**: Director General for Research and Innovation, OSI
5.	Patents and Intellectual Property Rights	**Ron Marchant**: CEO and Comptroller General, UK Patent Office
6.	UK Technology Programme – creation of the Technology Strategy Board	**David Evans**: Director of Innovation Technology, DTI **David Way**: Director Innovation Platforms and Key Technologies, DTI
7.	The Regional dimension	**Ed Metcalfe**: South East England Development Agency (SEEDA), Head of Science, Technology, Entrepreneurship & Management team, Chair of Society of Chemical Industry, and national RDA lead role for regional Science and Innovation via DTI **David Mulligan**: SEEDA
8.	UK business and industry perspectives	**Chris Francis**: IBM UK **David Clarke**: Rolls Royce **Norman Price**: DTI industry secondee
9.	Support to the research base	**Neil Viner**: OSI, Research Base **Prof Stuart Palmer**: Deputy Vice-Chancellor, Warwick University **Catherine Coates**: Director, Planning and Communications, EPSRC
10.	Knowledge transfer	**Ashley Malster**: OSI, Research Base **Professor Rob Massara**: Deputy Vice-Chancellor and Pro-Vice Chancellor (Research & Business Development), University of Essex **Dr Doug Yarrow**: Director Innovation, BBSRC
11.	Bio-medical research	**Dr Roberto Solari**: MRC Technologies **Dr Mark Palmer**: Head of International Policy, Corporate Affairs Group, MRC
Dinner	At a dinner hosted by David Evans and Jeremy Clayton, the team were able to talk to some of those they had already met together with additional representatives of the UK innovation system. The meal ended with a round-table discussion of key issues.	**Dr Mike Tubbs**: DTI Business and Finance Investment Unit (R&D Scoreboard) **Chris Hale**: Policy Adviser, Universities UK **David Rawlins**: Acting Director International Technology Policy, OSI

ANNEX 2

Key Issues Addressed

This section presents the main issues addressed within each of the twelve interview sessions.

A. Finance and fiscal innovation issues

Key points addressed included:

- The National Reform Programme in the UK context, particularly the UK's 2.5% target for GERD/GDP by 2014 (in contrast to the 3% Lisbon target)
- Need to re-define key innovation indicators
- The role of FDI
- R&D Tax Credits – implementation, costs and impact
- Structural implications of the UK economy (for innovation and indicators): i.e. role of services (particularly financial services) and SMEs
- Suitability of R&D input as an indicator
- UK Science Forum
- Skills shortages and strategic responses
- Policy mix as an 'ecosystem approach' – role of other financing schemes

B. UK innovation system – impact assessment

Key points addressed included:

- Innovation support and the role of other Government Departments
- Policy levers to support innovation
- The Science and Innovation Investment Framework 2004-2014
- Role of evaluation
- The separation of strategy from implementation
- Sources of evidence – UK strengths and weaknesses – problems with indicators – the issue of benchmarking (with whom, against what?)
- The UK's evaluation culture and resources allocated to evaluation
- Need for greater attention on incentives (to various innovation actors)
- Moves towards more continuous system of monitoring and evaluation rather than periodic/ex post.

C. Coordination and Governance of Science

Key points addressed included:

- Coordination of scientific advice (to immediate needs/emergencies and for longer term R&D requirements)
- International science commitments and relationships (role of Global Science and Innovation Forum)
- UK Foresight programme (focus on how S&T can address future challenges)
- Moves towards 'horizon scanning' activities by departments
- Improving public confidence and dialogue on science and technology

- Challenge of cultural attitudes to innovation
- Universities' and industrial funding motivations
- Benefits of longer term strategic planning, e.g. the Science and Innovation Investment Framework 2004-2014 and the three-year Comprehensive Spending Review cycle.
- Threats to STEM (Science, Technology, Engineering and Mathematics) skills

D. Innovation budget and Science Budget

Key points addressed included:
- Role of the Research Councils, Research Budget, the Innovation Budget and HEIF
- Key challenges for governance: understanding role of innovation in the service sector; how to measure innovation beyond the framework of R&D; understanding ways in which government can stimulate both public and private sector investments
- Creation of the Technology Strategy Board and the Technology Programme
- Stimulating HE – industry collaboration and the issue of SMEs
- The Higher Education Innovation Fund
- UK strengths – why are financial sector and banking doing so well?
- Problem of capturing R&D in service sector
- UK political focus on productivity as generator of sources for investment – translating this to 'well-being'

E. Patents and Intellectual Property Rights

Key points addressed included:
- Role of IP, copyright, design, etc. in supporting innovation
- Findings of the Gowers Review into Intellectual Property
- Issue of balancing IP regimes to assist innovation
- Role of IPR in HE/business collaboration – need for frameworks and guidelines
- Next steps - multi-party collaboration agreements
- Lessons of Lambert models
- Key role of technology transfer offices in universities – need for TT staff qualifications?
- Need for dissemination of information on IP to business
- Community Patent – discussion of need versus issue of duplication

F. UK Technology Programme – creation of the new Technology Strategy Board

Key points addressed included:
- Role and need for the TSB
- Specific instruments: Innovation Platforms, Knowledge Transfer Networks, Collaborative R&D
- TSB stakeholders (presence of HE representatives, Unions, etc.)
- Use of co-financing model, inclusion of Structural Funds, role of RDAs
- How to assess impact of TSB

- Issue of GDP outstripping R&D spend
- Policy mix issues – balance of direct and indirect measures (need for evaluation of impact of tax credits), reinforcement of strengths versus supporting weaker areas
- Role of defence spending
- Role of procurement for encouragement of innovation

G. The Regional Dimension

Key points addressed included:

- History of RDAs
- Establishment of Science and Innovation Councils – development of strategic role for RDAs
- Issues concerning collaboration
- Sources of funding and the 'single pot'
- RDAs: role in forming networks and developing skills
- Weakness in the market for technical skills
- Innovation Advisory Service
- Problem of addressing full range of UK companies

H. UK business and industry perspectives

Key points addressed included:

- Absence of attention to innovation in public sector (reference NAO report on innovation in Government[13])
- Need to address balance of services component of economy (70% of economy) – questions relevance of UK R&D figures – need for redefinition of Frascati – measurement tools may not fit the UK situation as they are tech-focused
- Fragmentation of UK R&D base efforts
- Absence of continuity of funding (support) from pure research through to innovation: gaps seem to lie in development and demonstration areas
- SME perspective echoes this – good at basic research, poor at translational research. Strengths in pharmaceuticals reflect its reliance on pure research
- Absence of venture capital support for investment in intangible outputs
- SMEs also suffer from poor absorptive capacity – no UK equivalent of Fraunhofers
- Skills and STEM issues – is the supply of graduates to the City really a problem, and is it why the City does well?
- Industry concern over the introduction of Full Economic Costing and its potential impact on university research commissioned by industry
- R&D base too focused on excellence rather than adequacy, especially for SMEs

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[13] National Audit Office, *Achieving innovation in central government organisations*. HC 1447-I Session 2005-2006, the Stationery Office, 25 July 2006

I. Support to the research base

Key points addressed included:

- Issue of Research base/Industry linkage: what is the benchmark? Some areas exhibit high levels of linkage. Not a problem for large companies who may establish strategic partnerships – problem for SMEs
- Role of RDAs – some RDA targets and requirements are not relevant to University missions
- Impacts of Ten-year Science and Innovation Investment Framework (SIIF) – too early to measure as most data stop in 2003/2004
- UK science base is high quality – industry may go abroad but cheaper research may not be suitable – FEC may be a deterrent to collaboration
- Shift to larger, longer term grants funding well defined projects
- Does Research Council funding substitute for industry funding?
- Loss of research labs over past 10 years or so threatens research capabilities in energy, steel, nuclear, etc. Role of specialised institutes such as Energy Technology Institute
- Closure of physics, chemistry departments may be overstated, but shortages of graduates in certain areas are a concern, particularly for longer term. However, demand from industry will always outstrip supply
- Gender and diversity issues

J. Knowledge transfer

Key points addressed included:

- Details of development of HEIF – critical role of HEIF as initiator of third stream support (but not on equal scale to Research Council and Funding Council inputs) – diversity of activities supported by HEIF
- Introduction of 'proof of concept' funding by Research Councils
- Role of Research Council institutes and PSREs Fund; spin-outs from RC Institutes
- Positive impacts of University Challenge and Science Exploitation Challenge funds
- Role of RAE as primary driver in university research behaviour – contradictory goals to HEIF which is too small to influence behaviour
- Demand for economic returns from Research Council activities
- Concern over long-term stability of third stream funding (which is liked by industry)
- Strength of venture capital into university sector
- Concern over lack of policy governance/guidance on individual knowledge transfer activities (difficult due to diversity of activities)

K. Bio-medical research

Key points addressed included:

- Treatment of IP by MRC (differs from other Research Councils)

- Activities of MRC Technology – covers gap in late stage IP take up and undertakes proof of concept
- Allocation of MRC funds and prioritisation
- Funding and governance of institutes and units
- Tensions between HE and institutional demands for funding
- Significance of Wellcome Trust and other medical charities
- Modes of industry collaboration and interaction – MRC Showcases
- Examples of MRC flotations etc.
- Outsourcing of industrial research overseas
- MRC/Department of Health relationships – single medical research funding pot
- Skills and research base shortages – no major problems – funding for repatriation of UK PhDs

ANNEX 3

CREST 3% OMC Third Cycle
Policy Mix Peer Review

Background Report
United Kingdom

September 2007

Paul Cunningham
Manchester Institute of Innovation Research

This report was prepared on behalf of the ERAWATCH ASBL as part of the IPTS support to the CREST 3% OMC Policy Mix Peer Reviews
(Specific Contract No. C150176.XII)

CREST 3% OMC Third Cycle
Policy Mix Peer Review
United Kingdom Background Report

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CREST 3% OMC Third Cycle
Policy Mix Peer Review
United Kingdom Background Report

Executive Summary

This background report has been produced to support the CREST OMC 3% Peer review of Member States. It presents a structured set of information relating to the overall innovation system of the UK.

For the purposes of this report, the National Innovation System has been broken down into four domains relating to: the Science Base; Business R&D and Innovation; Economic and Market Development; and Human Resources. Central to, and linking all four domains is 'Governance'. This country report follows this structure and consists of six main sections corresponding to a general introduction (which provides a general overall picture of the key features of the UK innovation system), four separate sections dealing with challenges and policy responses in each of the four separate innovation system domains (policies dealing with the interface between domains are treated just once to avoid duplication), and a final section again dealing with the innovation system as a whole, but focusing on challenges and responses, conflicts and synergies, policy orchestration and lessons relevant to the Lisbon agenda.

Each of the four major analytical sections is summarised by means of a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis each of which is presented as a table. These tables are reproduced below to provide an overview of the main findings of each section of the report:

Science Base

This section provides a picture of the strengths and weaknesses of the public sector science base and the policy initiatives in place to improve overall performance. The section reviews of some of the more important quantitative and qualitative indicators describing the science base and then covers: the governance of policies affecting the science base; major policy objectives in the area; the range and nature of policy instruments currently in place to effect change; and any evidence of the effectiveness of policies in this area.

The UK Science Base: SWOT analysis

Strengths	Weaknesses
• **Public sector spending on R&D (PUBERD) has generally increased over last decade** • **Strong performance and world ranking in research outputs (publications and citations); second to USA in most metrics.** • **Very strong in terms of research outputs per researcher, with balanced strengths across all fields.** • **UK has 2nd largest (and growing) share of world's most highly cited papers**	• **UK is spending less on research as proportion of GDP than its competitors and EU15.** • **Gap between research performance and translation into commercially competitive products, processes and services.** • **Frequency of R&D personnel is also low (0.45% of population); UK is below EU average and below all except Italy in G8.** • **Falling percentage of HERD funded by Business Enterprise sector.**

Strengths (cont.)	Weaknesses (cont.)
• **UK has above EU average output of PhDs per unit HERD spend.** • **UK PhD awards concentrated in natural sciences where the UK has a relative research strength.**	• **UK is weak in provision of basic and intermediate skills in the workforce.**
Opportunities	Threats
• **Translation of research excellence into competitive performance.**	• **GERD as % of GDP has declined recently** • **Public sector spending on R&D (PUBERD) has recently dropped** • **Numbers of UK PhD awards are average but smaller (EU and SE Asian) countries are increasing their shares.** • **Uptake of some science degrees (physics, chemistry) are dropping – some university departments face closure.** • **Below comparator group average productivity of medical sciences PhDs and falling outputs of PhDs in engineering.** **Introduction of FEC may discourage industry spending in HE sector**

Business Enterprise R&D and innovation:

This section offers a picture of the strengths and weaknesses of the technological and innovative performance of industry and the policy initiatives in place to improve overall performance. Structurally, it follows the same format as the preceding section.

UK Business Enterprise R&D and innovation: SWOT analysis

Strengths	Weaknesses
• **Above EU average for total innovation expenditure.** • **Above EU average for employment in high-tech services.** • **Above EU average in triadic patents.** • **Strongly performing pharmaceuticals and aerospace sectors with strong R&D capabilities.**	• **Consistently relatively low levels of innovation activity and BERD, with recent further decline.** • **Low share of firms that receive public funding for innovation (46% of EU average) –although CIS omits tax incentives (favoured in UK policy) and focuses on direct support (discouraged in UK policy).** • **UK performs at 33% of EU average for new-to-market product sales.** • **Weak on innovation demand due to very low levels of capital investment (and poor customer responsiveness).** • **Scores poorly on innovation governance (but due entirely to low score for e-governance)**
Opportunities	Threats
• **Strengthening the linkages between the business enterprise sector and the science base would improve the capture of the latter's outputs and capabilities and enhance productivity and competitiveness.** • **Strengths in services sector could benefit from targeted innovation**	• **Long term effects of deficiencies in skills base and declining interest in physics, chemistry and engineering may negatively affect industrial R&D capacity.**

policies.

Economic and Market development

This section deals with overall economic and market development, both in terms of the ways in which innovation shapes them and the ways if which the policies governing them can affect innovative behaviour in other parts of the innovation system, particularly in the business arena. It is particularly concerned with the ways in which policies can affect the absorptive capacities of markets, stimulate demand for new technologies and services and increase the flow of investment in innovative activities. Again, it follows the structure as the preceding sections.

UK Economic and Market development: SWOT analysis

Strengths	Weaknesses
• UK has experienced period of relative macroeconomic stability • Strongly performing science and engineering base • Relatively strong in innovation cooperation • Positive attitudes to enterprise • Good access to finance for start-ups • Indicators of healthy enterprise activity by SMEs • Openness to foreign competition, light touch product market regulation and highly regarded competition regime • High stock of inward investment	• Long-standing productivity gap (output/hr and output/worker) with main competitors • Low business and government investment levels resulting in comparatively poor infrastructure • Low total and business investment in R&D relative to GDP • Generally poor performance in patenting (but tendency to use design complexity and copyright as alternatives)
Opportunities	**Threats**
• Productivity gap is closing • Increasing levels of government investment • Scope to build on the strength of the science and engineering base. • Low start-up costs and administrative burdens • Light touch product market regulation and highly regarded competition regime	• Aversion to risk may prevent uptake of opportunities for enterprise • Firms report low customer demand for innovation

Human Resources

This section addresses the strengths and weaknesses of the human resource base and the policy initiatives in place to improve it. The section follows the same format as before.

UK Human Resources: SWOT analysis

Strengths	Weaknesses
• High output of S&E graduates (172% of EU average) • High participation levels in lifelong learning (215% of EU average) • Above EU average in terms of working population with tertiary education. • Relatively high proportion of workforce with SET degrees • High level of student mobility as measured by foreign student studying in UK	• UK has lower availability of highly skilled people with research training than its competitors (only 0.3% of population; 0.6% of labour force). UK ranks lowest in G8. • Poor performance in basic literacy and numeracy skills in workforce • Perception of poor management skills levels in some areas • Low proportion of its population qualified at the intermediate level, with concerns about the quality of vocational qualifications at the intermediate level.
Opportunities	**Threats**
• Scope for improvement of average performance in terms of % of population (aged 20-24) having completed at least upper secondary education • Improving entrance to and retention of S&E	• Large proportion of population with low-level skills • Risk of loss of university departments teaching of S&E subjects in strategically critical areas of the

graduate output in innovation-relevant workforce could benefit overall industrial innovation performance	economy (e.g. physics, chemistry, engineering) due to low student uptake of these subjects.

Overall Innovation System

Building on the analyses of policy mixes in specific innovation system domains, the aim of this section is to look across all relevant domains and develop an overview of the national innovation system policy mix, prioritising policy challenges across the innovation system and commenting on the appropriateness of policy responses to them. It also comments on actual and potential conflicts and tensions between policy objectives and instruments across domains and reflect on the ability of governance structures to orchestrate innovation system level responses. The section concludes with a perspective on the lessons learned in the context of the Lisbon agenda.

With regard to the overall UK Innovation System, the three major identified **challenges i**t faces can be summarised as:

1. To increase the intensity of innovation activity in enterprises;
2. To strengthen linkages between the public research base and business; and
3. To match future skills needs and improve the supply of high quality labour.

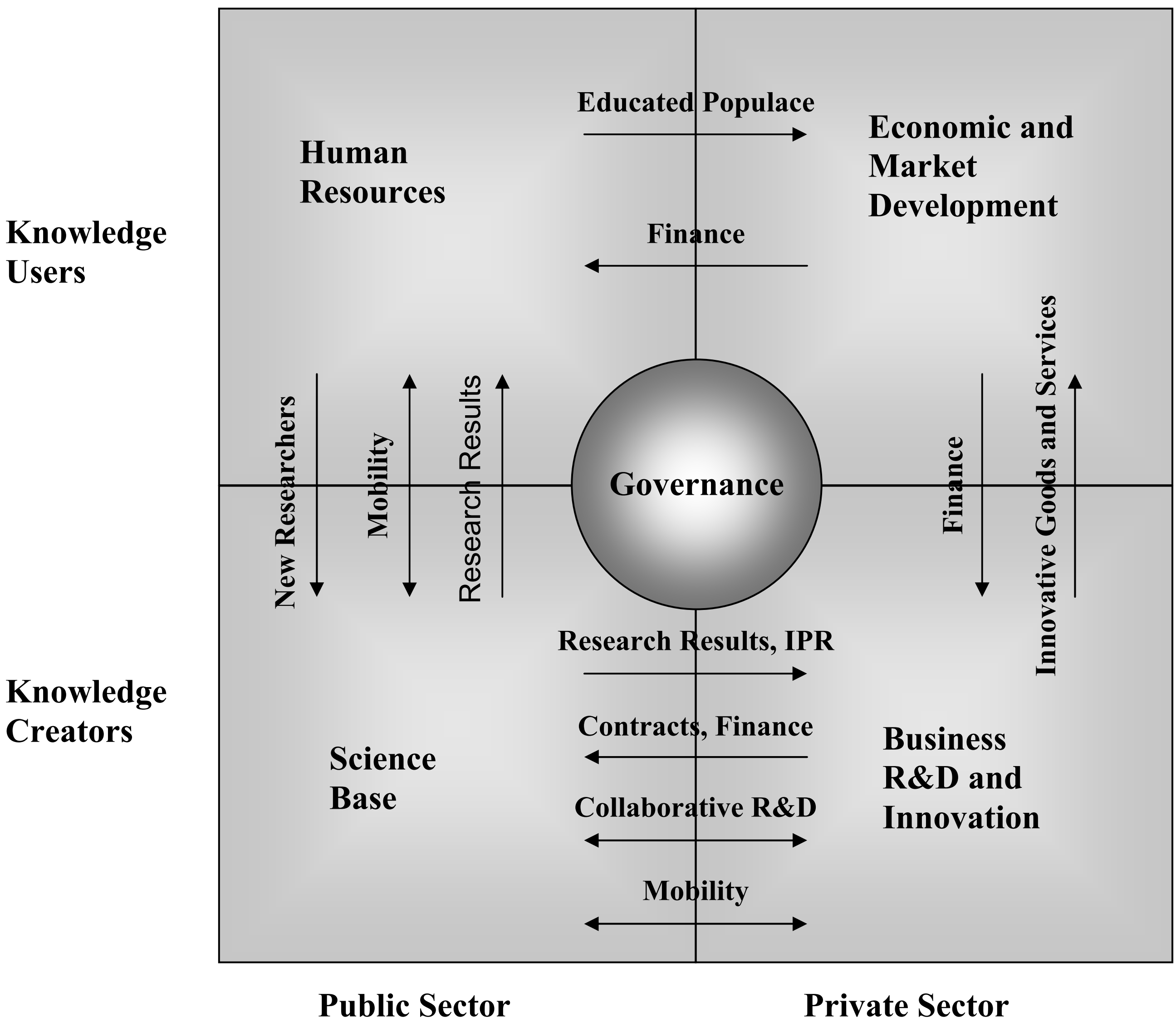
Finally, the **main lessons** that may be drawn from this review of the UK's innovation policies, in the context of the Lisbon Agenda, may be summarised as:

- The critical role played by coordinated approaches to policy formulation, with the presence of a clearly identifiable lead agency with responsibility for innovation concerns and with good coordination links to all other relevant policy actors.
- The setting of clear and realistic long-term targets and goals, together with the production of strategies which clearly communicate the Government's intentions to all actors in the innovation system.
- 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.

CREST 3% OMC Third Cycle
Policy Mix Peer Review
United Kingdom Background Report

1 General Introduction

This background report is based on the one used in the pilot exercise in the second OMC cycle. It derives from a fairly simple model of an innovation system, specifically one that considers four basic domains within an overall innovation system and the links and flows between them. The diagram below depicts these domains and just some of the more important links and flows between them.



Although innovation systems are typically much more complex than depicted here, this simple model provides a convenient way of visualising some of the more important domains within an innovation system and the relationships between them. It also provides a useful framework within which to ask questions relating to:

- The relative scale of the challenges nations confront both within each of the four innovation system domains and across them;
- The range of policy responses to these challenges and their ‘location’ within the innovation system, e.g. ‘reinforcement’ policies to strengthen particular domains such as the science base or business R&D and innovation, or ‘bridging’ policies designed to improve the links or flows between domains, e.g. policies to enhance university-industry interactions or to improve the flow of capital from capital markets to innovative high-tech firms and start-ups;
- The match between problems and policy responses within and across domains;
- The conflicts and synergies between policies within and across domains;
- The governance of policies within and across domains.

This framework has been used to structure each country report into six main sections corresponding to a general introduction, four separate sections dealing with challenges and policy responses in each of the four separate innovation system domains (with policies dealing with the interface between domains treated just once to avoid duplication, but cross referenced in other relevant sections), and a final section dealing with the innovation system as a whole and focusing on challenges and responses, conflicts and synergies, policy orchestration and lessons relevant to the Lisbon agenda.

The data sources used for compiling and constructing each of these sections include material contained in the ERAWATCH baseload, Trend chart reports, National Reform Programme reports, OECD reports and documents made available by the CREST national contact points for the Policy Mix exercise.

The basic aim of these reports is to interpret available evidence and provide commentary that will suggest lines of enquiry during the subsequent visits to the countries under review, and to provoke discussion in the eventual peer review meeting later in the year.

2 Overview: broad characterisation of the UK

The UK has a long history of political stability. There are three major political parties, although since the Coalition Government of the Second World War only the Conservative (Tory) and Labour parties have provided the Government. For the past nine years, the country has been governed by a Labour administration which was elected in the General Election of 1997 and which gained re-election in 2001 and again in 2005. The preceding Conservative administration had been in power from 1979.

Over the past decade, the UK's **economic growth** has been steady and has matched or exceeded that of most other major industrialised countries. The economy is operating at close to full capacity and, according recent estimates from the International Monetary Fund, it will continue growing at about 2.5% annually. The IMF's 2005 review of UK economic performance noted that:

> "Macroeconomic stability in the United Kingdom remains remarkable. Over the past decade, the growth of real GDP per capita has been strong and stable. Unemployment and inflation have been low, and the current account deficit has been moderate. This impressive record owes much to good macroeconomic, financial, and structural policies, underpinned by sound policy frameworks and supported by a generally favourable external environment."[14]

Inflation in December 2006 was running at 2.4%, whilst GDP was £1,881 million and per capita GDP £31,436 (both OECD (2004) figures). In the second quarter of 2006, the balance of trade indicated a deficit of £7 billion. Public sector net debt, as a percentage of GDP, was 36.8% (October 2006). This figure peaked at 44.0% GDP in 1997, its highest since the mid 1980s. The debt ratio then fell steadily as public sector finances improved, reaching a low of 30.1% in February 2002. Since then it has risen. The Budget forecast for the end of March 2007 is 37.5%. The employment rate for people of working age was around 74.5% for the three month period to September 2006. Over the same period, the number of people in employment was 28.99 million, from a total population of just over 60 million. The unemployment rate was 5.6%, with the total of unemployed people reaching 1.71 million in 2006[15].

Overall, the country shows a **relatively strong innovation performance** both in absolute terms for specific indicators and in terms of recent trends. Thus, for example, the UK ranks eleventh on the summary innovation index (SII) out of 25 EU Member States based on the European Innovation Scoreboard (EIS 2005).

In terms of these indicators the **UK's main strengths** include its excellent performance on several education indicators, most notably S&E graduates and

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[14] http://www.hm-treasury.gov.uk./documents/uk_economy/imf_reports/ukecon_imf_articleIV2005.cfm

[15] Sources: http://www.statistics.gov.uk/downloads/theme_economy/ET637.pdf and http://www.hm-treasury.gov.uk/media/04D/F2/tweba3201106.pdf

lifelong learning, and mid-range performance in several other categories (see Figures 1a and 1b, below).

Figure 1a: UK performance on European Innovation Scoreboard indicators (2005)

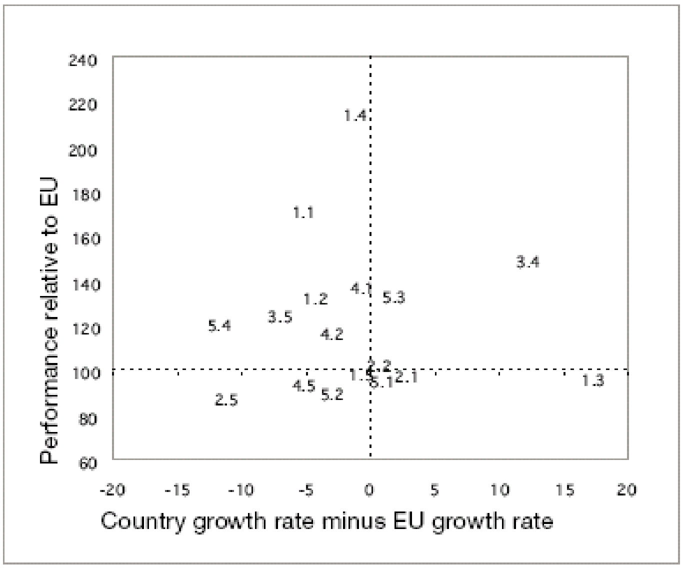
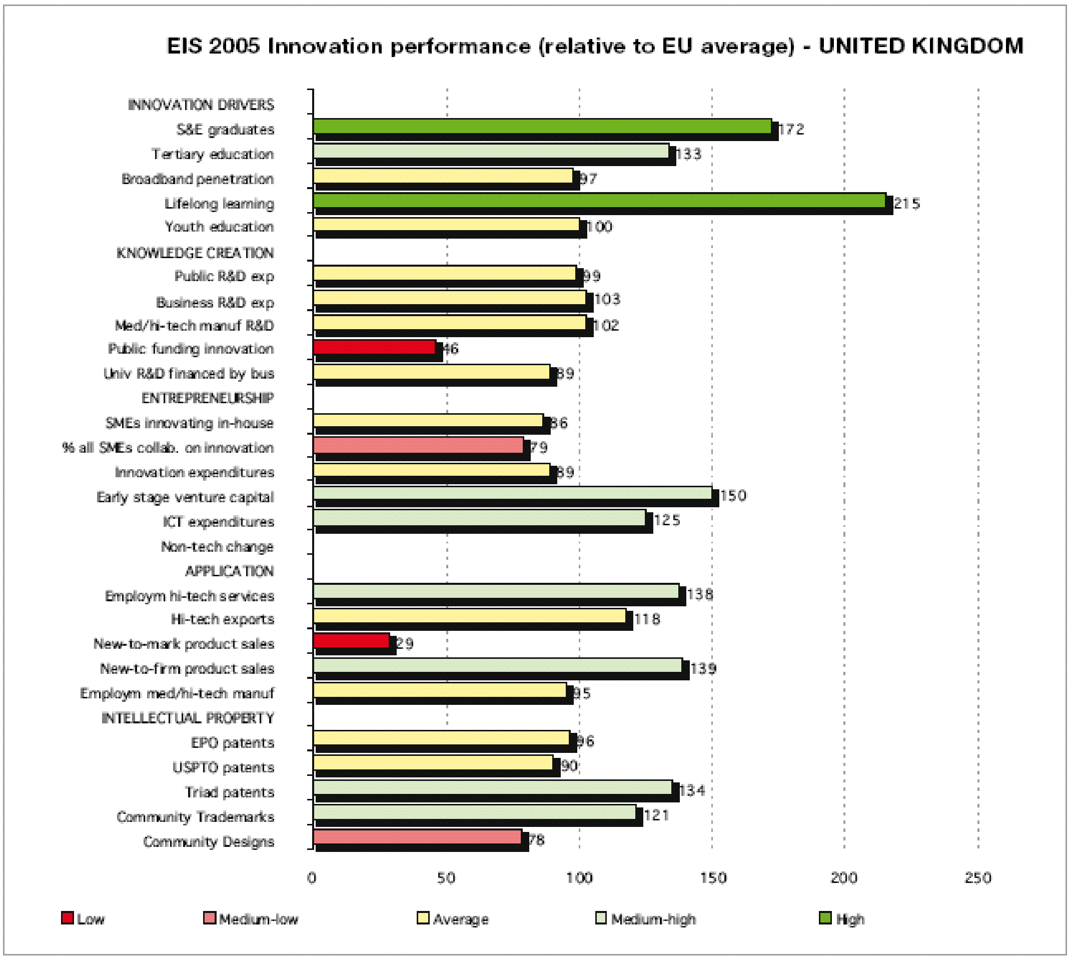


Figure 1b: Relative performance of UK to EU average EIS performance



The UK also performs well above the EU average for a number of indicators, for example, early stage venture capital, ICT expenditures, employment in high technology services and Triad patents. Nonetheless, the trends are persistently negative in several indicators, most notably business-financed university R&D where the overall EU trend is positive.

The UK seems surprisingly weak on innovation demand, which might be mainly due to very low levels of capital investment and a high percentage of firms that report a lack of customer responsiveness as a barrier to innovation. The UK fails to translate its potential in knowledge generation into commercial products or services, which is highlighted by the indicator of market output of innovation activity in UK enterprises being well below the EU25 average in terms of sales of new-to-market products (29% of EU25 average).

The OECD publication *"Going for Growth"* (2006), which reviews various measures of innovation performance at the national level, highlighting their strengths and weaknesses, also confirms that the UK is characterised by a strong science base and strong innovation capacity in the services sector, but business R&D spending relative to GDP is only average for the OECD.

Currently the UK's **national objectives in innovation policy** refer largely to the Government's framework document published in 2004 that sets out its ambition for

UK science and innovation for the period 2004-2014 (the *Science and Innovation Investment Framework 2004-2014).* This derived from an extensive consultation exercise launched in march 2004. Subsequently the Government published a *Science and Innovation Investment Framework 2004-2014 First Annual Report* in July 2005, which reported on progress over the first year. Whilst noting progress on several issues, the document recognised that significant challenges remained, although the Strategy was only in its early stages. In early 2006, a consultation review "next steps" document was released, whilst later in the year, a *Science and Innovation Investment Framework 2004-14 Annual Report 2006*, reiterated the Framework objectives and provided additional updated details on progress towards meeting them. The Annual Report 2006 also presents progress against a number of indicators, namely:

1. Research excellence
2. University Knowledge Transfer from 1996 to 2003
3. Businesses' engagement on R&D and Technology transfer initiatives
4. Supply of Scientists, Engineers and Technologists (noting a mismatch between supply and demand)
5. Public engagement with scientific Research and Innovation.

It also presents some significant case-studies and notes areas in which the Government's targets are being met and those where further progress is sought - although it does note that the strategy is only in its second year. The Office of Science and Innovation, located in the Department of Trade and Industry and which takes the lead for UK S&T matters, has published a full set of indicators and policy measures in the ten-year framework together with a brief summary of progress against each.

The Science and Innovation Investment Framework makes clear the Government's intention to take a long-term view and place science and technology above its other spending priorities. The document notes the following broad targets or challenges that have been identified:

- "World class research at the UK's strongest centres of excellence:
- Greater responsiveness of the publicly-funded research base to the needs of the economy and public services:
- Increased business investment in R&D, and increased business engagement in drawing on the UK science base for ideas and talent:
    - Increase business investment in R&D as a share of GDP from 1.25% towards goal of 1.7% over the decade
    - Narrow the gap in business R&D intensity and business innovation performance between the UK and leading EU and US performance in each sector, reflecting the size distribution of companies in the UK
- A strong supply of scientists, engineers and technologists by achieving a step change in:
- Sustainable and financially robust universities and public laboratories across the UK:
- Confidence and increased awareness across UK society in scientific research and its innovative applications:
    - Demonstrate improvement against a variety of measures, such as trends in public attitudes, public confidence, media coverage, and

> acknowledgement and responsiveness to public concerns by policy-makers and scientists"

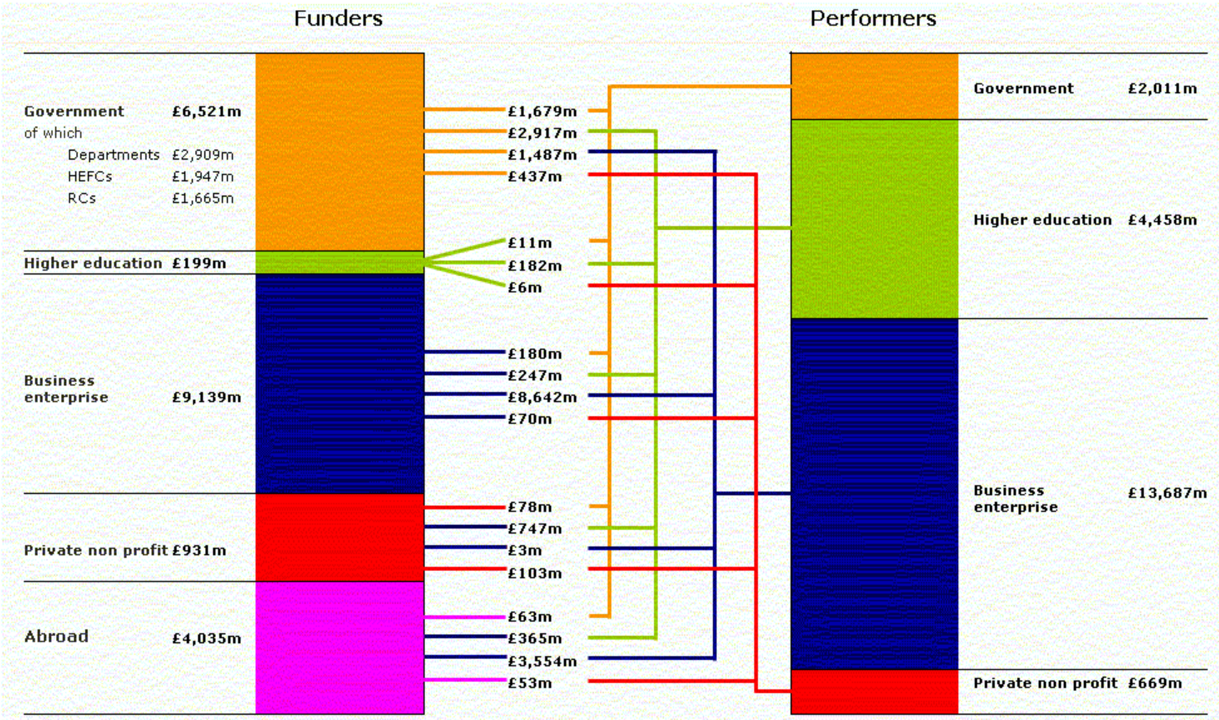
Overall, the Government's **long-term objective** for the UK economy is to increase the level of knowledge intensity (expressed as R&D as a percentage of GDP) from its current level of around 1.9% to 2.5% by around 2014 (a less ambitious figure than the European Union's Barcelona target of 3% of GDP on R&D by 2010).

Turning to the **UK innovation system**, the main components comprise: the Government - responsible for policy setting, implementation and funding; the Science and Engineering Base, largely comprising the Higher Education sector but also including the remaining (i.e. non-privatised) Government laboratories and the research council institutes, which undertakes the majority of basic and strategic research in the UK; and the Business Enterprise sector, which funds and undertakes the largest share of UK R&D (see Figure 2, below). To these may be added the independent research and technology organisations which carry out a broad range of research activities, generally in a consultancy capacity and the not-for-profit sector, which although small contains some significant providers of funding in the fields of medical and biosciences research.

A central point for the UK system of innovation governance is the Department of Trade and Industry (DTI). The DTI has the overall aim of increasing "competitiveness and scientific excellence in order to generate higher levels of sustainable growth and productivity in a modern economy". More specifically, the DTI influences UK innovation through a variety of channels. In April 2006, a new Office of Science and Innovation (OSI) was established within the DTI, bringing together the former Office of Science and Technology (OST) and the DTI Innovation Group (which includes the Technology Strategy Board). The OSI is responsible for the funding of basic research both within, but largely via, the UK's Research Councils (see under Section 3 – Science Base). It also provides the secretariat for the Chief Scientific Advisor (the Government's Chief Scientist) who coordinates science and technology issues across Government.

Apart from the DTI, several other Departments and Ministries undertake research and innovation related activities, for example, by commissioning intra- and extra-mural R&D in support of their departmental objectives. Of particular relevance is the Department for Education and Skills (DfES), which has responsibility for all issues relating to education in England (from primary age through to higher education, training and lifelong learning and skills development). It also oversees the Learning and Skills Council and the Higher Education Funding Council for England (HEFCE), which provide funding for staff and infrastructure in institutes of further and higher education respectively. The Department for Work and Pensions (DWP) forms a single contact point for matters relating to jobs, job vacancies, unemployment and other state benefits, child support, and pensions. Lastly, the Department for Communities and Local Government (DCLG) has oversight of sustainable economic development in the English regions. Regional innovation policy, however, lies with the DTI and is delivered via the Regional Development Agencies, for which the DTI has responsibility. The UK Government aims to operate a policy of "joined-up government", which attempts to ensure that policy decisions and implementation are coordinated across all government departments and agencies. See Annex 2 for an overview of the UK innovation system.

Figure 2. The flow of funds for UK R&D, 2003



Source: Office of Science and Technology, SET Statistics, Table 6.1[16] (Figure last updated 31 October 2005) (€1 = £0.7).

In 2003, total UK GERD was £20,825 million (almost €30 billion). This represented a real terms increase of 2% over the previous year and approximates to 1.86% of GDP. Of the total amount of GERD, 31% was funded by the public sector and 44% by the business enterprise sector. Overseas sources contributed a total of £4,035 million (€5,760 million) or 19% of GERD and around 88% of the income from overseas was used in the business enterprise sector. In the UK, a significant proportion (11% of all R&D or £2,366 million (€3,380 million)) of total R&D expenditure is devoted to defence objectives, 59% of which is provided by Government sources contributing. In comparison, Civil GERD was £18,459 million (€26,370 million), 28% of which came from the public sector. The business enterprise sector contributed £8,729 million (€12,470 million) or 47% of civil R&D and £410 million (€585 million) or 17% of defence R&D expenditure.

The flow of funds diagram illustrates the contribution of various actors. It is clear that the largest source is Business Enterprise, although this is balanced by the fact that it is also the largest performer of R&D. Government forms the second largest funding source, with funding split between government departments, the Higher Education Funding Councils (which provide block grant funding to universities) and the

[16] Flow of funds for UK R&D, OST website: http://164.36.164.104/setstats/6/f6_4.htm (accessed 10/05/2006)

Research Councils (which fund research, again largely in universities and in their own in-house institutes). Consequently, Higher Education forms the second largest performer of R&D. Government also performs a significant amount of research intramurally largely in support of departmental and ministerial policy objectives.

In terms of **policy advice**, the Government has recourse to a diverse array of committees and advisory groups. These are located at various levels of the governmental system, from Cabinet level, through Parliament and departmental levels, down to the various *ad hoc* and standing committees (official and unofficial). Advice can range from highly specific scientific issues to areas of wider innovation concern. This advice is further supplemented by a number of non-governmental bodies and interest groups, for example, the Parliamentary Office of Science and Technology (which offers apolitical advice on S&T issues to parliamentarians), the Campaign for Science and Engineering (a scientific lobby group) and the Confederation of British Industry (which represents the interests of business employers). Government may also commission specific studies on aspects of innovation policy from the UK's community of public and private sector policy research groups.

3 Science Base (R&D Capacity)

3.1 Introduction

The UK Science Base broadly comprises the Higher Education sector, Research Council institutes and Government laboratories (known as Public Sector Research Establishments or PSREs), together with the not-for-profit sector.

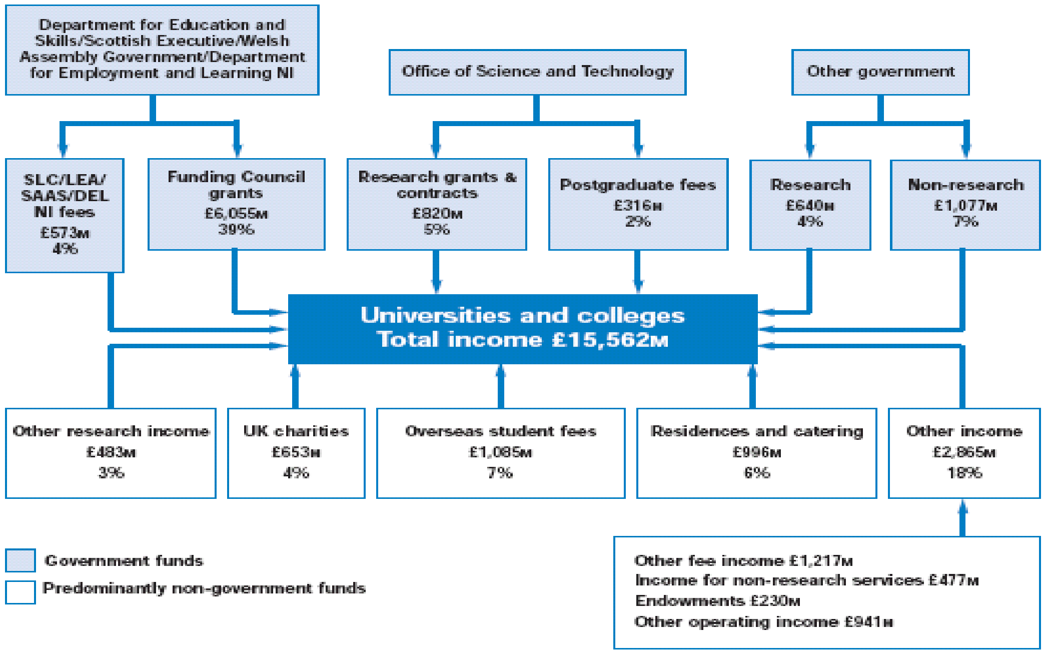
The **Higher Education sector** is largely composed of universities (but also includes a number of Higher Education colleges) and is the main performer of basic and strategic research in the UK. In 1992, the sector underwent extensive expansion when the polytechnics were awarded university status (hence they are often referred to as 'new' universities). At present there are approximately 120 university institutions in the UK, counting separately the colleges of the federal universities of London and Wales (as several colleges have recently acquired university status, the precise total is an estimate). Universities range in size from around 4,500 students (Abertay) to over 32,000 students (Manchester).

Universities in the UK are autonomous bodies, with charitable status, and are free to seek funding from a variety of sources. However, the majority of their funding comes via what is known as the dual support system. Under this system, the Higher Education Funding Councils (separate bodies exist for England, Scotland, Wales and Northern Ireland, with funds derived from the ministries responsible for education[17]) provide general funding, used mainly for academic salaries and research infrastructure, while the Research Councils provide funding for projects (including the salaries of contract researchers), research training and centres. Research Council funding is allocated on a 'responsive-mode', competitive peer-reviewed basis. The other principal funding source for research is the charitable, non-profit sector, notably the Wellcome Trust, which is the largest single funder of medical research. While around 60% of university funding comes from UK Government or EU sources, in fact, the funding picture is quite complex and a number of other funding streams also exist (see Figure 3).

Overall, Higher Education institutions in the UK employ an estimated 300,000 staff. These include around 96,000 full-time and around 38,000 part-time academic staff. Academic staff in most universities, and in some colleges, perform research as well as teaching. Most have doctorates and many have professional qualifications.

[17] Thus, for example, the Higher Education Funding Council for England receives its funding from the Department for Education and Skills (DfES).

Figure 3: Sources of finance for UK higher education institutions (2002/03)



Source: *Guide to Higher Education in the UK*, HEFCE, April 2005 (revised October 2005).

Turning to the Research Councils, there are currently eight Councils responsible for funding research in eight broad areas, although interdisciplinary programmes are also funded:

- Arts and Humanities Research Council (AHRC)
- Biotechnology and Biological Science Research Council (BBSRC)
- Central Council for the Laboratory of the Research Councils (CCLRC)
- Engineering and Physical Science Research Council (EPSRC)
- Economic and Social Research Council (ESRC)
- Medical Research Council (MRC)
- Natural Environment Research Council (NERC)
- Particle Physics and Astronomy Research Council (PPARC)

Plans are in place to merge the research infrastructure development, funding and provision activities of PPARC, CCLRC and the nuclear physics strand of EPSRC to form a Science and Technology Facilities Council. Thus, CCLRC and PPARC will be subsumed into the new Research Council.

In addition to their funding of research undertaken by the Higher Education sector (in the form of supported research programmes, centres and individual grants), some of the Research Councils (BBSRC, MRC and NERC) also directly support a number of their own institutes or research units, often based in or attached to universities. These also form an important component of the Science Base and sometimes receive funding from other Government Departments (see Table 1).

Table 1: Research Council Institutes and Centres

Biotechnology & Biological Science Research Council		Medical Research Council	Natural Environment Research Council
Babraham Institute	biomedical, biotech. & pharmaceutical	National Institute for Medical Research (NIMR)	British Antarctic Survey (BAS)
Institute for Animal Health	health & welfare of farm animals/human food chain	MRC Laboratory for Molecular Biology (LMB)	British Geological Survey (BGS)
Institute of Food Research	food safety, diet & health, food materials & ingredients	MRC Clinical Sciences Centre (CSC)	Centre for Ecology and Hydrology (CEH)
Institute of Grassland and Environmental Research	sustainable grassland systems & the wider managed environment	27 MRC Research Units	Proudman Oceanographic Laboratory (POL).
John Innes Centre	plant & microbial research with strategic relevance for food, health, sustainable agriculture and industrial innovation	8 MRC Centres	
Roslin Institute	farm and other animals		
Rothamsted Research	sustainable plant-based agriculture and the environment		
Silsoe Research Institute	bio-systems engineering (agricultural, food, environmental and biomedical sectors)		

The next component of the Science base is formed by the Government laboratories. Each Ministry or Department may have a significant research portfolio within the areas of its specific responsibility and several commission R&D intramurally through their own laboratories and institutes. In the UK these are known collectively as public sector research establishments (PSREs).

The size of this sector has been considerably reduced in recent years through the privatisation or semi-privatisation of a number of the former government laboratories, such as the National Physical Laboratory and the Laboratory of the Government Scientist. In addition, and partially as a consequence of this reduction, civil spending on R&D by Government departments has declined over recent years and is now disbursed primarily on a competitive basis. Over the last year or so, a number of agencies have also gone through a process of rationalisation which has seen, for example the merger of the Centre for Applied Microbiology Research with the Health Protection Agency; and English Nature, the Countryside Agency and the Rural Development Service to form Natural England. Nonetheless, the former government laboratories remain the major performers of this research. Major Government research players, in terms of intramural research, are the Department for Environment, Food and Rural Affairs, the Ministry of Defence and the Department of Health (see Table 2).

Table 2: Government Agencies and Laboratories

Ministry/Department	Agency/Laboratory (and status)
Department of Trade and Industry	National Weights and Measures Laboratory (Executive Agency)
	British National Space Centre (coordinatory only)
Department for Environment, Food and Rural Affairs	Central Science Laboratory (Executive Agency)
	Centre for Environment, Fisheries and Aquaculture Science (Executive Agency)
	Pesticides Safety Directorate (Executive Agency)
	Veterinary Laboratories Agency (Executive Agency)
	Veterinary Medicines Directorate (Executive Agency)
	Natural England (executive Non-Departmental Public Body)
	Environment Agency (Executive Agency)
Department of Health	Health Protection Agency (Non-Departmental Public Body)
	Medicines and Healthcare Products Regulatory Agency (Executive Agency)
Home Office	Forensic Science Service
Ministry of Defence	Defence Science and Technology Laboratory (DSTL)
	The Meteorological Office
	Hadley Centre for Climate Prediction and Research

Finally, the private non-profit sector contributed around £931 million in research expenditure in 2003-04 (about 14% of total funding) and performed £669 million 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. The financial contribution of these charities to medical research in the UK exceeds £400 million per annum.

In terms of the volume of support, the five largest of these foundations and charities are the Wellcome Trust, Cancer Research UK, the British Heart Foundation, the Arthritis Research Campaign and the Nuffield Foundation. The Wellcome Trust is the major funder of research in this sector in the UK. It is one of the largest charitable foundations in the world and supports clinical and basic scientific research in biomedical science and the history of medicine. It operates a number of support schemes for scientists in both clinical and non-clinical science, and funds a range of projects. It also forms a major contributor to several UK Government research support schemes, such as the Science Research Investment Fund (SRIF), to which the Trust contributed £225 million (€335 million) in 2001, and which supported the provision of university research infrastructure within the Trust's area of concern.

3.2 Indicators and Challenges

The UK Science base is generally viewed as being in good shape. UK science is felt to have a good international reputation, and UK researchers participate in a large number of international cooperation programmes, with very good representation in the European Commission's Framework Programmes. According to the Science and Innovation Investment Framework Annual Report 2006, "the UK has increased its share of world citations to 12% and its share of highly cited papers to 13.2%. The UK 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 and efficiency measures". In brief, in terms of the number and its world share of citations in ten research fields, the UK ranks 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.

A selection of available indicators is presented in the following Tables.

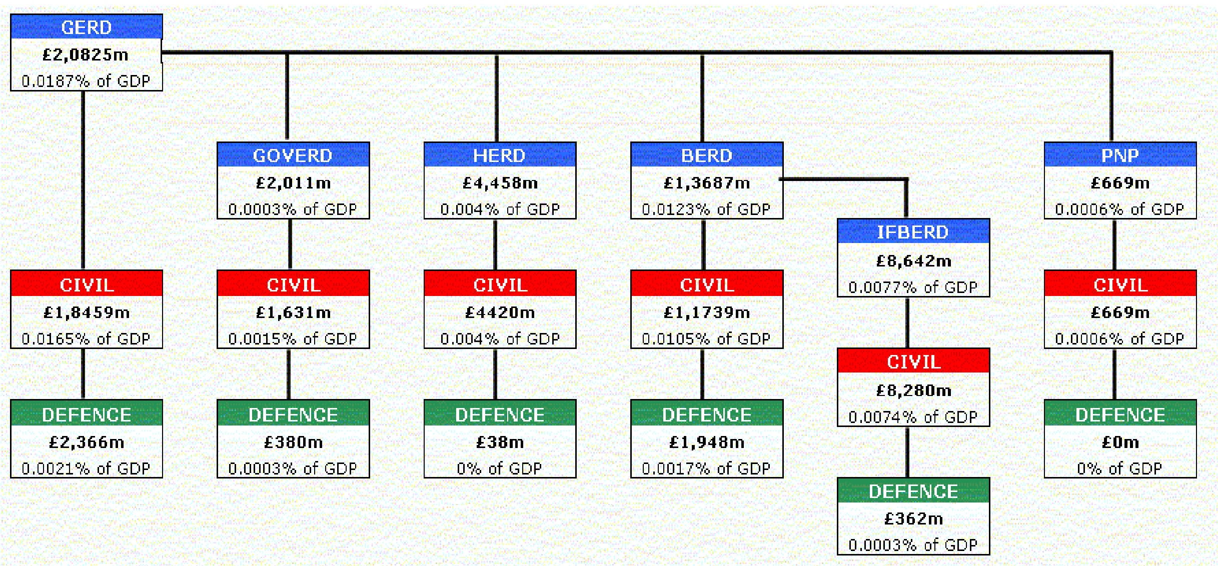
Table 3: Indicative Indicators for the Science Base*

Indicator	**value (date)**	**Source**
S&E graduates as a percentage of the 20-29 age range	18.1 (2004)	EIS
,, ,, *EU-25 comparison*	*12.7 (2004)*	*EIS*
S&E students as % of all students	23.8 (2004)	EIS
,, ,, *EU-25 comparison*	*25.8 (2004)*	*EIS*
S&E graduates as % working population	4.5 (2004)	RTD
,, ,, *EU-25 comparison*	*4.0*	*RTD*
Public expenditure on R&D (GOVERD+HERD) as a % of GDP	0.57 (2003)	PSA
Researchers as a percentage of the population	0.30 (2003)	PSA
Researchers per 1000 labour force	5.5 (2003)	RTD
,, ,, *EU-25 comparison*	*5.4 (2003)*	*RTD*
R&D personnel as percentage population	0.45 (2003)	PSA
R&D personnel as percentage workforce	0.88 (2003)	PSA
Scientific publications per million population	1086 (2003)	RTD
,, ,, *EU-25 comparison*	*639 (2003)*	*RTD*
Publication count - % share of world output	8.81 (2004)	PSA
Citation count - % share of world output	12.23 (2004)	PSA
GERD as a percentage of GDP	1.78 (2004)	3%AP
GERD breakdown: Government, (*EU-25 average*) (see also Fig. 4)	32.8 (*34.6*)	RTD
GERD breakdown: Business, (*EU-25 average*) (see also Fig. 4)	44.2 (*54.9*)	RTD
GERD breakdown: Abroad, (*EU-25 average*)	17.2 (*8.2*)	RTD
Business Enterprise expenditure on R&D perf. in HE sector (% total HERD)	5.56 (2003)	PSA
PhDs awarded per 1000 population	0.24 (2002)	PSA
HRST core (25-64 years old) as % of labour force	18.4 (2003)	RTD
,, ,, *EU-25 comparison*	*15.9 (2003)*	*RTD*

Key: OECD = Organisation for Economic Cooperation and Development; EIS = European Innovation Scoreboard; RTD = RTD Indicators Report; SET = UK SET Statistics; 3%AP = 3% Action Plan; PSA = PSA metrics report 2005

* There is some overlap with indicators relevant to other domains and between indicators from different sources.

Figure 4: UK GERD and its constituents: civil and defence splits, 2003



Source: SET Statistics, OSI, last updated 31 October 2005.

Table 4: UK researchers: Papers and citations per head of population

G7 comparison, 1998-2003
Index, UK = 100

	Papers per head	Citations per head
US	77.0	88.7
Germany	67.6	63.8
France	66.5	58.6

Source: Evidence Ltd, ISI Thompson

Table 5: Highest qualification, UK

Comparison, 1996-2005
Per cent of economically active adults

	Below NVQ level 2	Proportion at level 2	Proportion at level 3	Proportion at level 4+
1996	36.9	21.6	17.8	23.8
1997	34.9	22.1	18.8	24.2
1998	33.8	21.8	19.0	25.4
1999	32.2	21.8	19.7	26.3
2000	31.0	21.6	19.9	27.4
2001	30.8	21.5	20.3	27.4
2002	29.9	21.7	20.5	27.9
2003	28.9	21.4	20.6	29.0
2004	28.2	21.0	20.5	30.2
2005	27.2	21.5	20.4	30.9

Source: UK Labour Force Survey

Based on the above analyses and indicators, the following table (Table 6) summarises the Strengths, Weaknesses, Opportunities and Threats facing the UK Science base.

Table 6: SWOT analysis of the UK Science Base

Strengths

- **Public sector spending on R&D (PUBERD) has generally increased over last decade**
- **Strong performance and world ranking in research outputs (publications and citations); second to USA in most metrics.**
- **Very strong in terms of research outputs per researcher, with balanced strengths across all fields.**
- **UK has 2nd largest (and growing) share of world's most highly cited papers**
- **UK has above EU average output of PhDs per unit HERD spend.**
- **UK PhD awards concentrated in natural sciences where the UK has a relative research strength.**

Weaknesses

- **UK is spending less on research as proportion of GDP than its competitors and EU15.**
- **Gap between research performance and translation into commercially competitive products, processes and services.**
- **Frequency of R&D personnel is also low (0.45% of population); UK is below EU average and below all except Italy in G8.**
- **Falling percentage of HERD funded by Business Enterprise sector.**
- **UK is weak in provision of basic and intermediate skills in the workforce.**

Opportunities

- **Translation of research excellence into competitive performance.**

Threats

- **GERD as % of GDP has declined recently**
- **Public sector spending on R&D**

(PUBERD) has recently dropped

- **Numbers of UK PhD awards are average but smaller (EU and SE Asian) countries are increasing their shares.**
- **Uptake of some science degrees (physics, chemistry) are dropping – some university departments face closure.**
- **Below comparator group average productivity of medical sciences PhDs and falling outputs of PhDs in engineering.**
- **Introduction of FEC may discourage industry spending in HE sector**

3.3 Governance

In terms of the Science base, the major policy advisory body is the Council for Science and Technology (CST), chaired by the Government's Chief Scientific Adviser, although policy advice is provided by a range of committees and other bodies from within and outside the Government structure. Each ministry tends to have its own policy making body and several have departmental Chief Scientists. The Department of Trade and Industry takes the lead in research issues (and oversees the Government's innovation policy agenda) and forms the major source of research funds for public sector via the Science Budget (which is administered by the Office of Science and Innovation located within the DTI and which is channelled via the Research Councils[18]).

Overall coordination of Research Council policy is the responsibility of Research Councils UK (RCUK). One of RCUK's tasks is to develop an investment strategy for the Research Councils aimed at enhancing the quality of research investment prioritisation.. Each Research Council defines its own set of research priorities. This process varies between the councils but is generally based on a combination of the directions of a guiding research board, or similar body, consultation with the broader scientific community and historical patterns of demand

The UK tends not to prioritise specific areas of research, but rather applies horizontal support to maintain the overall performance of the research system, particularly in terms of ensuring the production of high quality, world-leading research, maintaining and developing research infrastructures (such as universities and public laboratories) and ensuring a constant supply of scientists, engineers and technologists. This is coupled to the objectives of making the science base responsive to the needs of the economy and both increasing the level of business investment in R&D and the level of engagement with the science base. Despite the tendency not to identify specific priority fields for research, the Government has identified six broad scientific and technical areas for the provision of additional funding and to stimulate cross-Research Council collaboration. These areas are: stem cell research; sustainable energy

[18] A small portion of the Science Budget also funds the Royal Society (the UK's 'academy of science') and the Royal Academy of Engineering.

economy; rural economy and land use; e-science, post-genomics and proteomics; and basic science.

Also of relevance is a recent announcement (November 2006) that the Government's Technology Strategy Board (TSB), which was established to promote technological development, is to become an executive non-departmental public body, an agency at arm's length from direct government control. The TSB will be expected to build strong links with business and the research base, including the existing Research Councils, although Ministers will continue to set innovation policy. Most government-funded applied technological R&D was abolished by Conservative administrations during the 1980s and this move brings the UK system back into line with most other advanced economies, with the TSB – previously responsible for advising ministers on technological priorities - taking control of the £178 million Technology Programme, which promotes new technological developments by funding research projects in firms and universities along a number of priority themes including low carbon energy technologies; biopharmaceuticals' manufacture; and sensors and imaging. The TSB will also administer the government-funded Knowledge Transfer Networks (KTNs).

3.4 Policy Objectives

The UK Government's main objectives concerning R&D policy are very much an integral part of its broader policy on innovation. Over the last decade or so there have been a number of relevant policy documents produced which set out the Government's priorities in this area, namely:

- "Opportunity for All in a World of Change – Enterprise, Skills and Innovation" (DTI White Paper, 2001)
- "Investing in Innovation – The Government's Strategy for Science, Engineering and Technology" (DTI Strategy Report, 2002)
- "21st Century Skills: Realising Our Potential" (Department for Education and Skills (DfES) White Paper, 2003)
- "Prosperity for All – the Strategy: DTI 2003" (DTI Strategy paper, 2003)
- The Lambert Review of Business-University Collaboration (HM Treasury Consultation Review, 2003)
- "Competing in the global economy – the innovation challenge" (DTI Strategy Review/Action Plan, 2003)
- "Science & innovation investment framework 2004-2014" (HM Treasury, DTI, DfES Strategy Report, 2004)
- "DTI Five Year Programme – Creating wealth from knowledge" (DTI Strategy Paper, 2004)
- "Skills: Getting on in business, getting on at work" (DfES White paper, 2005)
- "Science & innovation investment framework 2004-2014: next steps" (HM Treasury, DTI, DfES, Department of Health Consultation Review, 2006)

Overall, in terms of broad policy objectives, the Government's priorities have not altered considerably and tend to focus on the relationship between skills, innovation and enterprise in raising productivity. Thus, the DTI's Innovation Report (*Competing* *in the Global Economy – The Innovation Challenge,* 2003) [19], which summarises the key priorities and the strategies adopted towards their achievement in an Action Plan, lists the following key priorities:

- ensuring the skills are in place to support innovation
- maximising potential in the workplace
- supporting innovation in SMEs
- supporting women entrepreneurs
- incorporating design to add value
- increasing the pull-through of new ideas from the SET base
- capitalising on UK measurement expertise

These objectives are re-emphasised in the Government's Science and Innovation Investment Framework 2004-14. 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.

The Ten-Year Framework has been subsequently updated, first in July 2005 with the publication of a first "Annual Report on the ten-year Science and Innovation Investment Framework" which detailed progress made. This noted that substantial progress had been made in implementing the ten-year framework but that significant challenges remained including:

- raising business investment in R&D, and
- increasing the supply of science, technology, engineering and mathematics (STEM) skills in the workforce.

The Annual Report was followed by a "Next Steps" report which detailed further progress made and revised actions. According to the Government, it intends to take a long-term view and place science and technology above its other spending priorities. Within this broad scope, the following areas are designated as priorities of particular relevance to the Science Base:

- "World class research at the UK's strongest centres of excellence:
    - Maintain the UK's overall ranking as second to the USA on research excellence, and its current lead against the rest of the OECD; close the gap with the leading two nations where current UK performance is third or lower; and maintain the UK's lead in scientific productivity
    - Retain and build sufficient world class centres of research excellence, departments as well as broadly based leading universities, to support growth in its share of internationally mobile R&D investment and highly skilled people
- Greater responsiveness of the publicly-funded research base to the needs of the economy and public services:

[19] *Competing in the global economy: the innovation challenge*, *DTI Innovation Report*, December 2003. Available at: http://www.dti.gov.uk/innovationreport/innovation-report-full.pdf

    - Research Councils' programmes to be more strongly influenced by and delivered in partnership with end users of research
    - Continue to improve UK performance in knowledge transfer and commercialisation from universities and public laboratories towards world leading benchmarks
- A strong supply of scientists, engineers and technologists by achieving a step change in:
    - The quality of science teachers and lecturers in every school, college and university, ensuring national targets for teacher training are met
    - The results for students studying science at GCSE level
    - The numbers choosing SET subjects in post-16 education and in higher education
    - The proportion of better qualified students pursuing R&D careers
    - The proportion of minority ethic and women participants in higher education
- Sustainable and financially robust universities and public laboratories across the UK:
    - 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.

3.5 Policy Instruments

Based on the above-mentioned set of policy objectives as defined in the *Science and Innovation Investment Framework 2004-2014*, the following major instruments may be identified.

With regard to "supporting the science base", the 2004 Spending Review allocated about €1 billion in additional funding for the Science Base up to 2007-08, including dedicated capital funding for the renewal of university infrastructure (see Table 7 and Annex 1). As noted above, the largest source of funding for the Higher Education sector is that provided through the 'dual support system', consisting of 'block grants' from the Higher Education Funding Councils paid to individual HEIs on the basis of allocations determined by the Research Assessment Exercise and of grants from the Research Councils paid to individual researchers, research groups or research centres located within HEIs. The Spending review also included a €104 million Strategic Fund administered by the Director General of the Research Councils, to support energy and clinical research.

Table 7: Spending Review 2004 budgets and projections

	2004-05	2005-06	2006-07	2007-08
DTI Office of Science and Technology				
Departmental expenditure limits[3] (£ million cash)	2,575	2,913	3,067	3,282
Average annual real growth rate since 2004-05				5.6%
DfES funding for research and knowledge transfer in English universities				
Departmental expenditure limits (£ million cash)	1,326	1,465	1,589	1,709
Average annual real growth rate since 2004-05				6.0%
UK Total science spending[4]	4,201	4,701	4,998	5,356
Average annual real growth rate since 2004-05				5.7%
UK science spend as a proportion of GDP (per cent)[5]	0.36	0.378	0.382	0.390

Source: Science and Innovation Investment Framework, 2004-2014

At the end of the last century, the issue of the declining quality of research infrastructure (i.e. scientific facilities, libraries, research equipment, etc.) in the Higher Education sector, which had resulted from a long-term under-investment, formed a particular area of concern. In response, the Government launched a Science Research Investment Fund (SRIF) worth around £500 (€715) million per year to support university research infrastructure plus £50 (€71) million per year for Research Council Institutes. The third round of the Science Research Investment Fund (SRIF) - announced in 2004 - contains €1.5 billion for 2006-08 available to HEIs.

In 2005, this short-term funding measure, which had partially addressed the infrastructure problem was complemented by further changes which aimed to put university funding on a more sustainable footing. This entailed the Research Councils making provision for the Full Economic Costs (FEC) of the research activities they funded, whilst at the same time maintaining the volume of research supported. In the first instance, an additional £120 million was made available from 2005/06, rising to £200 (€286) million from 2007/08 to enable the Research Councils to meet 80% of FEC. The 2004-14 Science and Innovation Investment Framework indicated that Research Councils will move towards 100% of FEC by 2010. Additional funds were also provided to the Higher Education Funding Councils to increase the research element (QR) of university block grant funding.

The implications for this are unclear: whilst there will be no additional funds available to increase the volume of research, payment of FEC means that each research project will be better funded. In particular the indirect and estates costs of research will receive better support, thereby allowing the recipient research organisation (usually an HEI) to invest more in improved research infrastructure (i.e. buildings, facilities, people and intellectual capital) to the ultimate benefit of researchers.

Other initiatives include:

- An announcement by partners from the UK Clinical Research Collaboration (including the MRC and Wellcome Trust) for a joint €110 million initiative in experimental medicine;
- Twenty Science and Innovation Awards from EPSRC and HEFCE to strengthen research capacity in areas of relative weakness (statistics, physical organic chemistry, structural materials, electronics design, energy R&D);
- EPSRC grants for five new consortia working in wind energy, biofuel cells, energy infrastructure, energy storage, and the nuclear option;
- ESRC to allocate 65 new fellowships in specific disciplines;
- MRC to increase its expenditure on clinical trials by €52 million per annum by 2007-08;
- the establishment of a charities partnership fund by HEFCE to underpin high quality research funded by charities.

The 2003 Lambert Review[20] of business-university collaboration concluded that the UK was strong in research, but less effective at translating the products of research into social and economic benefits. Hence a number of measures and instruments aimed at improving the linkage and flow of knowledge and ideas between Science Base and the Business Enterprise sector were also announced but the majority of these are detailed under Section 4.

The ten-year Science and Innovation Investment Framework set out the need to encourage greater responsiveness of the publicly-funded research base to the needs of the economy and public services, focusing especially on two targets:

- To continue to improve UK performance in knowledge transfer and commercialization for universities and public laboratories; and
- to make Research Councils' programmes more strongly influenced by, and delivered in partnership with, the end users of research.

The Ten-year Framework also announced increased support for knowledge transfer from universities in England through the Higher Education Innovation Fund (HEIF). Particular achievements include:

- a new metrics-based allocation system for the next round of HEIF;
- the development of knowledge transfer plans by the Research Councils;
- enhanced responsibility for the Regional Development Agencies to support business-university collaboration and regional innovation;
- a third round of the Public Sector Research Establishment (PSRE) Fund to assist commercialisation activity by PSREs; and
- implementation of the Lambert Review recommendations on IP management and university governance.

With regards to the important issue of the supply of scientists, engineers and technologists for the long-tem viability of the science base and the wider UK economy, the Ten Year Framework set clear ambitions to achieve a step change in:

[20] *The Lambert Review of Business-University Collaboration*, HM Treasury Consultation Review, 2003.

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

Key policy achievements in this area include:
- measures to attract more science teachers into the profession;
- support for the continuing professional development of science teachers;
- rationalisation of the range of initiatives to promote interest in STEM subjects at all levels; and
- creation of a Women's Resource Centre to increase the opportunities for professional women in SET.

The funding of PSREs should also be mentioned here. Funding for Research Council institutes forms part of the Government's Science Budget which is allocated and administered by the OSI. Allocations to specific institutes are made by the parent Research Council. Government ministries and departments provide funding for research in support of their policy objectives either intra-murally to the various (remaining) public sector government laboratories and extra-murally via commissioned research. As noted above, in recent years, a number of Government laboratories have undergone a process of partial or complete privatisation and many exist as private entities or as GOCO (Government-Owned, Contractor-Operated) bodies. Extra-mural contractors of Government-sponsored research include both private and public sector actors.

Also of relevance is the Public Sector Research Exploitation Fund, a specific innovation support measure intended to encourage public sector researchers to turn innovative ideas into commercially marketable products. Worth £25 million (€37 million) in Government funding[21], it was launched in August 2005. It is open to all public sector organisations that carry out research including Research Council Institutes, NHS Trusts, research institutions owned by Government Departments and major museums.

In 2005, the EPSRC introduced a series of Science and Innovation Awards as one way to provide support to strategic areas of research that are particularly at risk. Seven new programmes, in the areas of nanometrology, statistics, plasma physics and the Mathematics-Computer Science interface, were launched with a value of over £27 million funded by EPSRC, HEFCE, the Scottish Funding Council and the Department for Employment and Learning Northern Ireland. More recently, in response to the threatened or actual closure and merger of university physics, chemistry and mathematics departments, the Government announced an additional £75 million provided through HEFCE to be used at the discretion of individual universities (see Section 6).

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[21] *Government backing to turn ideas into reality* (2005), published as DTI press release P/2005/255 on 3 August 2005. More information available at: www.dti.gov.uk

3.6 Policy Effectiveness

The Ten-Year Science and Innovation Investment Framework has been in place since 2004, thus it is perhaps to early to attempt to judge the effectiveness of the policy measures that it has introduced. However, the associated 2006 Annual Report, which assesses the progress of the Framework against a series of metrics does offer a number of preliminary findings:

With regard to the health of the Science base, indicators seem to show that the UK is maintaining its strong position in terms of research outputs and their impact, although these are essentially historic measures and it will take time for any policies implemented under the Framework to have effect.

The Research Councils' Performance Management System has been in operation for over a year and all the Research Councils and Research Councils UK have published 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 have been noted and the Delivery Plans and scorecards were refreshed and republished in May 2006 to reflect these achievements.

UK HEIs have been implementing a Transparent Approach to Costing (TRAC) as a robust and effective costing system based on the principles of activity-based costing. This has been extended to allow the forecasting of Full Economic Costing at activity and project level and now offers HEIs better information to guide their further development into market-based and valued-based pricing. In addition, since September 2005, all proposals to the Research Councils have been submitted on the basis of FEC. The resulting grants have been funded at the rate of 80% FEC, which by 2007/08 should provides an extra £200 million per annum. It is too early to judge whether these efforts are realising the goal of returning the HE sector to a sustainable basis (as a Research Councils review in May 2006 concluded) although the implementation of the process has so far been straightforward, with no major problems reported.

An independent study into the future needs for infrastructure funding has been commissioned by the OSI and the UK funding bodies and the results were due to be reported by September 2006 although no reports could be located. Other studies undertaken by OSI indicate that "SRIF funding is achieving significant benefits such as the establishment of laboratories to a high standard enabling universities to carry out quality projects from various funding sources, and to compete globally. The refurbished laboratories and new equipment are also attracting world-class researchers and academics to the UK". Meanwhile, to focus on a single aspect of infrastructure, a study commissioned from external consultants by the Joint Information Systems Committee, the organisation in charge of information technology in higher education – has reported that IT provision in some UK universities prevents high speed internet access. The report notes that out-of-date computer networks prevent academics from accessing information electronically and video-conferencing. On the other hand, the study also found that ease of access to a university's computer network was contributing to the trend toward home working and other flexible patterns of work.

One industry-based opinion of the effects of FEC has come from the Association of British Pharmaceutical Industries (ABPI) which warns that drugs firms are seeking research partners elsewhere, rather than using UK universities. According to the most recent ABPI bi-annual survey, UK companies are forming fewer – but larger – research collaborations with UK universities, and increasingly looking overseas, driven by cost concerns and also by overly-aggressive university intellectual property policies. Apparently, it is felt that the FEC policy fails to take into account the intangible value of company collaboration to university researchers.

The UK Research Base Funders' Forum[22] has investigated various issues such as the health of disciplines, research careers and university financial sustainability, along with discussions for the next stage on FEC. A report from the UK Funding Councils[23] indicated that the great majority of UK HEIs are on course towards long-term sustainability.

The Annual Report for the Ten-Year Framework also notes that progress towards sustainability is taking place within PSREs. The OSI has established the RESUK forum where matters relating to the implementation of FEC and the Research Council Institute and PSRE Sustainability Study guidelines can be discussed. It has also undertaken an annual survey (the first of its kind) of sustainability in PSREs which is intended to provide a baseline against which to measure future progress. The first annual survey in 2006 indicated some concerns about the current sustainability of around one third of PSREs, but action is currently being taken to address the problems identified in some of these PSREs.

Thus, in the absence of more detailed or specific evaluations and reviews, it appears that overall the Government is responding to a series of correctly identified challenges with a mix of appropriate policy instruments.

[22] This consists of representatives of the major funders of 'public good' research including business, charities, Funding and Research Councils, Government Departments and HEIs in order to consider their collective impact on the sustainability, health and outputs of the UK Research Base.
[23] http://www.dti.gov.uk/science/science-funding/Funders_Forum/index.html

4 Business R&D & Innovation

4.1 Introduction

The private sector represents a major component of the UK system of innovation. However, before looking in detail at activities relating to R&D, it is best to obtain a picture of the overall structure of the UK business sector. Thus, Table 8 presents an overview of the structure of the business sector in terms of the number of firms, total numbers of employees and their turnover, broken down by size of firm in terms of number of employees.

It can be seen that in 2004, although only half a percent of the total number of firms employed over 250 people, these employed almost half the total number of business employees and contributed over half the total industry turnover. Further information on the contribution of small companies and SMEs will be presented below.

Table 8: Numbers, employment and turnover of UK businesses, 2004

	Number			*Percent*		
All Industries	Enterprises	Employment (1,000)	Turnover (£million)	*Enterprises*	*Employment*	*Turnover*
All employers	1,163,330	18,556	2,161,248	*100.0*	*100.0*	*100.0*
Micro (1 - 9 employees)	971,960	3,678	343,879	*83.5*	*19.8*	*15.9*
Small (10 - 49 employees)	159,580	3,168	335,748	*13.7*	*17.1*	*15.5*
Medium (50 - 249 employees)	25,810	2,579	337,031	*2.2*	*13.9*	*15.6*
Large (250 or more employees)	5,980	9,130	1,144,590	*0.5*	*49.2*	*53.0*

Source: Office of National Statistics, 2006[24]

The Office of National Statistics' breakdown of business expenditure on 'civil' and 'defence' R&D by broad product groups is shown in Table 9 below. In terms of R&D spending, the largest single manufacturing product group is the chemicals (including pharmaceuticals) group.

[24] **http://www.statistics.gov.uk/STATBASE/Expodata/Spreadsheets/D7070.xls**

Table 9: Expenditure on civil and defence R&D performed in UK businesses: by broad product groups (2004)

In cash terms (£million)	Civil 2004	Defence 2004	Total 2004
Manufacturing: Total	7,365	1,998	10,351
Chemicals (including Pharmaceuticals)	3,244**	-	3,810
Mechanical engineering	505	606	1,111
Electrical machinery	996	286	1,283
Transport equipment	896**	4	994
Aerospace	917	1,082	2,000
Other manufacturing	807**	20**	1,153
Services: Total	2,412**	61**	2,854
Other: Total	297	1	298
Agriculture, hunting & forestry; Fishing	107	-	107
Extractive industries	108	-	108
Electricity, gas & water supply	43	-	43
Construction	39	1	40
TOTAL	**11,248**	**2,256**	**13,504**

Source: derived from National Statistics BERD 2004 (18 May 2006)[25]
** Denotes disclosive figures
- Denotes nil, figures unavailable or too small to display

The largest single manufacturing product group in terms of R&D spending is pharmaceuticals, contributing 31% of manufacturing spend and 24% of the total spend. The top manufacturing spenders in 2004 were the pharmaceuticals (£3,244 million), aerospace (£2,000 million) and electrical machinery sectors (£1,283 million). Of particular note is the strong presence of the services sector which had a total R&D spend of £2,876 in 2003, placing it second to the pharmaceuticals sector overall.

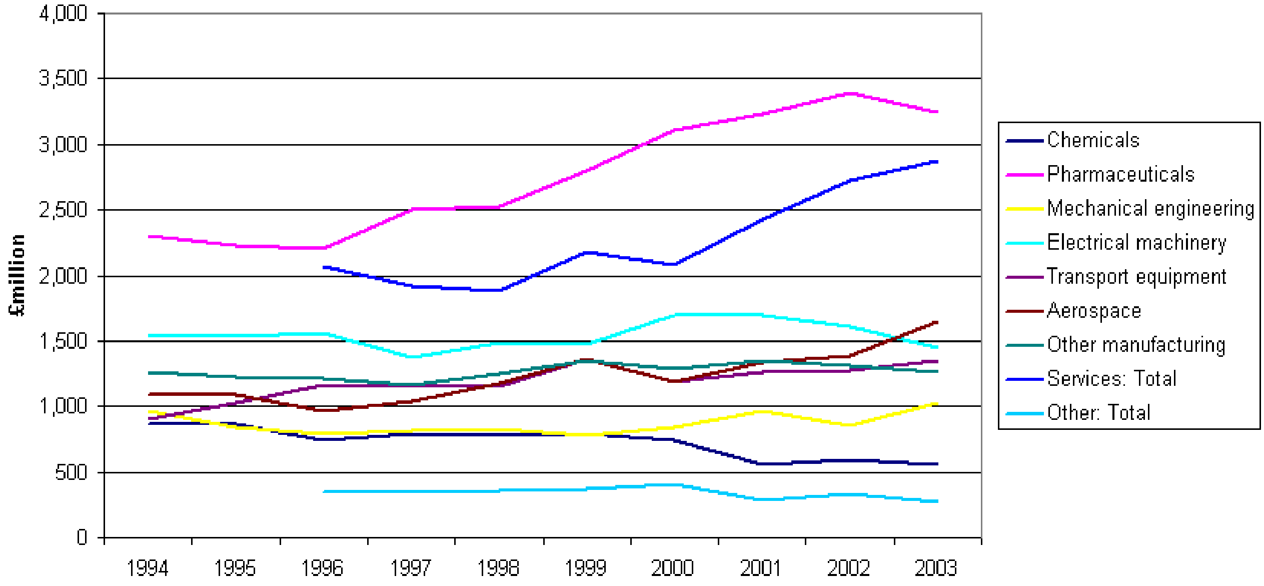
UK businesses spent 5% of their total current (excluding capital) expenditure on R&D on 'basic' research as defined in the OECD Frascati Manual. The major part (59%) of the expenditure is classed as 'experimental development', with a further 36% as 'applied' research. Intramural R&D expenditure as a percentage of sales of manufactured products was 3% in 2003.

Trends in annual R&D expenditure since 1989, by detailed product groups, are shown in Figure 5 below and overall trend data 1996-2004 are shown in Figure 6.

Perhaps the most significant point emerging from these figures is the decline in overall BERD in 2004, although figures are as yet not available to detect whether this is the start of a continuing trend or a one-off event.

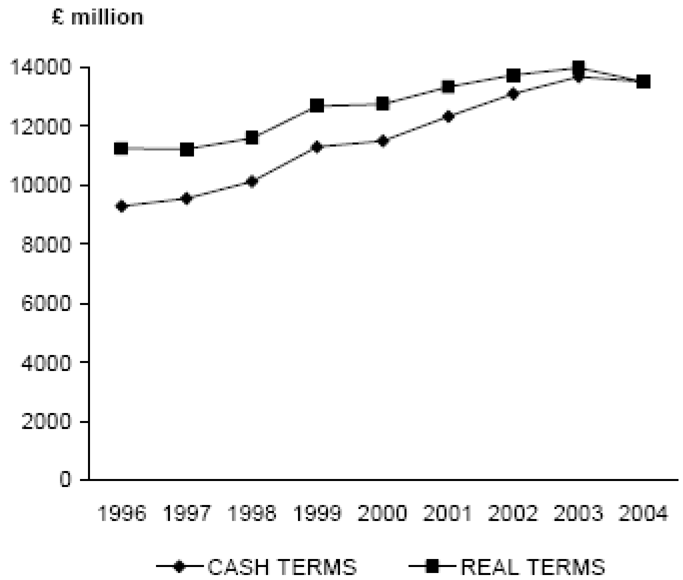
25 *Business Enterprise Research and Development 2004,* Issued by National Statistics (London), May 2006. See: http://www.statistics.gov.uk/pdfdir/berd1104.pdf

Figure 5: Expenditure on R&D performed in UK businesses (real terms), by broad product group.



Source: SET Statistics 2004, Office of Science and Technology[26]

Figure 6: Expenditure on R&D performed in UK businesses, 1996-2004

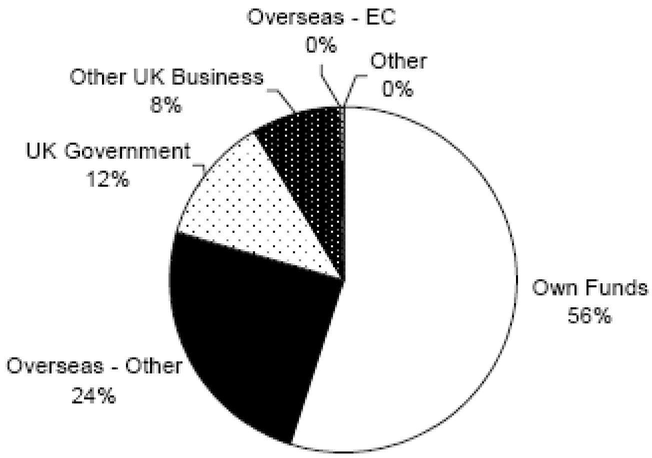


Source: National Statistics BERD 2004 (18 May 2006)

[26] SET Statistics 2004, see http://www.ost.gov.uk/setstats/4/f4_4.htm (31 October 2005)

The sources of funds for R&D performed in UK businesses in 2004 are shown in Figure 7. In monetary terms, of the total spend of £13,504 million, £7,443 million came from companies own funds, other UK businesses provided £1,117 million while UK Government sources accounted for another £1,602 million. From an overseas total of £3,336 million, European Commission grants accounted for £47 million, the remainder coming from other overseas sources. The final remaining income of £5 million cam from other sources.

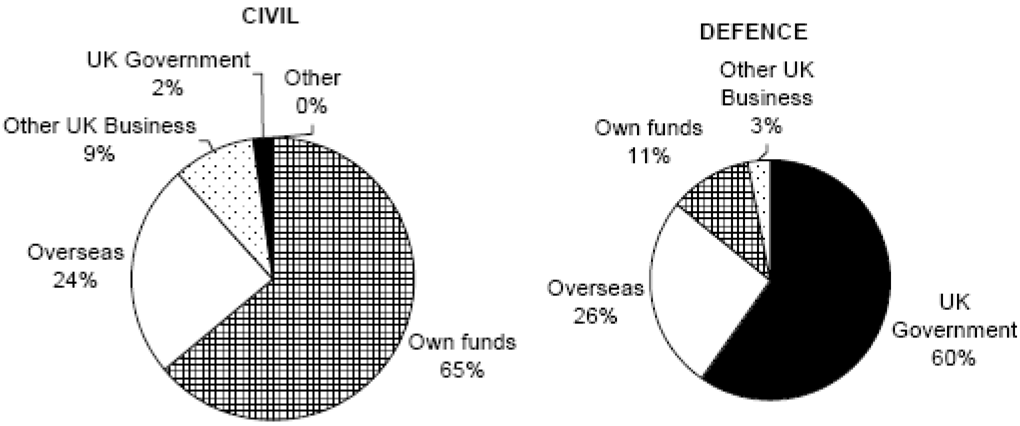
Figure 7: Sources of funds for R&D performed in UK businesses, 2004



Source: National Statistics BERD 2004 (18 May 2006)

If one looks at the civil and defence sectors separately, a very different picture is formed, as shown in Figure 8. It is immediately apparent that the UK Government forms the main source of funds for defence-related R&D, providing £1,346 million of a total spend of £2,256 million compared to its contribution of £257 million for civil R&D.

Figure 8: Sources of funds for civil and defence R&D performed in UK businesses, 2004



Source: National Statistics BERD 2004 (18 May 2006)

Table 10 provides information on the distribution of business R&D activity broken down by Government Office regions. It is clear that the location of R&D performers, and business in general, is far from homogeneous, and that there is a concentration in the south-eastern 'corner' of the UK which accounts for over half of the R&D spending and just under half of the R&D employment, with a smaller focus in the North West.

Table 10: R&D performed in UK businesses by Government Office region: expenditure and employment, 2004

	Expenditure (£million)	% of total	Employment (FTE in thousands)
United Kingdom	13,504	100.0	163
England	**12,546**	**92.9**	**148**
North East	**269**	**2.0**	**4**
North West	**1,691**	**12.5**	**16**
Yorkshire and the Humber	**372**	**2.8**	**6**
East Midlands	**978**	**7.2**	**14**
West Midlands	**800**	**5.9**	**14**
East of England	**2,969**	**22.0**	**31**
London	**842**	**6.2**	**12**
South East	**3,265**	**24.2**	**38**
South West	**1,361**	**10.1**	**13**
Wales	**228**	**1.7**	**4**
Scotland	**614**	**4.5**	**9**
Northern Ireland	**116**	**0.9**	**3**

Source: derived from National Statistics BERD 2004 (18 May 2006)

In terms of manpower, UK businesses employed 163,000 FTE personnel engaged in R&D in 2004[27]. Of these, almost two thirds (103,000) were scientists and engineers, 25,000 were technicians, laboratory assistants and draughtsmen, whilst the remaining 34,000 were administrative, clerical industrial and other staff. The majority of scientists and engineers were employed in the pharmaceuticals (13,000), computer and related activities, aerospace, and machinery and equipment (each 11,000) sectors. The research and development services sector employed a further 7,000. A total of 85,000 scientists and engineers were employed in the civil sector and 18,000 in the defence sector.

The total business enterprise expenditure on R&D, together with R&D employment, can also be disaggregated by company size, as represented by total number of employees (see Table 11). About 33% of the total R&D spend is accounted for by enterprises with between 1,000 to 4,999 employees, which also employee around 30% of the R&D workforce, while a further 11% of expenditure and 17% of R&D employees are accounted for by companies with less than one hundred employees.

Table 11: R&D expenditure and R&D employment by total company employment size-bands, 2004

Company size	**0-99**	**100-399**	**400-999**	**1,000-4,999**	**5,000-9,999**	**10,000 - 19,999**	**over 20,000**	Total
R&D Expenditure (£million)	**1,504**	**1,931**	**1,932**	**4,420**	**1,946**	**1,392**	**378**	13,504
R&D employment	**28**	**27**	**25**	**49**	**19**	**10**	**4**	163

27 *Business Enterprise Research and Development 2004,* Issued by National Statistics (London), May 2006. See: http://www.statistics.gov.uk/pdfdir/berd1104.pdf

('000 FTEs)

Source: derived from National Statistics BERD 2004 (18 May 2006)

The role of SMEs in terms of R&D expenditure is further elaborated in Table 12. This would seem to indicate that although companies with 250 employees or less contribute just under one-fifth of the total UK business R&D spend, the contribution from those defined as SMEs is actually much lower at around 3.5%.

Table 12: Expenditure on R&D performed in UK businesses: by small and medium size enterprises, 2004

£million	250 employees and over	0 to 249 employees	of which, SME	Total expenditure
	10,879	2,625	*473*	13,504

Note: The definition of SME used is that under the European Commission Recommendation (96/280/EC) of 3 April 1996, in which SMEs are defined as being enterprises with less than 250 employees, and also a criterion of independence is used to exclude enterprises that are part of a larger enterprise group.

Source: derived from National Statistics BERD 2004 (18 May 2006)

Looking at these figures a slightly different way (see Table 13, below), it can be seen that the top five companies in terms of R&D expenditure employ around 20% of the total R&D employees and account for almost one quarter of the total UK industrial R&D spend. They also receive almost half of the Government's total funding of business R&D.

Table 13: Expenditure and employment on R&D performed in UK businesses: top 100 enterprise groups, 2004

	R&D Employment (Full time equivalent in thousands)	Total Intramural Expenditure (£million)	Funded by UK Government (£million)
TOTAL ALL ENTERPRISES	163	13 504	1 602
Enterprise groups with the largest expenditure on R&D			
Top 5	32	3 325	721
Top 10	48	5 124	1 035
Top 15	63	6 310	1 155
Top 20	71	6 960	1 155
Top 50	90	8 828	1 379
Top 100	105	10 193	1 487

Source: National Statistics BERD 2004 (18 May 2006)

Another set of interesting statistics is offered by the Office of National Statistics analysis of expenditure on R&D performed in businesses located in the UK but whose country of ownership may be outside the UK. From Table 14 it can be seen that UK-owned businesses actually contribute just over 60% of total UK business R&D

expenditure and that foreign-owned businesses, particularly those with US-ownership, play a major role in terms of both R&D spending and employment.

Table 14: Expenditure and employment on R&D performed in UK businesses: by country of ownership of business performing R&D, 2004

	Intramural Expenditure (£million)	%	Employment (FTE in thousands)	%
TOTAL	13,504	100.0	163	100.0
United Kingdom	**8,294**	**61.4**	**99**	**60.7**
United States	**2,890**	**21.4**	**31**	**19.0**
Germany	**238**	**1.7**	**3**	**1.8**
France	**497**	**3.6**	**5**	**3.1**
Other EU	**801**	**5.9**	**8**	**4.9**
Japan	**299**	**2.2**	**3**	**1.8**
Rest of the world	**485**	**3.6**	**5**	**3.1**

Source: derived from National Statistics BERD 2004 (18 May 2006)

Turning to the R&D performance of individual firms, 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 2006 annual 'Scoreboard' examines expenditures on R&D and capital equipment for 1,250 companies worldwide and 800 from the UK, and presents a series of analyses. The main findings from the 2006 edition of the Scoreboard[28] include:

- Almost one quarter of the Global 1250 companies are mid-sized (with sales of £50million to £500 million); over three quarters of these are from the pharmaceuticals, software and technology hardware sectors. The USA has the largest proportion of its companies in the middle–sized category, whilst the UK has the second largest proportion amongst the top seven R&D nations.
- There are 72 UK–owned companies in the Global 1250, making it the third largest country group (equal to Germany). These have a total R&D expenditure of £13.1 billion, an increase of over 8% over the previous year. However, of the top 50 companies in the Global 1250, only three (GlaxoSmithKline, AstraZeneca and BAE Systems) are UK-owned.
- The total R&D of the separate UK 800 (which contains the 72 companies in the Global 1250) is £19.2 billion compared to £17 billion reported in the 2005 Scoreboard. The increase is due both to greater disclosure of R&D under IFRS by companies in sectors such as banks, insurance, media and retail[29] and to an increase in R&D more generally (up 4% in 2006 compared to a decrease of 1% in 2005). Listed UK companies have grown their R&D by over 8%.

[28] http://www.innovation.gov.uk/rd_scoreboard/highlights.asp

[29] Examples of companies included in the Scoreboard for the first time in 2006 are: Royal Bank of Scotland (£329m), HSBC (£245m), Tesco (£115m), Royal & Sun Alliance (£122m) and Reed Elsevier (£102m). Figures in brackets indicate R&D spend.

- UK R&D is particularly strong in pharmaceuticals and aerospace and contains a growing software sector (119 companies in 2006). The proportion of UK companies with R&D above £2.9 million and with high R&D intensity (over 10%) is rising and is significantly above that of the rest of the EU although still below the USA.
- The top ten foreign–owned UK companies account for just over half of the £4.4 billion of R&D performed by foreign–owned UK companies. Eight of these ten have higher R&D intensities than their overseas parents and this emphasises the attraction of the UK as a location for R&D.

The top 25 UK companies by R&D are shown below, five of these are foreign owned:

Figure 9: Top 25 UK companies by R&D in the UK 800

Rank 2006	Company	Rank 2003	R&D £1bn	R&D Growth (1yr)	Sector
1.	GlaxoSmithKline	1	£3.14bn	10%	Pharmaceuticals
2.	AstraZeneca	2	£1.97bn	-11%	Pharmaceuticals
3.	BAE Systems	4	£1.45bn	31%	Aerospace
4.	BT	7	£0.73bn	39%	Fixed Line Telecoms
5.	Ford**	3	£0.69bn	-10%	Automotive
6.	Unilever	5	£0.65bn	-8%	Food Producers
7.	Rolls Royce	9	£0.35bn	25%	Aerospace
8.	Pfizer**	6	£0.35bn	-41%[c]	Pharmaceuticals
9.	Airbus**	_[a]	£0.34bn	-1%	Aerospace
10.	Royal Dutch Shell	10	£0.34bn	6%	Oil & gas
11.	Royal Bank of Scotland	_[b]	£0.33bn	9%	Banks
12.	BP	11	£0.29bn	14%	Oil & gas
13.	HSBC	_[b]	£0.24bn	34%	Banks
14.	Land Rover**	_[a]	£0.23bn	2%	Automotive
15.	Vodafone	15	£0.21bn	-6%	Mobile Telecoms
16.	Marconi (now Telent)	8	£0.19bn	-6%	Technology hardware
17.	Shire	18	£0.17bn	49%	Pharmaceuticals
18.	ICI	16	£0.15bn	0%	Chemicals
19.	Smiths	19	£0.14bn	5%	Aerospace
20.	Eli Lilly**	21	£0.14bn	-5%	Pharmaceuticals
21.	Royal & Sun Alliance	_[b]	£0.12bn	4%	Non life insurance
22.	Reuters	13	£0.12bn	-5%	Media
23.	Tesco	_[b]	£0.12bn	35%	Food & drug retail
24.	Invensys	12	£0.11bn	-11%	Electronics
25.	Reed Elsevier	_[b]	£0.1bn	-7%	Media

a Not in 2003 Scoreboard: Airbus was 7th in 2004 and Land Rover 12th in 2005
b This is the first time that R&D has been disclosed in these companies' accounts
** – Foreign owned UK company

c A substantial part of the reduction in Pfizer (UK) R&D is due to a change in the way R&D is reported in their latest accounts compared to previous years; see notes in Volume 2 for further details.

At this point it is also worth mentioning that the UK has around 60 **science parks** in which businesses are located usually on or near a university campus or research centre. This gives the companies the opportunity to engage in collaborative research, professional training or other knowledge transfer. Many science parks include incubator units for start-up companies. The parks house over 2,200 companies, employing over 47,000 scientists and engineers, 85% of these firms are small or medium sized with a technology base. Evidence shows that companies based on UK science parks grow more quickly, and have higher turnovers than similar companies based off science parks. They are also more likely to access all forms of finance for start up and business growth than off-park counterparts.

The issue of linkages between the business enterprise sector and the Science Base forms a core focus of UK innovation policy and this section will deal with the various forms of policy instrument in place to encourage knowledge transfer between the two sectors.

4.2 Indicators and Challenges

The objective of the preceding section was to set a general scene and context of UK Business R&D and innovation. The following Table presents a number of specific stand-alone indicators which may also contribute to this picture.

Table 15: Indicators for Business R&D and Innovation

Indicator	**value (date)**	**Source**
Percentage of workforce in medium-high and high-tech manufacturing	6.27 (2003)	EIS
Percentage of workforce in high-tech services	4.40 (2003)	EIS
Innovation expenditure as a percentage of turnover	1.61 (2000)	EIS
EPO patents per million population	128.7 (2002)	EIS
USPTO patents per million population	64.5 (2002)	EIS
Number of triad patents per million population	30.0 (2000)	EIS
Number of new community trademarks per million population	105.8 (2004)	EIS
Number of new community designs per million population	65.8 (2004)	EIS
Percentage of SMEs innovating in-house	22.4 (2000)	EIS
Percentage of SMEs involved in innovation co-operation	7.2 (2000)	EIS
Percentage of SMEs using non-technological change	n/a	EIS
Share of high-tech venture capital investment	n/a	EIS
Share of manufacturing value-added in high-tech sectors	n/a	EIS
Sales of 'new to market' products as a percentage of turnover	1.7 (2000)	EIS
Sale of 'new to the firm but not to the market' products as a % of turnover	16.7 (2000)	EIS
Exports of high technology products as share of total exports	21.0 (2003)	EIS
Business expenditure on R&D (BERD) as a percentage of GDP	1.30 (2003)	EIS
Share of medium-high-tech and high-tech R&D	91.1 (2003)	EIS
Share of enterprises receiving public funding for innovation	3.8 (2000)	EIS
University R&D expenditures financed by business sector	5.6 (2003)	EIS
Share of BERD in GERD	43.9 (2003)	3%AP
Share of BERD financed by Government	12.0	ONS
SME share of R&D executed by business and financed by government	n/a	
Early stage venture capital (% of GDP)	0.038 (2003)	EIS
Share of seed and start up venture capital in GDP	n/a	3%AP
Share of seed and start up venture capital by sector	n/a	3%AP
Expenditure on innovation as % of turnover in manufacturing industry	1.61 (2000)	EIS

Key: OECD = Organisation for Economic Cooperation and Development; EIS = European Innovation Scoreboard; RTD = RTD Indicators Report; 3%AP = 3% Action Plan; ONS = Office of National Statistics

* There is some overlap with indicators relevant to other domains and between indicators from different sources.

In order to assess the degree of linkage between the business enterprise sector and the Higher Education sector, HEFCE sponsors an annual *Higher education-business and community interaction* (HE-BCI) survey. This is used to inform the strategic direction of so-called 'third stream' action undertaken by funding bodies and higher education institutions (HEIs) in the UK. The term 'third stream' is used as it implies that this represents an additional form of higher education support over the dual support system (see Section 2). Data are gathered on a wide range of third stream activities, 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 key results from the 2006 Survey[30] are shown in Table 16.

Table 16: Key indicators: Higher Education-Business and Community Interaction Survey 2000-2004.

	2000-01	2001-02	2002-03	2003-04
Number of disclosures	2,159	2,478	2,710	3,029
Consultancy income (£M in real terms*)	112	129	172	211
Collaborative research income (£M in real terms*)	447	495	491	541
A required contracting system for all staff-business consulting activities (% of UK HEIs)	60%	65%	66%	68%
An enquiry point for SMEs (% of UK HEIs)	83%	85%	89%	90%
Regeneration income (£M in real terms*)	129	134	150	216
Facilities and equipment related services income (£M in real terms*)	28	53	68	80
HEIs providing short bespoke courses on companies' premises	62%	67%	78%	80%
HEIs providing distance learning for business	52%	52%	66%	66%

Source: Higher Education-Business and Community Interaction Survey, 2006.

The HE-BCI collects a range of indicators, including disclosures, patents, licences and spin-off companies. Amongst other things, the 2006 Survey indicated that:

- The number of disclosures increased from 2,710 (2002-03) to 3,029 (2003-04).
- Patent applications and new patents granted increased by 7% and 23% respectively. The UK HE sector holds 5,707 patents (up from 3,938 in 2002-03) although some of the increase may be due to HEIs' improved management information systems.

[30] http://www.hefce.ac.uk/pubs/hefce/2006/06_25/

- The number of active licences granted by UK HEIs rose sharply from 2002-03, with over 1,200 non-software licences reported in 2003-04. Income from non-software licences was over £22 million, up by over £2 million from 2002-03. Many more active software licences (908) were reported in 2003-04 compared with the previous year, the majority granted to SMEs. Income from software licences was over £2 million, down slightly from 2002-03.
- Income from the sale of equity in spin-off companies was down by around £4 million compared with 2002-03 at £7.3 million.
- UK HEIs spent nearly £15 million protecting IP, nearly £2 million more than in 2002-03.
- The number of spin-off companies created fell for the fourth year in a row, with 133 companies created in which the HEI has maintained an ownership stake. However, the number of firms that have survived for three years has increased in each of the last three years.
- There are currently 920 spin-off companies active from UK HEIs, with 562 being older than three years. HEIs have reported increases in both staff and turnover from spin-offs.
- Fifty new staff start-up companies were formed in 2003-04 and around 570 graduate start-up companies were formed. On average, staff start-up companies employ more people and have substantially higher turnover than those of graduates.
- Comparisons with activity in the US continue to show that more spin-off companies are created per £1 of research income in the UK. However, US institutions continue to generate proportionally more income from the licensing of IP than UK HEIs.

In the light of the foregoing analyses, the following table (Table 17) summarises the Strengths, Weaknesses, Opportunities and Threats facing business R&D and innovation in the UK.

Table 17: SWOT analysis of UK Business Enterprise R&D and innovation

Strengths	Weaknesses
• **Above EU average for total innovation expenditure.** • **Above EU average for employment in high-tech services.** • **Above EU average in triadic patents.** • **Strongly performing pharmaceuticals and aerospace sectors with strong R&D capabilities.**	• **Consistently relatively low levels of innovation activity and BERD, with recent further decline.** • **Low share of firms that receive public funding for innovation (46% of EU average) –although CIS omits tax incentives (favoured in UK policy) and focuses on direct support (discouraged in UK policy).** • **UK performs at 33% of EU average for new-to-market product sales.** • **Weak on innovation demand due to very low levels of capital investment (and poor customer responsiveness).** • **Scores poorly on innovation governance (but due entirely to low score for e-governance)**
Opportunities	Threats
• **Strengthening the linkages between the business enterprise sector and the**	• **Long term effects of deficiencies in skills base and declining interest in**

science base would improve the capture of the latter's outputs and capabilities and enhance productivity and competitiveness.

- **Strengths in services sector could benefit from targeted innovation policies.**

physics, chemistry and engineering may negatively affect industrial R&D capacity.

In support of this SWOT analysis, it is worth noting that two of the three major identified challenges facing the UK economy fall under this section, namely:

- **Boosting the intensity of innovation activity in enterprises** has been a long-standing challenge for the UK and the subject of policy debate in recent years. This challenge includes the recent negative trend of BERD, where the low investments in business R&D expenditure are now fully recognised by policy makers. Linked to this challenge is the 'cultural barrier', where usual consumer demand may not have created the market for new and innovative products. Therefore, the Government believes, public procurement can play a major part in creating the demand for innovation, which can subsequently boost the intensity of innovation in enterprises. Whether or not public procurement offers such rewards is still the subject of academic and policy debate.
- **Strengthening the linkages between the research base and business (including services)**: A major challenge for the UK is the decline of business-funded university R&D, which has been a continuous trend since the late 1990s. Given the strong policy push to increase private funding of university research, the continual decline from 7.3% in 1999 to 5.6% in 2004 may be considered as a failing of UK innovation policy. This decline is probably contributing to the crisis in the public research sector, due to inadequate public funding and the assumption that the gap would be covered by private sources. The UK performs below average on this indicator and its trend performance has been strongly below the EU average trend. A better level of science-business cooperation or knowledge transfer is at the core of various DTI reports and several initiatives and programmes exist.

4.3 Governance

As noted above (Section 2) the Department of Trade and Industry forms the focal point for the governance of innovation policy in the UK. In order to promote the exploitation of S&T, the DTI takes the lead on a number of mechanisms (such as Foresight) and has joint responsibility with the DfES on others like the Higher Education Innovation Fund, which are designed to promote the commercial exploitation of Government funded research and stimulate collaboration between the research community (including universities) and industry. The new Office of Science and Innovation (OSI) established within the DTI in April 2006 now incorporates the former DTI Innovation Group which aims to create the right climate for innovation by changing attitudes within the public and private sectors. The Innovation Group also includes the Technology Strategy Board. The Government expects the Technology Strategy Board to play an increasing role in contributing to the development of the

Government's innovation strategy across all important sectors of the UK economy[31]. This wider remit will require the Board to set priorities for its support on innovation, on areas which offer the greatest scope for boosting growth and productivity, in the context of an increasingly globalised economy. Plans for delivery of the Board's remit to operate at arms length from central government are being implemented, to secure improved value for money and better delivery to business. There will be a particular focus on driving up business engagement with universities. The OSI is headed by David King, the government's Chief Scientific Adviser, whilst Keith O'Nions, formerly Director General of Research Councils, became DG for Science and Innovation, and the DTI's CSA. The post of DG of the Innovation Group, created in 2002, has been abolished.

The DTI operates and/or funds a number of schemes for the promotion of innovation in companies mainly based around the identification and dissemination of best practice and the exchange of people (and their ideas and expertise). The DTI also attempts to foster the creation and growth of new companies (especially New Technology Based Firms) and it encourages the acquisition, development and use of technology and provides R&D support and advice to SMEs (and larger firms, in the fields of energy, space, and civil aeronautics) through a number of measures.

At the higher innovation policy-making level, following the publication of the 2003 Innovation Report (*Competing in the Global Economy - The Innovation Challenge*) by the Department of Trade and Industry[32], the Prime Minister asked the Secretary of State for Trade and Industry to establish a cross-departmental "Ministerial team to lead the innovation agenda across the whole of Government and drive forward the implementation [of the report]". In March 2005, the Prime Minister agreed to the formation of a new Cabinet Committee on Science and Innovation that subsumed the former Cabinet Science (Policy) committee ("SCI") and the Ministerial Group on Science, Innovation and Wealth Creation ("SIKE"). The formal terms of reference of this Committee are: *"to determine and oversee the implementation of the government's policies in relation to science, innovation and wealth creation."*

Regional innovation policy governance is operated through nine Regional Development Agencies in England and through the devolved administrations for Wales, Scotland and Northern Ireland (see Table 18).

Table 18: Regional governance of innovation policy matters

Level of regional/local government	Legislative &/or administrative authorities	Powers related to innovation policy, if any
Nine English Regional Development Agencies	Each RDA is led by a Chair and a Board of 15 people. With the exception of London, where appointments are made by the Mayor, board members, including the Chair are appointed by DTI Ministers. Since April	Responsibility for funding or co-funding and delivery of some innovation policy measures (e.g. HEIF, Regional Innovation Fund, Business Link etc.). Have powers to develop joint strategy between RDAs to

[31] HM Treasury, Department for Trade & Industry, Department for Education and Skills and Department of Health, *Science & innovation investment framework 2004-2014: next steps,* March 2006, Available online at:
http://www.hm-treasury.gov.uk/media/1E1/5E/bud06_science_332.pdf

[32] *Competing in the global economy: the innovation challenge*, *DTI Innovation Report*, December 2003 Available at: http://www.dti.gov.uk/innovationreport/innovation-report-full.pdf

	2002, RDAs have been financed through a Single Programme. Monies from the contributing Departments (DTI, DCLG, DfES, DEFRA and DCMS) are pooled into one single budget. The funding, once allocated, is available to the RDAs to spend as they see fit to achieve the regional priorities identified in their Regional Economic Strategies and the challenging targets set by them in their Corporate Plans.	promote science and innovation initiatives (e.g. Northern Way initiative between 3 RDAs) and to develop the notion of 'Science Cities', which provides a focal point for businesses seeking to collaborate with world-class research establishments in the regions (e.g. currently being developed in Manchester, Newcastle, York, Birmingham, Nottingham and Bristol).
Three Devolved Administrations in Scotland, Northern Ireland and Wales	The powers of the National Assembly in the three devolved administrations is mainly administrative and secondary legislative powers in areas which have been specifically devolved: (e.g. economic development, agriculture, industry and training, education, local government services, health and social services, housing, the environment, planning and transport, and sport and heritage).	Significant aspects of the innovation policy agenda are the responsibility of the Devolved Administrations. This revolves around gaining active participation and consensus of all the key regional stakeholders and partners, and with a view to providing a framework for the creation of an innovation-driven regional economy.

One key aspect of UK innovation policy governance is the role played by processes such as review and evaluation in the formulation, design and assessment of innovation policy and policy instruments. The following text is derived from the 2006 Trend Chart Report for the UK.

Design of policy measures: Policy making for innovation promotion in the UK is strongly evidence-based. As mentioned above, the Government seeks and receives policy advice from a diverse array of committees and advisory groups. The specific design of policy measures is undertaken within the lead ministries responsible for their delivery or, in cases where delivery is through an agency or innovation support structure, such as the Small Business Service (SBS), the ministry directly responsible for funding the measure. Responsible agencies (including ministries) hold Public Service Agreements (PSAs), the mechanism of accountability to the ultimate controller of funding, HM Treasury. Failure to meet PSAs can affect future budgetary allocations; hence it is in the clear interest of ministry officials to ensure that their policies are designed to effectively and efficiently meet Treasury targets. A range of stakeholders may be consulted on the technical and operational details of policy measures, depending on the type of measure being designed. For example, fiscal measures will involve major inputs from HM Treasury and the Inland Revenue, while technology transfer measures will take account of the views of business representatives, universities, intermediary organisations, employers' representatives, etc. The way in which this involvement is handled will vary on a case by case basis.

Decision making process for policy design: Although policy making is made by Government, generally by the lead responsible agency (i.e. DTI for industrial or S&T policy-related issues, DfES for skills, training and higher education issues, HM Treasury and Inland Revenue for fiscal issues), the approach involves cross-departmental coordination and policies and measures are frequently shared between two or more ministries/departments. The Government will also make use of consultation, with a wide range of stakeholders in its policy formulation process. This is typically achieved through the release of a consultation document or position paper either by the Government itself, or by the individual (chairperson) or working group specifically commissioned to undertake the study. Such documents are freely available and invite feedback from the entire range of concerned stakeholders, either on an individual or collective basis. Lobby groups and equivalent representative organisations are equally welcomed to respond to these documents and these responses are frequently published in the public view by the group concerned. In addition, the UK maintains, through a number of bodies, a good array of statistical and indicator based information on the inputs, outputs and performance of the UK innovation system. Leading agencies involved in the collection, maintenance and analysis of this data include the Office of National Statistics, the OSI (notably through its SET Statistics), the Higher Education Statistics Agency and the DTI's Competitiveness Indicators. Data is also collected through the Community Innovation Survey. The DTI's Competitiveness Indicators provide a major input to the Government's innovation strategies. These indicators are derived from a variety of sources including OECD, CIS, and nationally compiled information, together with information from international studies and reviews.

Frequency and nature of policy reviews: The UK Government regularly publishes strategic documents and policy review papers of various types. Several examples are listed in Section 3.4.

Appraising the impact of other policy or regulatory proposals on innovation performance: Innovation is increasingly regarded as an issue to be considered in other policy areas, such as health policy, energy policy, defence policy, transport policy, environmental policies, etc., but there appears to be little evidence that demonstrates the appraisal and impact of other policy or regulatory proposals on innovation performance or potential in the UK. Other policy areas are only just recognising innovation as an important component in policy review and consultation type documents. Therefore innovation is now on the agenda of a number of other types of policy areas as it can be seen to cut across such areas as trade, competition, employment, finance, education, etc. Examples of this can be found in recent publications such as the Ministry of Defence industrial strategy white paper[33], and the Home Office strategy paper[34] (see Section 7.2).

Coordination mechanisms: As mentioned earlier, cross-departmental coordination of policies and measures is frequently shared between two or more ministries/ departments (see the Cabinet committee on Science & Innovation above).

Evaluation of policy measures: Evaluations of measures are carried out systematically, where this is appropriate, and the UK can be regarded as having a strong "evaluation culture"[35]. The use of assessment, monitoring, evaluation and related activities has been broadly accepted throughout UK Government for several

[33] Ministry of Defence (2005), "Defence Industrial Strategy" – Defence White Paper, December 2005, presented to Parliament by The Secretary of State for Defence. Available online: http://www.the-dma.org.uk/Secure/Admin/Diary/Attachments/1849.PDF

[34] Home Office (2005), "Science and Innovation Strategy 2005-08", 22 November 2005. Available online at: www.scienceandresearch.homeoffice.gov.uk

[35] An "evaluation culture" (or culture of evaluation) is one in which evaluation, and the lessons drawn from it, form an important element of innovation programme management and policy formulation.

years, and has been progressively developed to meet changing needs and pressures. These activities are applied at various levels (programmes, sectors, institutes) by a range of UK Government agencies.

Nature of evaluations: Recently the use of ROAME-F[36] in the UK Department of Trade and Industry has been superseded by the use of "business case documents". Any (internal) proposals for innovation and business support measures and programmes (and which cost in excess of £10 million/€14 million) are supported by a business case. Business cases must be approved by the Investment Committee and the Secretary of State for Trade and Industry, before funds are released for their realisation. As under ROAME-F, during the lifetime of a product or programme, it will be subject to ongoing monitoring and analysis, and periodic impact evaluation.

The business case documents take the place of "ROAME" statements. They continue to set out the rationale and objectives for a new product, with particular attention to the supporting evidence, and they also provide a description of the proposed form of intervention and how it will be delivered. However, the business cases also include a number of new features that provide useful information for evaluators and help to support improved monitoring and evaluation:

- Option appraisal and cost benefit analyses: A record is provided of any alternative policies that have been considered, and also of key assumptions about the expected costs and benefits associated with the proposed option;
- Logic model: This outlines the inputs and activities, and their anticipated outputs and outcomes. The logic model has a key role in identifying monitoring and evaluation measures and indicators;
- Balanced scorecard: The balanced scorecard translates the product's logic model into a summary set of objectives, and associated monitoring measures which will be used to track progress against these objectives. The scorecard focuses on measures for which meaningful monitoring data can be obtained within quarterly and annual reporting periods, and takes account of the time frame over which the product is expected to generate economic outcomes.

In addition to balanced scorecard reporting, the DTI also makes use of monitoring surveys of business users, intermediaries and delivery partners, data-linking and econometric studies and impact evaluation.

Transparency of evaluation/review procedure: In the DTI, evaluation reports are aimed at DTI managers and programme participants and are generally made available to the public[37]. In addition the Inland Revenue's Regulatory Impact Assessment (RIA) documents are published with regulatory proposals and new legislation to assist public debate and ensure regulations are necessary and in proportion to the issue being addressed. Only a small proportion of the policy measures identified for the UK have been found to have a publicly available evaluation. Thus, locating evaluation reports and reviews can be problematic.

[36] An acronym for: Rationale; Objectives; Assessment; Monitoring; Evaluation; and Feedback.

[37] Summaries of past evaluations (back to 1987) may be found at: http://www.dti.gov.uk/tese/aulist.htm

The 2006 Trend Chart Report for the UK also presents an overall appraisal and SWOT of innovation governance. Table 19 reproduces a simplified overview of the main strengths and weaknesses, as well as opportunities and threats, of the governance system in innovation policy in the UK.

Table 19: Innovation governance SWOT overview

Strengths	**Weaknesses**
• Strong stakeholder involvement in policy design • Policy design and implementation strongly linked • Frequent policy reviews • Strong international linkages evident • Use of international benchmarking (but still more room for improvement here) • Strong culture of evaluation at various levels • Appraisal of policy implementation	• Lack of dissemination of evaluation results, which might demonstrate how results are being incorporated in new policy design. • Absence of policy co-operation with other countries (however co-operation is good at EU programme level) • Business-university engagement remains inconsistent across industries and regions
Opportunities	**Threats**
• Use of linkages to learn more on evaluation of innovation programmes • Improved coordination of business support organisations to help implement innovation policies • Effective use of cross-ministerial team to lead innovation agenda across whole of Government • The Technology Strategy Board can play an increasing role in contributing to development of Government's innovation strategy across all important sectors of UK economy	• Political uncertainty surrounding effects of impending public sector cut-backs on government departments/ agencies • Minor danger of stakeholder lock-in • Impact of UK and EU regulations can be seen as barriers to innovation, particularly for smaller enterprises

Strengths: A major strength of the UK innovation governance system is the strong stakeholder involvement in policy design and the strong linkage between the design of policy and its implementation, followed through with good appraisal of policy implementation. Evidence of this strength can be seen where the Government is committed to monitoring the impact of policy measures presented in its *Science & Technology Investment Framework 2004-2014,* as part of annual reporting on this framework. This also links to another strength that is the regular frequency of policy reviews. A range of stakeholder organisations exist within the business enterprise sector. These include various trade bodies and associations and the employees organisation, the Confederation of British Industry, which is perhaps the most influential. Stakeholder bodies are frequently proactive in terms of providing policy input, which often takes the form of detailed and sometimes influential reports (an illustrative example is the report quoted above from the Association of British Pharmaceutical Industries).

Weaknesses: Although the UK possesses a strong 'evaluation culture', there is a (minor) weakness linked to this, which is relative lack of dissemination of evaluation results, which might demonstrate how results are being incorporated into new policy design. Another weakness in the governance system is that business-university engagement remains inconsistent across industries and regions. The Government together with HEFCE is taking steps to promote best practice in business-university interaction. In respect of this goal the Government is inviting views from different stakeholders, in particular outside Higher Education, which can be taken into account in developing best practice models.

Opportunities: The recent creation of the new OSI within the DTI, bringing together the OST and the DTI Innovation Group, provides an opportunity to consider how policies addressing science "push" and innovation "pull" can be brought together more effectively, which might help to improve coordination of business support organisations to help implement innovation policies. On the one hand, the UK is well placed to benefit from the increasingly global nature of R&D and innovation, with a track record of scientific excellence, world-class universities, and leading R&D intensive businesses in a number of key sectors. On the other hand, the UK has not always been effective in translating the products of excellent research into economic gain, and public and private investment in R&D remains lower than that of many leading competitors. In order to help effectively translate excellent research into economic gain, there are opportunities to create a more favourable environment for science and innovation. The Technology Strategy Board can, in theory, play an increasing role in contributing to development of Government's innovation strategy across all important sectors of UK economy. This wider remit will require the Board to set priorities for its support on innovation, on areas which offer the greatest scope for boosting growth and productivity, in the context of an increasingly globalised economy.

Threats: In terms of national innovation governance the Government places considerable emphasis on working with key stakeholders including business, employees and their trade unions, consumers and the science base, to help focus more on science and innovation, enterprise and investing in people. This brings with it the comparatively minor threat of stakeholder 'lock-in' and the need to seek consensus. Another threat is highlighted by the *First Findings of the UK Innovation Survey, 2005*[38], which found that the impact of UK and EU regulations are thought to be a barrier to innovation, particularly for smaller enterprises.

4.4 Policy Objectives

As noted already, the Government's innovation policy objectives are made explicit in the *Ten-Year Science and Innovation Investment Framework 2004-14*. Of particular relevance to this Section, the Framework set out the following objectives:

- Increased business investment in R&D, and increased business engagement in drawing on the UK science base for ideas and talent:
    - Increase business investment in R&D as a share of GDP from 1.25% towards goal of 1.7% over the decade

[38] Economic Trends 628, March 2006, Office of National Statistics, pp. 58-64: March 2006. Available online at:
http://www.statistics.gov.uk/articles/economic_trends/ET628.PDF
Note: This survey is the UK contribution to a fourth Europe-wide Community Innovation Survey (CIS), where the 2005 survey is the largest innovation survey so far conducted, sent to 28,000 UK enterprises with ten or more employees and achieving a 58% response rate.

- Narrow the gap in business R&D intensity and business innovation performance between the UK and leading EU and US performance in each sector, reflecting the size distribution of companies in the UK

The ten-year framework outlined a range of support measures to encourage greater business investment in R&D, including the R&D tax credits and the DTI's Technology Strategy.

According to the Ten-Year Framework's 2006 Annual Report, key achievements include:

- enhancement of R&D tax credits;
- a Technology Strategy Board to provide direct business input to funding priorities for the DTI Technology Strategy Fund (topics covered include nanotechnology, renewable energy, advanced materials, computing, and bioprocessing).
- setting of an obligatory target for Government departments and agencies to place 2.5% of their extra-mural R&D contracts with SMEs, to support small innovative companies; and
- creation of a high-level UK Science Forum to bring together Government, business leaders and scientists in support of the UK's R&D and innovation goals.

The issue of IPR policy should also be mentioned at this point. The official government body responsible for granting Intellectual Property (IP) rights in the UK is the Patent Office, an Executive Agency of the DTI under the Office for Science and Innovation. The Patent Office has responsibility for matters concerning patents, designs, trade marks and copyright and is also responsible for the role of IP rights in supporting innovation.

Following a request by the Chancellor of the Exchequer in December 2005, a comprehensive review of the intellectual property framework in the UK was conducted by Andrew Gowers. The resulting report, published in December 2006, made 54 recommendations across the spectrum of IP. The Patent Office itself launched a consultation on innovation support in May 2006 but suspended consideration of responses pending the outcome of the Gowers Review. The Office supports innovation through its activities in a number of ways, for example, through a series of projects to raise awareness of the use of IP amongst SMEs. It will also be responsible for implementing the Gowers Report recommendations[39].

4.5 Policy Instruments

In terms of policy support for business R&D and innovation, alongside its direct policy instruments, a wide range of business support organisations and mechanisms are operated by the UK Government or on its behalf. These include Business Links (which provide local support to business needs), Regional Development Agencies, Regional Technology Centres, technology brokers such as the British Technology

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

Group, contract R&D companies and other information providers. Other agencies include the Learning and Skills Council (formed by the merger of the Training and Enterprise Councils and the Further Education Funding Council for England), and Chambers of Commerce. Some of these organisations acts as channels for Government support (particularly to SMEs) whilst others offer more indirect forms of business support (such as Advisory services, dissemination of best practice, etc.).

In general, UK innovation policy tends not to favour the direct support of R&D but relies more on indirect measures (such as fiscal incentives) or on measures designed to encourage the linkage of elements of the innovation system (notably the public and private sectors) or to facilitate the dissemination of knowledge and best practice through personnel mobility or information exchange, improve IP regulations and the understanding of IP issues, etc. Other measures include the use of public procurement to promote innovation; supporting entrepreneurship and small business, e.g. through supporting SME access to finance and promoting best practice such as the business performance diagnostic tool; developing the UK skills base through the Skills Strategy; having a wide intellectual property rights framework including copyright and trademarks, not just patents; and using standards and regulations to promote innovation.

It is also worth noting that the UK has no innovation support measures that apply specifically to the service sector but rather tends to operate 'sector-neutral' instruments. In reality, the nature of some of these instruments tends to convey an inherent bias towards high-tech areas that may have greater relevance to the manufacturing sector, although it should be noted that the personnel mobility schemes which aim to improve public-private sector linkage are not just technology focused; management skills and operational practices may also form the basis of the exchange projects.

Thus, the UK has no large-scale direct funding programme for industrial R&D, the Government tending to believe that indirect and 'soft' measures to promote and stimulate R&D represent a more effective use of financial resources, via their leveraging effects, rather than the direct provision of funds to firms. However, Government funding for defence-related R&D forms a considerable part of the UK's Gross Expenditure on R&D. Thus, while Government planned expenditure on R&D for the Science and Engineering Base will total £2,545.6 million in 2006-07 and that from the Higher Education Funding Councils will total £2,187.3 million, planned Government expenditure on defence will total £3,116.5 million in the same period.

It is not the intention to provide an exhaustive list of innovation support mechanisms. Thus, only the more significant instruments are detailed below.

- Grant for Research & Development: Formerly known as SMART and run nationally, Grants for Research & Development are now run by local DTI Small Business Service offices and administered by the English Regional Development Agencies (the devolved administrations operate their own versions of SMART). The grant provides finance to individuals and SMEs in England to research and develop technologically innovative products and processes. The four types of grant (Micro projects; Research projects; Development projects; and Exceptional development projects) each support different types of R&D project, ranging from simple low-cost development projects of up to 12 months' duration, costing £20,000 or less, to projects aiming at significant technological advances that are strategically important for a particular technology or industrial sector, costing up to £500,000.

- The Technology Programme: This supports three categories of research: Pure or oriented basic research; Applied research; and Experimental development. It comprises two 'products':
  - Knowledge Transfer Networks (KTN) are single national over-arching networks in a specific field of technology or business application. They are intended to bring together a variety of organisations (businesses, suppliers and customers, universities, research and technology organisations, the finance community and other intermediaries) in order to enable the exchange of knowledge and stimulation of innovation. Their objective is to increase the breadth and depth of knowledge and technology transfer into UK-based businesses and accelerate the rate at which this process occurs. The Networks are aligned to the priorities of the UK's national Technology Strategy, as determined by the TSB within the DTI. Support is provided for three types of network: managed; information; and issues networks. Grants are also given to intermediaries to set up networks in priority technology areas.
  - Collaborative Research and Development (CRD) supports collaborative R&D projects in strategically important areas of science, engineering and technology between private sector actors, universities and other potential collaborators. It is intended to facilitate collaboration between different businesses and the Science, Engineering & Technology base (including universities and other potential collaborators). CRD projects must involve two or more collaborators, at least one of which is from industry.

- Knowledge Transfer Partnerships (KTP), formerly known as the Teaching Company Scheme, fund project-based collaborations between universities, colleges or research organisations and companies. Graduates (KTP Associates) are recruited to work in a company for up to three years in close cooperation with their university or college, on a strategically important project. The major objective is to stimulate collaboration and facilitate knowledge transfer and dialogue between host and parent organisations.

- CASE (Cooperative Awards in Science and Engineering) is a scheme, operated through a number of the Research Councils, which funds the training of postgraduate students to PhD level in projects of joint interest to industry and higher education institutions. Generally the lead is taken by the students HEI. "Industrial CASE" is a variation of CASE where studentships are allocated direct to an industrial partner with the company devising its own projects.

- Higher Education Innovation Fund (HEIF) represents a "third stream" of higher education funding for universities to encourage them to work with industry and the wider community alongside their teaching and research. Cooperation with the regional community is emphasised. The scheme is sponsored by the DTI, DfES and HEFCE. It is primarily designed to build capacity in English universities for knowledge transfer and commercialisation activities. Continued funding from

2006-08 for 22 Centres for Knowledge Exchange (CKEs) was announced in August 2006, under the third round of the HEIF. Designed to provide 'specialised shared services for business and community partners and act as exemplars of good practice in the business of knowledge exchange', each centre may be awarded up to £500,000 per year from 2004-2009. Continued funding was conditional on the production of a short report by each centre, detailing its strategy and plans for 2006-08; evidence of user validation of the value added provided; an explanation of its distinctiveness amongst knowledge transfer activities and how the lead CKE plan and overall HEIF plan demonstrate an integrated approach. It was also agreed in March 2006 that the centres would undertake a mid-term self-evaluation with an emphasis on how they could become self-sustaining after 2008-09.

- Faraday Partnerships are intended to link businesses, scientists and engineers in universities, research organizations, and capital providers on collaborative research projects and commercialisation processes. Faraday Partnerships or centres are technology specific. They also involve some education and training programmes. Many of theses partnerships have been migrated to the more recently established Knowledge Transfer Networks programmes.

- The Micro and Nanotechnology Manufacturing Initiative includes £90 million to help industry harness the commercial opportunities offered by Micro and Nanotechnologies (MNT). It includes the funding of collaborative R&D (between the public and private sectors) and a new network of MNT facilities, and forms the first step of developing and implementing a new Technology Strategy. Some £40 million of this funding has been allocated towards facilities development for a UK MNT Network. The DTI has allocated £40m towards Capital Projects for the MNT Network, which can be used for capital and operating costs, although this appears to mainly target private sector actors.

- Foresight LINK Awards: These provide funding for collaborative projects which address UK Foresight priorities. This instrument represents another technology transfer mechanism which offers 50% grants plus provisions for university overhead funding.

- The Technology Strategy Board, in its first Annual Report in November 2005, introduced the concept of Innovation Platforms. Two pilot Innovation Platforms have been announced in the areas of Network Security and Intelligent Transport Systems and Services, each with an initial £10 million earmarked in order to kick-start activities. Rather than focusing on sectoral issues, Innovation Platforms are intended to address broader challenges and to facilitate the integration of "a range of technologies and better coordination of policy and procurement, resulting in a step-change in UK performance, in the quality of public services and the ability of UK businesses to provide solutions"[40], through a risk-sharing approach by Government. The key features of an Innovation Platform are:
    - an engagement with business and the research community
    - cooperation between government stakeholders and funders
    - the identification of appropriate levers to use

[40] http://www.dti.gov.uk/innovation/technologystrategy/innovation_platforms/index.html

- the objective of aligning funding streams from separate sources
- linkage of research to the market through procurement opportunities

Outside of the remit of the DTI and other main innovation policy actors, it is interesting to note that complementary innovation measures are also being launched by other Government departments. Thus, at the launch of the Government's new Defence Technology Strategy (DTS) the Ministry of Defence (MoD) announced a new £10 million programme to encourage academia and industry to provide innovative new ideas in areas such as prediction, protection and networking, whilst announcing further new innovation programmes to be launched at a later date. The DTS, which sets out the technology priorities considered vital to the nation's military interests, is intended to build on the Defence Industrial Strategy White Paper published late last year. The MoD is one of the largest Government investors in R&D with an annual spend of approximately £2.6 billion (around £639 million of which is classified as research, the rest being classified as development).

4.6 Policy Effectiveness

Assessing innovation performance remains a challenge, despite co-ordinated efforts in better defining different types of innovation activities and in improving data collection, direct and internationally comparable measures of innovation outcomes remain limited. The policy indicators used to "explain" innovation performance often encompass framework conditions, such as regulations affecting competition in product markets, as well as more specific policies like public R&D spending. Innovation performance can be measured through patents or R&D intensity but these need to be interpreted with care, however: R&D spending is not an end in itself; and patents, while obviously a product of innovative activity, are only one way to protect innovators' rights, not to mention that many of them are never exploited commercially and that some are filed for litigation purposes.

Whilst evaluation and monitoring processes may provide an insight into how individual instruments are performing in terms of process issues such as uptake, ease of access, utility of funds, administrative procedures, etc., and even some output issues such as new products, publications, cooperative agreements, etc., much of the evidence collected, particularly concerning outputs, is often qualitative or anecdotal. Moreover, effective evaluation processes for the elucidation of longer-term impact have yet to be designed. Furthermore, the cumulative and (hopefully) synergistic effects of the various measures comprising the policy mix are difficult to disentangle and are frequently overlaid or masked by larger framework conditions and macroeconomic effects.

Thus, in terms of the effectiveness of the suite of policy measures in place in the UK, it is only possible to either refer to the evaluation studies that have been conducted over time on a number of the instruments, which, in general have been positive[41] or to

[41] Particularly in the sense that many of those measures evaluated have been long-standing policy instruments which, although subject to revision and amendment, have not been terminated.

the findings of the Science and Innovation Investment Framework 2004-14 Annual Report 2006[42], which notes that:

> "Raising the level of business engagement in innovation and investment in R&D is a challenge for which the major decisions are outside the control of government. The business-led Technology Strategy Board (TSB) ensures the needs of business are reflected in Government thinking and that activities such as the development of a national Technology Strategy are market focused. By developing a clear picture of the environment for business innovation through more sophisticated measurement, Government can help business develop the clarity necessary to make informed decisions on future development. Work is underway to develop better outcome-focused measures of innovation. Government is able to further facilitate business engagement with the challenges of innovation by providing targeted support. There has been much progress with R&D tax credits, the development of Knowledge Transfer Networks (KTNs) and support for Collaborative Research projects through the Technology Programme…"

> "Universities are continuing to strengthen their links with business and community organisations. The Higher Education Innovation Fund (HEIF) and a number of smaller knowledge transfer schemes are helping them build their capacity to do this. While the most recent Higher Education – Business Community Interaction (HEB-CI) survey showed a decline in the number of spin-out companies being created, this was more than counterbalanced by an increase in the number of licenses granted. This suggests that institutions have recognised that licensing is inherently less risky than the spin-out route and more likely to succeed in a shorter time period. The PSRE community has also demonstrated an increased number of successful applicants in the PSRE3 competition, while the Regional Development Agencies (RDAs) and Research Councils capacity building fund is under way and helping to increase university-business interactions…".

Policy effectiveness has to be judged in relation to two of the major challenges facing the UK's innovation performance, i.e. the declining level of business innovation activity and low level of BERD, and the need to increase links between the public sector research base and the business sector for the greater translation of knowledge and ideas into new products, processes and services. It appears that former, whilst outside the direct influence of Government, as noted in the Ten-Year Framework's 2006 Annual Report, and subject to a range of framework and macroeconomic factors, (see next section) is not being effectively addressed by the current policy mix and that further efforts are required in this area. Likewise, the issue of linkage remains a long-standing challenge in the UK despite the deployment of a range of (positively evaluated) measures designed to tackle this issue. The fact that many of these have been in place for several years and yet the challenge is still present begs the question as to whether these measures are a) less successful in meeting their long-term goals

[42] Continued progress against the Framework is charted in the (web-based) S*cience and Innovation Investment Framework: Progress Against Indicators* available on the DTI website at: http://www.dti.gov.uk/science/science-funding

than their individual evaluations would suggest, or b) effective in maintaining the *status quo* level of interaction but are unable to deliver further improvements.

Overall, whilst it appears that the UK is deploying a mix of instruments that would seem to be appropriate to the challenges it faces, these challenges remain in place.

5 Economic and Market Development (Absorptive Capacity)

5.1 Introduction

Many of the issues encompassed by this section have already been dealt with in previous sections, particularly Section 4. Thus, this section will focus mainly on market, labour market, finance and competition issues, together with the broader issues of public acceptance of science and technology and the uptake of innovative products by the public.

According to the latest version of the Government's Productivity and Competitiveness Indicators[43], policy responses to poor innovation indicators (where they do accurately signal an underlying problem in the economy) may not offer a cost effective remedy and may themselves create additional problems. Thus, government intervention will be more likely to succeed if the intervention has a strong rationale based on the existence of a market failure. Such rationales occur where "problems in the economy cannot be resolved through normal market forces within a reasonable time period and where Government intervention is likely to mitigate those problems in a relatively non-distortionary way and at reasonable value for money".

Normal market forces may fail to solve problems in the economy for a variety of reasons and such 'market failures' may be categorised as:

- **Externalities (or 'spillover effects')** occur when the benefits (or costs) generated by an individual's or firm's actions are not fully captured (or borne) by that individual or firm.
- **Barriers to firm entry** restrict competition and distort markets. They may be created by strategic private action or public regulation.
- **Imperfect information and uncertainty** may affect the decisions of firms and individuals, leading to an inefficient allocation of resources as individuals do not make the choices they would have made in the presence of perfect information.
- **Public goods and services** are those where a large group of people can enjoy the benefits of their production without necessarily having paid for them. There may be under-provision of these goods, as the consumers of public goods have an incentive to 'free-ride' and producers are not able to appropriate the full returns from their output.

Such market failures can occur in factor markets, such as those for labour and capital, and in final product markets. Financial market failures can lead to inefficient outcomes across all sectors, as investment in all its many forms may suffer due to a lack of access to finance.

Having set the scene in terms of the range of market factors that can affect innovation, and hence, productivity and competitiveness, the Productivity and Competitiveness Indicators assess UK performance under a number of headings: Investment, Innovation, Skills, Enterprise and Competition. The following extracts and key points

[43] http://www.dti.gov.uk/about/economics-statistics/economics-directorate/page21913.html

are particularly relevant in the context of the UK's economic and market development.

Investment:

- New frameworks for the operation of monetary and fiscal policy in the 1990s have helped the UK to achieve high and stable levels of growth and low inflation. Despite relatively volatile GDP growth in the 1990s, the UK has seen less fluctuation in growth than its competitors since 1998.
- Interest rates in the UK have, on average, been less volatile relative to its international competitors since 1998, mainly due to lower and more stable inflation, a consequence of the shift of operational independence of monetary policy to the Bank of England, together with measures to ensure the accountability and transparency of monetary policy.
- However, despite this period of strengthening macroeconomic stability fundamentals, UK companies have failed to respond and business investment in terms of capital flows has generally remained lower than that of the UK's main competitors over the last decade. Moreover, the cyclical effects of the 2001-2003 world economic slowdown has held down business investment in the UK and in its main competitor countries.
- For most of the past two decades the UK public sector has invested less than its major competitors and previous UK governments chose to cut capital budgets and withdraw from certain activities that had previously been delivered by the public sector. However, UK government investment stabilised as a proportion of GDP in 2000, and has since been increasing[44]. In recent years, spending on transport, education and health has increased and from 1997 to 2004, grew in real terms at an annual rate of over 4%.

Innovation:
(Indicators here relate mainly to the strength of the science and engineering base, R&D expenditures, patents, networks and collaborations, and innovative products. These have been dealt with in previous sections (notably Sections 3 and 4).)

Skills:
(Refer to Section 6)

Enterprise:
Enterprise can be defined as the seizing of new business opportunities, both by start-ups and existing firms. Enterprising firms bring new ideas, knowledge and skills into an economy and provide incentives for others to become more innovative. This increases competitive pressure in markets and has a direct impact on productivity through the process of 'productive churn', where productive, new entrants win market share and less productive firms exit the market. As global competition intensifies, the ability of firms and individuals to identify and take advantage of entrepreneurial opportunities becomes increasingly important. In addition, small businesses make a positive contribution to employment, as they are an important source of job creation. The UK Government monitors performance on the enterprise driver in three main

[44] With the exception of the most recent figures.

areas – the enterprise culture, barriers to enterprise and the extent of enterprise activity.

- *Enterprise culture*: The Global Entrepreneurship Monitor (GEM) survey compiles a cultural support index based on: perceptions of entrepreneurs and entrepreneurship; its suitability as a career choice; and its coverage in the media, giving a score out of 3.0. The UK scores a relatively high 1.83, ahead of France and Germany. Overall, there is a relatively favourable attitude to enterprise in the UK. However, the risk aversion may act as a barrier to the pursuit of opportunities for enterprise. Entrepreneurial education to improve skills and entrepreneurial attitudes are identified as a critical issue by both the GEM and the OECD.

Barriers to enterprise may limit the creation and growth of smaller businesses. Important factors that may lead to the creation of such barriers include regulations which impose unnecessary burdens on business and poor access to finance (both bank and venture capital). For the UK:

- Barriers to enterprise are on average lighter than in France or Germany, and the UK performs well in terms of levels of administrative burdens and start up costs. In the World Bank's 'ease of doing business' index, the UK came 9th behind the US, but well ahead of France and Germany.
- In addition to low start-up costs, the UK has relatively well-developed capital markets and the significance of finance as a barrier to enterprise growth has fallen in the last decade, although new businesses continue to be more likely to experience difficulties in accessing finance than established firms. However, the picture is more positive than France and Germany. Indicators also show that the three European countries experienced a much smaller 'dot-com bubble' in venture capital than the US, from 1998 to 2002.
- There is evidence that general financing conditions for small businesses are improving. Firms now find it easier to access debt finance and total private equity funds invested in the UK have increased in the last decade, although venture capitalists are still appear somewhat reluctant to invest in early-stage businesses.
- While the administrative burden imposed on new UK businesses is limited, it is important that the whole range of regulations governing business achieve their intended regulatory outcome without imposing unnecessary costs on business. This is particularly important for SMEs. Hence, the Government is pursuing the better regulation agenda (see below).

Enterprise activity: Enterprise refers to start-up and new businesses as well as 'enterprising' behaviour by existing businesses. SMEs are a very important part of the economy; in 2003, SMEs accounted for nearly half of total employment and turnover in the UK while in the period 1995-1999 they accounted for 66% of new jobs. In terms of performance:

- The GEM's Total Entrepreneurial Activity (TEA) index provides an indicator of the extent to which new businesses are starting in the economy. It is defined as the percentage of members of the labour force who are in the process of starting a new business, or who own or manage a business less than 42 months old. As measured by the TEA index, entrepreneurial activity in the UK (6.2%), is stronger than in France and Germany (both at about 5.5%), but remains significantly lower than in the US (12.4%).

- In the UK, SMEs have enjoyed faster productivity growth than large firms in the last five years. Gross value added per employee grew by 25% in SMEs over the period, compared to 19% in large firms. Small businesses are on average more productive than larger ones in certain sectors, notably agriculture and construction.

The main conclusion to be drawn is that lower than optimal levels of enterprise, especially in certain areas of the UK, are probably holding back UK productivity.

Competition:
The degree of competition in product, labour and capital markets affects market efficiency. The rules and institutions of these markets, determined in large part by government policy, are the major factor behind the degree of competition. There is no single measure of the intensity of product market competition within an economy. Therefore, the UK Government monitors aspects of the competitive environment using the following Indicators: Openness to international trade and investment – the percentage of GDP which is traded as imports and exports; Product market regulation – the extent to which product market regulation is restrictive as measured by the OECD; and Effectiveness of the competition regime – peer review of the effectiveness of competition regimes.

Openness to international trade and investment:

- The UK performs relatively well in terms of trade as a proportion of output (exports + Imports/GDP), with a value of 54% (in 2004), roughly the same as France but behind Germany (71%).
- The UK is a strong advocate of free trade in the EU and WTO, and although the economy's total trade as a percentage of GDP has declined since 1999, this is largely due to a slowdown in demand from the UK's main export markets.
- The UK is also relatively open to FDI, with the highest stock of inward investment of any G7 country, as a percentage of GDP. The UK's stock of inward investment rose from 21% of GDP in 1990 to 36%, above those of France, Germany and the US.

Product market regulation:

- The UK ranks second on the OECD international comparison of the competitive impact of product market regulation, with the UK's regulatory environment found to be less restrictive than those of comparator countries. Since 1998, the UK has dropped from 1st place and lies behind Australia due to rapid regulatory reforms made by the latter. Better regulation is an important focus of current UK Government policy.

Effectiveness of the competition regime:

- The UK competition regime's performance, as measured by the 2004 KPMG expert Peer Review, has increased slightly since 2001, although the UK remains in third place, behind the US and Germany, which were judged to have also improved. However, as in 2001, the UK is ahead of all other OECD economies and above that of the EU.

- The Global Competition Review for 2004 confirms that the UK's competition regime is among the best in the world. The UK's Competition Commission and the Office of Fair Trading were rated joint first and joint second in the world, respectively, in the ranking of individual competition enforcement agencies.

5.2 Indicators and Challenges

Several key indicators have been mentioned in the preceding section. This section presents a selection of more generic indicators.

Table 20: Indicators for Economic and Market Development*

Indicator	Value (date)	Source
Sales of 'new to market' products as a percentage of turnover	1.7 (200)	EIS
Sale of 'new to the firm but not to the market' products as a % of turnover	16.7 (2000)	EIS
Share of high-tech venture capital investment		EIS
Share of early stage venture capital in GDP	0.038 (2003)	EIS
Broadband access (per 100 inhabitants)	10 (2004)	OECD
Access to internet (share of households)	56% (2004)	OECD
Access to home computer (share of households)	65% (2004)	OECD
ICT expenditures as a percentage of GDP	7.9 (2004)	EIS
Labour productivity	$39.6 (2004)	OECD
Relative trade performance in high-tech goods		RTD
Share of seed and start up venture capital in GDP		3%AP
Share of seed and start up venture capital by sector		3%AP
Technology balance of payments per capita		3%AP
High tech products as % of manufacturing exports	35% (2003)	OECD
Composite indicator on investment in a knowledge-based economy (KBE)		3%AP
Composite indicator on performance in the transition to a KBE		3%AP

Key: OECD = Organisation for Economic Cooperation and Development; EIS = European Innovation Scoreboard; RTD = RTD Indicators Report; 3%AP = 3% Action Plan

* There is some overlap with indicators relevant to other domains and between indicators from different sources.

Table 21 presents an overview of the strengths, weaknesses, opportunities and threats arising from the above indicators and analyses.

Table 21: Economic and Market development SWOT analysis

Strengths	Weaknesses
• UK has experienced period of relative macroeconomic stability • Strongly performing science and engineering base • Relatively strong in innovation cooperation • Positive attitudes to enterprise • Good access to finance for start-ups • Indicators of healthy enterprise activity by SMEs • Openness to foreign competition, light touch product market regulation and highly regarded competition regime • High stock of inward investment	• Long-standing productivity gap (output/hr and output/worker) with main competitors • Low business and government investment levels resulting in comparatively poor infrastructure • Low total and business investment in R&D relative to GDP • Generally poor performance in patenting (but tendency to use design complexity and copyright as alternatives)
Opportunities	**Threats**
• Productivity gap is closing • Increasing levels of government investment • Scope to build on the strength of the science and engineering base. • Low start-up costs and administrative burdens	• Aversion to risk may prevent uptake of opportunities for enterprise • Firms report low customer demand for innovation

• Light touch product market regulation and highly regarded competition regime	

5.3 Governance

The main actors in the context of the governance of economic and market development issues are the DTI and HM Treasury. The remit and activities of the DTI have been covered in earlier sections. HM Treasury is the UK's economics and finance ministry. As such it has responsibility for the formulation and implementation of Government's financial and economic policy. Its broad aim is "to raise the rate of sustainable growth, and achieve rising prosperity and a better quality of life with economic and employment opportunities for all". To meet this aim it has eight major goals accompanied by a set of ten performance targets[45]:

1. Demonstrate by 2008 progress on the Government's long-term objective of raising the trend rate of growth over the economic cycle by at least meeting the Budget 2004 projection.

Objective I: Maintain a stable macroeconomic environment with low inflation and sound public finances in accordance with the Code for Fiscal Stability.

2. Inflation to be kept at the target as specified in the remit sent by the Chancellor of the Exchequer to the Governor of the Bank of England (currently 2% as measured by the 12-month increase in the Consumer Prices Index).
3. Over the economic cycle, maintain:
    - public sector net debt below 40% of GDP; and
    - the current budget in balance or surplus.

Objective II: Increase the productivity of the economy and expand economic and employment opportunities for all.

4. Demonstrate further progress by 2008 on the Government's long-term objective of raising the rate of UK productivity growth over the economic cycle, improving competitiveness and narrowing the gap with its major industrial competitors. Joint with the DTI.
5. As part of the wider objective of full employment in every region, over the three years to spring 2008, and taking account of the economic cycle, demonstrate progress on increasing the employment rate. Joint with the Department for Work and Pensions.
6. Make sustainable improvements in the economic performance of all English regions by 2008, and over the long term reduce the persistent gap in growth rates between the regions, demonstrating progress by 2006. Joint with the Department for Communities and Local Government and the DTI.

Objective III: Promote efficient, stable and fair financial markets, for their users and the economy.

[45] http://www.hm-treasury.gov.uk/about/about_aimsobject.cfm

Objective IV: Promote a fair, efficient and integrated tax and benefit system with incentives to work, save and invest.

7. Halve the number of children in relative low-income households between 1998-99 and 2010-11, on the way to eradicating child poverty by 2020. Joint with the Department for Work and Pensions. Also to halve by 2010-11 the numbers of children suffering a combination of material deprivation and relative low income.

Objective V: Promote UK economic prospects by pursuing increased productivity and efficiency in the EU, international financial stability and increased global prosperity, especially protecting the most vulnerable.

8. Promote increased global prosperity and social justice by:
- working to increase the number of countries successfully participating in the global economy on the basis of a system of internationally agreed and monitored codes and standards;
- ensuring that 90% of all eligible Heavily Indebted Poor Countries committed to poverty reduction that have reached Decision Point by end 2005, receive irrevocable debt relief by end 2008 and that international partners are working effectively with poor countries to make progress towards the UN 2015 Millennium Development Goals. Joint with the Department for International Development; and
- working with European Union partners to achieve structural reform in Europe, demonstrating progress towards the Lisbon Goals by 2008.

Objective VI: Improve the quality and the cost-effectiveness of public services.

9. Improve public services by working with departments to help them meet their:
    - PSA targets, joint with the Cabinet Office; and
    - efficiency targets amounting to £20 billion a year by 2007-08, consistently with the fiscal rules.
10. Deliver a further £3 billion saving by 2007-08 in central government civil procurement, through improvements in the success rate of programmes and projects and through other commercial initiatives.

Objective VII: Achieve world-class standards of financial management in government.

Objective VIII: Protect and improve the environment by using instruments that will deliver efficient and sustainable outcomes through evidence-based policies.

A further level of governance applies to the issue of competition. The strength of enforcement powers and the degree of political independence given to competition authorities determine the effectiveness of the authorities in deterring anti-competitive behaviour. The Competition Act 1998 and the Enterprise Act 2002 strengthened the powers and increased the independence of the UK competition authorities, taking government Ministers out of the decision making process for mergers and market investigations. As a consequence, competition policy is now delivered and enforced independently by the Office of Fair Trading and the Competition Commission.

5.4 Policy Objectives

A number of the objectives outlined in the Ten-Year Science and Innovation Investment Framework 2004-14 are of relevance here, notably:

- Increased business investment in R&D, and increased business engagement in drawing on the UK science base for ideas and talent:
    - Increase business investment in R&D as a share of GDP from 1.25% towards a goal of 1.7% over the decade
    - Narrow the gap in business R&D intensity and business innovation performance between the UK and leading EU countries and US performance in each sector, reflecting the size distribution of companies in the UK

In terms of positively affecting the market for innovative goods and services, the following objective is also relevant:

- Confidence and increased awareness across UK society in scientific research and its innovative applications:
    - Demonstrate improvement against a variety of measures, such as trends in public attitudes, public confidence, media coverage, and acknowledgement and responsiveness to public concerns by policy-makers and scientists.

The these may be added the broader HM Treasury objectives already outlined in Section 5.3, in particular:

Objective I: Maintain a stable macroeconomic environment with low inflation and sound public finances in accordance with the Code for Fiscal Stability.
Objective II: Increase the productivity of the economy and expand economic and employment opportunities for all.
Objective III: Promote efficient, stable and fair financial markets, for their users and the economy.
Objective IV: Promote a fair, efficient and integrated tax and benefit system with incentives to work, save and invest.

- the UN 2015 Millennium Development Goals. Joint with the Department for International Development; and
- working with European Union partners to achieve structural reform in Europe, demonstrating progress towards the Lisbon Goals by 2008.

Objective VII: Achieve world-class standards of financial management in government.

Lastly, with regard to public engagement with scientific research, the Ten-Year Framework set an objective to:

- demonstrate improvement against a variety of measures, such as trends in public attitudes, public confidence, media coverage, and acknowledgements and responsiveness to public concerns by policy-makers and scientists.

5.5 Policy Instruments

Clearly, it is more difficult to identify specific policy instruments that directly affect macroeconomic factors such as overall growth rates, labour flexibility and access to capital. These tend to be restricted to broader policies which encompass a range of policy actors and actions, framework conditions and regulatory environments.

The UK Government's approach to promoting investment is to maintain a stable macroeconomic environment and to remove microeconomic barriers that prevent the market from functioning properly. Government actions in recent years to stimulate private sector investment include steps to enhance the efficiency of the capital market and therefore reduce the cost of borrowing and make investment more attractive to firms. These involve an attempt to enhance the 'private investment chain' through improved interaction between fund managers, firms and capital markets, and the implementation of the principles of the Myners review to increase efficiency in the allocation of capital. Moreover, corporation tax has been cut to its lowest ever level. In addition to these measures, the existence of complementarities between different forms of investment implies that policies to improve skill levels and foster knowledge transfer are also expected to facilitate investment in physical capital.

Reducing the burden that businesses face when complying with regulations is seen as a means to enhance their ability to innovate and to compete. In terms of addressing regulatory barriers to innovation, the Government has developed its 'Better Regulation Agenda', a programme of reforms which will ensure that regulation is delivered according to the "five principles of proportionality, accountability, consistency, transparency and targeting"[46].

The Government has also accepted the recommendations of the Hampton report[47], and the 'Less is More' report[48] of the Better Regulation Task Force (BRTF). These reports focused on the importance of regulators behaving in fair, open and proportionate ways, basing their actions on risk so that regulators' resources are focused on areas where the risk to society is greatest. Furthermore, a reduction in the number of national regulatory bodies (31 will be consolidated into seven new bodies) is intended to reduce the number of different interfaces that businesses have with Government.

The reports also called for greater emphasis on simplifying regulations and a focus on compensating for the introduction of new measures by simplifying existing measures. As part of this strategy, all departments were due to publish plans by Autumn 2006 to identify regulations that can be simplified, repealed, reformed, and/or consolidated, and where the administrative burdens can be removed or reduced; a Better Regulation Bill was due to be introduced by 2006, in order to make it easier for departments to remove or amend outdated, unnecessary or over complicated regulations; and the Government has set up an online portal for businesses and other stakeholders to

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[46] Better Regulation Task Force (1998), 'Principles of Good Regulation'

[47] Hampton (2005), 'Reducing Administrative Burdens: effective inspection and enforcement', HM Treasury

[48] Better Regulation Task Force (2005) 'Regulation – Less is More, Reducing Burdens, Improving Outcomes'

submit proposals for simplifying regulations, with a commitment to respond within 90 working days.

The Government has also accepted the BRTF's recommendations on minimising the administrative burdens imposed by regulation on business. These include the costs of form-filling, the paperwork associated with inspection and other data requirements such as permits and licenses. Work on estimating the administrative burden of regulation faced by businesses in the UK is currently underway, drawing upon the successful Dutch approach[49] and a target for departments to reduce the burdens they impose was also due to be published by the Government in 2006.

Government policy to boost enterprise has focused on three main themes: increasing the incentives for enterprise; removing any obstacles discouraging individuals from pursuing entrepreneurial projects; and promoting an enterprise culture. Tax cuts on small firms (see below) have increased the incentives to start new businesses, whilst the better regulation agenda (referred to above) is also expected to boost the incentives for enterprise by reducing the costs of doing business. Initiatives to reduce barriers to enterprise have focused primarily on access to finance, especially to early-stage businesses which are least likely to access capital from the market.

Measures include changes to eligibility criteria for the **Small Firms Loan Guarantee** to ensure that support is provided to the newest businesses. The Small Firms Loan Guarantee Scheme guarantees loans from the banks and other financial institutions for small firms that have viable business proposals but who have tried and failed to get a conventional loan because of lack of security. This measure was inspired by a successful experience of this scheme in USA.

The **Venture Capital Trust** scheme is designed to encourage individuals to invest in smaller trading companies not listed on the Stock Exchange, through Venture Capital Trusts which are listed. The aim is to provide such trading companies with funds enabling them to develop and grow. Meanwhile, the **Regional Venture Capital funds** are intended to make risk finance available to growing SMEs. In particular they provide funding in amounts of up to £500,000 (€790,000). They are commercial funds operated by professional venture capital fund managers. They form an element of the Enterprise Fund and have been granted European State Aid clearance. **Enterprise Capital Funds** (ECFs) are designed to be commercial funds, investing a combination of private and public money in small high-growth businesses that are seeking up to £2 million of equity finance. Each ECF will be able to make equity investments into eligible SMEs that have genuine growth potential but whose funding needs are currently not met. ECFs address a market gap in the availability of equity finance. The first Enterprise Capital Funds announced in March 2006 were the IQ Capital Fund and the 21st Century Sustainable Technology Growth Fund. **Early Growth funds** provide risk capital to SMEs with high growth potential, and the **Phoenix Fund** increases access to finance and risk capital for entrepreneurs from disadvantaged or under-represented groups. Also of relevance is the **Biotechnology Finance Advisory Service**. This was originally conceived to signpost entrepreneurs to sources of funding and services but has evolved into a body which also advises and

[49] The Standard Cost Model: see http://www.cabinetoffice.gov.uk/regulation

coaches entrepreneurs through the process of thinking through the commercialisation issues of their science.

In 2000, **Tax Credits for R&D** were introduced for SMEs. These were extended to include all sizes of company in the 2002 Budget. The 125% tax credit is intended to help improve the quantity and quality of R&D undertaken by British firms. The Large Companies Tax credit also targets R&D carried out in the UK by multinational enterprises in order to encourage inward investment into R&D and relocation to the UK. The estimated combined value of both tax credit schemes (i.e. for SMEs and larger companies) was €790 million in 2002.

In addition to strengthening the incentives for enterprise, policy has focused on improving attitudes to entrepreneurship in the UK. A number of initiatives have been introduced to promote enterprise, particularly in schools, including the Budget 2005 announcement that all 16-year olds will receive a week of enterprise education. Steps have also been taken to encourage enterprise amongst under-represented groups and in disadvantaged communities with the goal of bringing entrepreneurial activity in these communities closer to the UK average.

UK Government policy is likely to increase product market competition in coming years through increasing the openness of UK markets to foreign competition. Technological change and market forces have substantially increased competitive intensity in some markets, for example the provision of back-office functions and IT services. But competition in some sectors remains limited by government regulation and trade restrictions. Agreements to cut tariffs through the Doha Development Agenda and, closer to home, agreement to extend the EU Single Market to cover services should both yield substantial increases in competitive pressures in UK product markets.

The Better Regulation agenda is also likely to be important for the competition driver in the coming years. Successful implementation of the proposed regulatory reforms should yield substantial benefits for enterprise and, in turn, contribute to the goal of increasing product market competition. In contrast, the potential to increase competitive intensity through further reforms to the competition regime is limited. The past few years have seen extensive legislative change and time is required before the impacts of these reforms, and any implications for future policy, can be identified.

Finally, action is taking place across Government to establish meaningful indicators that are relevant to the public, scientists and policy-makers alike and funding for science and society issues is set to more than double, from €6.3 million per year in 2005-06 to over €13 million in 2006-07.

In terms of specific programmes concerning the public understanding of and engagement with science, the **Sciencewise** programme has moved to directly commission work that delivers a legitimate public voice into scientific decision-making. New technologies can have new ethical, safety, wealth and environmental complications, and these regulatory issues need to be considered and debated before the technologies come to the market. Therefore to encourage greater public engagement with these issues this grant scheme aims to increase public debate by funding projects to facilitate dialogue between scientists and the public. Priority has been given to building public engagement in the key areas of nanotechnology, brain science and stem cell research. These have been chosen to reflect the importance of public debate in developing areas deemed critical to future economic success.

5.6 Policy Effectiveness

Again it is difficult to gauge the effectiveness of some of the broader macroeconomic policies that have been implemented by the Government without looking at the indicators already examined. Historically, the UK does seem to be improving its position *vis a vis* a number of international competitors which may provide indirect evidence of the success of these policies. Furthermore, the UK seems to have been less badly affected by the 2001-2003 economic downturn than some of these competitors. However, UK productivity growth has not increased substantially over the past twenty years, although several OECD countries (e.g. the US, Australia, Canada, Finland and Ireland) have shown significant productivity acceleration in the second half of the 1990s. Moreover, assuming that recent productivity growth rates were maintained, the UK should be catching up rather slowly to the higher productivity levels found in the US and the most productive EU economies. Noting the wide range of structural reforms undertaken in the past twenty years or so, this catching up might have been expected to be more rapid[50].

The UK has many of the key framework conditions in place: monetary policy has achieved low and stable inflation, due to credible inflation targeting and the independence of the Bank of England; public finances are in a more robust condition than in other large EU countries and the US, although the fiscal position has deteriorated in recent years. Moreover, fiscal policy has been counter-cyclical and has contributed to the dampening of economic fluctuations. As a result of sound monetary and, to a lesser extent, fiscal policies macroeconomic volatility has been reduced dramatically. Over the past decade, the standard deviation of OECD output gap estimates has been lower in the UK than in any other OECD country, while it was previously quite high. Similarly, the UK has the most liberal regulation of product markets across the OECD and, combined with its strong protection of intellectual property, this should provide the best possible combination for innovation. In addition, it also has fairly unrestrictive employment protection legislation, which ought to facilitate major innovations and speed up the adoption of new technologies.

Some of the measures described above have been subject to review, whilst others have not been running for long enough to offer a full assessment of their impact. For example, the Government accepted in full the recommendations set out in the Graham Review[51] of the Small Firms Loan Guarantee scheme which benchmarked the UK scheme against several international loan guarantee programmes and set out 38 recommendations to ensure its continuing relevance. The Government announced its intention to implement these recommendations from December 2005 in order to encourage use of the Scheme by as wide a range of eligible SMEs as possible and through as diverse a range of lenders as possible.

[50] Cotis, J-P, "Economic Growth and Productivity", Address at the Annual Conference, Government Economic Service, Nottingham UK, 13-14 July 2006

[51] The Graham Review of SFLG scheme can be viewed at:
http://www.hm- treasury.gov.uk/independent_reviews/graham_review/review_graham_index.cfm

The introduction of Tax Credits for SMEs followed an extensive period of consultation by the UK Government. Hitherto, the idea of tax incentives for R&D ran counter to political thinking, thus the introduction of the scheme was viewed as something of a radical turnaround. Some idea of the effectiveness of the scheme may be inferred from the Government's later decision to extend it to all companies, including foreign multinationals. Comparatively speaking, fiscal incentives for private R&D are average, although tax incentives are high. Given that thee were only introduced in 2000, it may be too early to see the full effects of these as yet, although figures from the Ten-Year Science and Innovation Investment Framework Annual Report 2006 note that nearly 22,000 claims have been made for R&D tax credits; over 19,000 under the SME scheme and nearly 3,000 under the large company scheme. A total of almost £1.8 billion of support has been claimed (SMEs claiming just under £1 billion of this). An independent survey of almost 1,000 R&D performing companies[52] suggests some encouraging early signs that R&D tax credits are affecting business R&D activity, with half of the companies surveyed who had successfully made a claim reporting an ability to change their R&D spending and/or the type of R&D projects they undertook because of R&D tax credits.

The UK also has first-class financial markets, although these may be too fragmented in terms of specialised areas such as venture capital and it is a very open economy, particularly with regard to restrictions to inward FDI (least stringent within the OECD) and it is at the head of OECD's worldwide list of FDI recipients. This raises a paradox in terms of what is actually causing the UK's comparatively low levels of productivity.

Finally, concerning the issue of public engagement with science and technology, a scoping study was through the Sciencewise programme conducted to explore the desirability and feasibility of establishing a resource centre on public dialogue on science and technology to work across government. Also, in 2005, the Council for Science and Technology undertook a consultation with key stakeholders in the science, engineering and technology community regarding *Rigour, Respect and Responsibility: a Universal Ethical Code for Scientists*. The consultation concluded that there was widespread support for the code, "both in terms of its content, but also in terms of its value in broadening debate, enabling individuals and institutions to make a public statement of the values expected from scientists, engineers and technologists, and as an educational tool for use in schools, colleges and universities". At the more general public level, the OSI-sponsored National Science Week 2006 generated record-breaking numbers of events around the country, with more people participating than ever before and drew strong media coverage.

The UK Science Forum has explored public engagement with science (in 2005) and noted that the public is generally positive about science, but that scientists feel that they have insufficient reward and recognition for engaging with society. The Government is working with HEFCE, RCUK, the Wellcome Trust, the Royal Society and others to develop a public engagement scheme for universities and colleges and will continue to support this initiative.

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[52] See: http://www.hmrc.gov.uk/research

6 Human Resources (Human and Social Capacity)

The main issues addressed by this Section include skills, the education system and educational outputs, R&D personnel and mobility.

Empirical evidence shows that higher levels of skills in the workforce are associated with higher levels of productivity. Skills are integrally linked to innovation, as higher skills levels allow workers to generate new ideas and adapt to the changing economic environment. With a more skilled workforce, firms are better able to introduce new technology and organisational change. Skills can be developed through education and also training throughout an individual's working life[53]. Management skills have also been shown to play an important role. Managers and leaders, as the decision-makers setting the organisational strategy and environment, are pivotal to investment, innovation, skills development, delivery of service and quality of performance across both the public and the private sectors. Thus, management can influence productivity outcomes directly, and also indirectly through its role in determining innovation, workforce skills, investment and enterprise outcomes.

An effective education system is also a major requirement for producing not only a well-educated workforce at all skills levels (including basic literacy and numeracy) but also more highly trained scientists, engineers and technicians who are able to populate the science and engineering base and train the workforce of the future. Moreover, a well-educated population forms a more receptive and demanding market place for the supply of innovative products, processes and services. Customer demand can act as a strong driver to business innovation. Similarly, well educated citizens are also less likely to be resistant to new scientific approaches and developments or, in the case of controversial issues such as GM and stem cell therapies, are more able to participate in informed debate and act as stakeholders in the formulation of appropriate and acceptable policies. The rapid development of the knowledge society also means that the learning of new skills is also critical, hence life long learning forms a further essential driver for innovation overall.

6.1 Indicators and Challenges

Education and Skills:

The UK performance on workforce skills levels is mixed:

- It performs relatively well in terms of higher-level skills, defined as the achievement of a university degree or other higher-level qualification in the National Vocational Qualification (NVQ) system. It is behind the US, level with Germany and ahead of France in terms of the percentage of the working age population possessing high-level qualifications, with all four countries being strong performers by OECD standards. UK participation rates in higher education now exceed 30%, having improved significantly since the early 1990s.39 A large proportion of this expansion in higher education has been in Science, Engineering and Technology (SET) degrees.

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[53] UK Productivity and Competitiveness Indicators 2006

- However, compared to Germany and the US again, the UK has a significantly lower proportion of its workforce educated to an intermediate level. Intermediate level skills cover two key stages in the UK education system, 'Level 2' (equivalent to five or more passes at GCSE), and 'Level 3' (equivalent to two 'A' levels). OECD data indicates that 35% of the UK's working age population had not managed to acquire skills equivalent to Level 2 in 2002, a proportion higher than in Germany and the US, but level to that of France.
- UK workers are less well equipped than their colleagues in many other OECD countries in terms of basic literacy and numeracy skills. For example, in the years 1994-1998 over 20% of the UK's adult population was at the lower level of literacy and numeracy skills.

Over the last ten years, the UK has made some progress in addressing skills gaps and equipping workers with the skills they need to make them more productive and is making steady progress in addressing the ongoing gap with its main competitors in terms of intermediate qualifications. The UK performs comparatively well internationally in terms of the proportion of the population with higher/degree-level qualifications and is retaining its strong position with respect to high-level skills which are associated with higher productivity and value-added and slowly improving with respect to intermediate skills where we have traditionally been weak. However, the UK still has too many people with low literacy and numeracy skills, holding back their potential to excel in their current roles and making them less adaptable in the face of the changing demand for skills, threatening their future employability.

With regard to management skills, there is a lack of robust internationally comparable data on management skills and definitions of managers and management vary across countries. However:

- according to the latest survey on management perceptions by the International Institute for Management Development, UK managers are perceived to lag their colleagues in France, Germany and the US in terms of their experience and competence. Other studies have found that on average, UK manufacturing firms perform less well than firms in the US, France and Germany in terms of overall management practice, including talent management and performance management; and that the UK is believed to have relatively high levels of professional management, but that in the manufacturing sector the UK adopts modern management techniques later and less often than its competitors. A tentative conclusion is that the problems appear to be concentrated at the lower and middle management levels, reflecting the UK's overall skills deficit.
- The UK also has a relatively low share of managers with advanced formal qualifications, although this could due to the UK using a broader definition of management than elsewhere.

In terms of educational achievements, Tables 22 to 24 and Figure 10 provide some indications of the UK's performance in basic education activities. Overall, the UK appears to perform around the OECD and EU averages for secondary education attainment, and above average for tertiary education attainment. In terms of expenditure on education, the UK lies below the OECD average but above the EU-19 average for expenditure on all levels of education as a proportion of total public expenditure, above the OECD and EU-19 average for expenditure on all non-tertiary education expenditure as a proportion of GDP but below the OECD and EU-19 average for total tertiary expenditure as a percentage of GDP. It also ranks quite low in terms of its expenditure on higher education institutions as a proportion of GDP. Figures of expenditure by discipline are not available for the UK.

Table 22: Population that has attained at least upper secondary education (2004)

Percentage, by age group

	Age group 25-64	25-34	35-44	45-54	55-64
United Kingdom	65	70	65	64	59
OECD average	**67**	**77**	**71**	**64**	**53**
EU19 average	**67**	**78**	**71**	**63**	**52**

Source, OECD, Education at a Glance, 2006.

Table 23: Population that has attained tertiary education (2004)

Percentage of the population that has attained tertiary-type B education or tertiary-type A and advanced research programmes, by age group

	Tertiary-type B education					Tertiary-type A and Advanced research programmes					Total Tertiary				
	25-64	25-34	35-44	45-54	55-64	25-64	25-34	35-44	45-54	55-64	25-64	25-34	35-44	45-54	55-64
UK	9	9	10	9	7	20	26	20	18	15	29	35	29	27	23
OECD average	**9**	**11**	**10**	**8**	**6**	**19**	**24**	**20**	**17**	**13**	**25**	**31**	**27**	**23**	**18**
EU19 average	**9**	**11**	**11**	**9**	**6**	**17**	**22**	**17**	**15**	**12**	**23**	**29**	**24**	**21**	**17**

Source, OECD, Education at a Glance, 2006[54]

Table 24: Total public expenditure on education (1995, 2003)

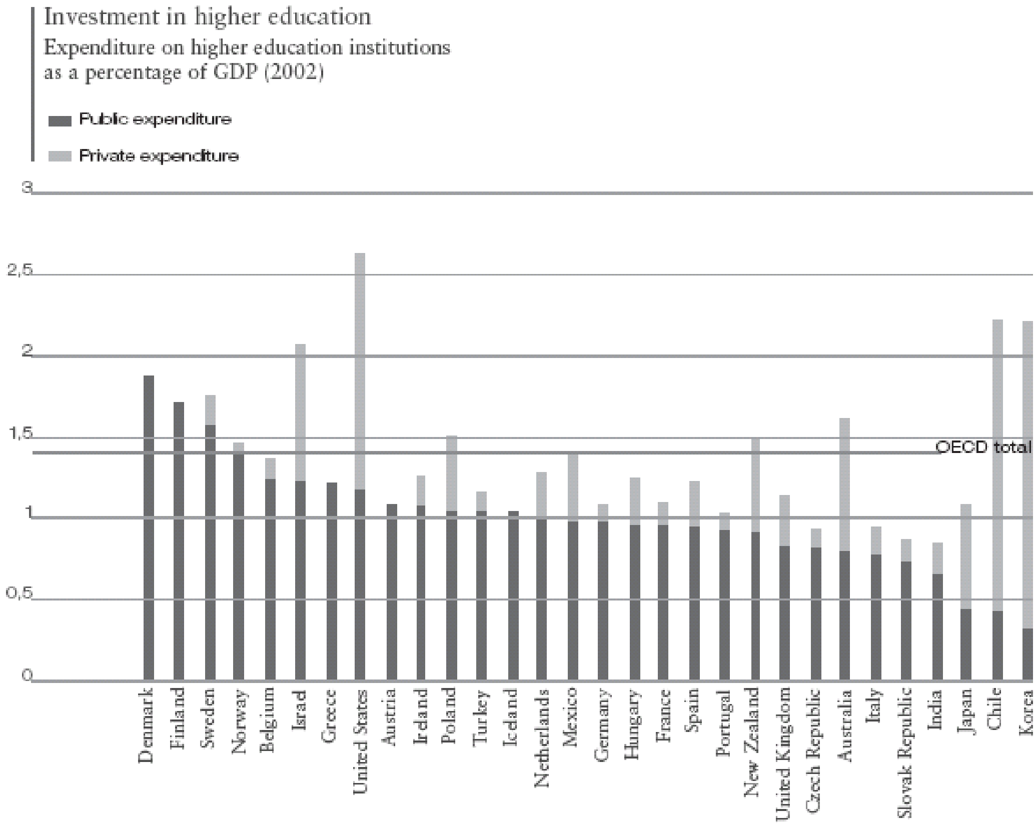
Direct public expenditure on educational institutions plus public subsidies to households (which include subsidies for living costs) and other private entities.

	Public expenditure on education as a percentage of **total public expenditure**				Public expenditure on education as a percentage of **GDP**			
	2003			1995	2003			1995
	1°, 2° and post-2° non-3° education	Tertiary education	All levels of education combined	All levels of education combined	1°, 2° and post-2° non-3° education	Tertiary education	All levels of education combined	All levels of education combined
UK	8.8	2.4	11.9	11.4	4.0	1.1	5.4	5.2
OECD average	**9.0**	**3.1**	**13.3**	**12.0**	**3.8**	**1.3**	**5.5**	**5.3**
EU19 average	**7.6**	**2.7**	**11.2**	**10.6**	**3.7**	**1.3**	**5.5**	**5.4**

[54] http://www.oecd.org/edu/eag2006

Source, OECD, Education at a Glance, 2006

Figure 10: Expenditure on higher education institutions as %GDP



Source, OECD, 2006 http://www.oecd.org/dataoecd/30/7/36960580.pdf

Current Government projections suggest an increasing demand for Science, Technology, Engineering and Mathematics (STEM) skills over the next ten years. However, these are not broken down by individual subjects and rely on a number of assumptions, in particular the continuation of historic growth in demand for skills. Thus, while the projections of increases in supply of STEM skills and progression rates to STEM-dependent jobs would suggest that, at the broadest level, supply is likely to meet the increase in demand for these skills over the next ten years, there may be problems with specific subjects. For example, a number of UK universities have met well-publicised difficulties with attracting sufficient numbers of students in certain subjects, notably physics and chemistry and have been forced to merge, or consider the closure of, departments that teach these disciplines. A report by the University College Union has revealed that 10% of science and maths university courses have been scrapped in the last decade, leaving some regions of the UK without access to science subjects. Around 70 UK university science departments have closed over the last seven years. Moreover, based on current trends the supply of engineering and physical sciences is relatively weak and with over half the graduates in these subjects not going on to STEM occupations straight away there is a possibility that demand for these skills will not be met by supply.

This issue is of particular concern as it involves a potential downward cycle in which low student demand for strategic subjects leads to the loss of teaching provision and the inability to train any students in case of a future upward trend in demand.

Mobility:
The UK performs well in terms of student mobility (Table 25), with both a high number of foreign born students studying in the UK and high numbers of highly educated UK-educated people as residents in other OECD countries. It has around twice the OECD average in all types of tertiary enrolments and scores particularly well in advanced research programme participation. However, whilst these levels of mobility are increasing, they are doing so at a slower rate than the OECD average.

Table 25: Student mobility and foreign students in tertiary education (2000, 2004)

International mobile students enrolled as a percentage of all students (international plus domestic), foreign enrolments as a percentage of all students (foreign and national) and index of change in the number of foreign students

	Student mobility				Foreign enrolments				
	International students as a percentage of all 3° (tertiary) enrolment				Foreign students as a percentage of all 3° (tertiary) enrolment				Index of change in no of foreign students, total 3° (2000=100)
	Total 3°	3°-type B progs	3°-type A progs	Adv. research progs	Total 3°	3°-type B progs	3°-type A progs	Adv. research progs	
UK	13.4	5.6	14.4	38.6	16.2	10.7	16.6	40.3	135
OECD average	**6.5**	**3.5**	**7.2**	**16.1**	**7.3**	**5.1**	**8.0**	**19.5**	**161**
EU19 average	**5.8**	**2.4**	**6.4**	**13.3**	**6.5**	**4.1**	**6.8**	**16.7**	**152**

Source, OECD, Education at a Glance, 2006

Also relevant to the issue of mobility is the degree to which HEIs interact with the broader community. The Higher Education – Business and Community Interaction Survey sponsored by the Higher Education Funding Council for England seeks information from HEIs on their priorities for economic impact with a strong emphasis on regional activities. The results for 2006 (presented in Table 26) indicate that the development and maintenance of regional skills needs form important priorities.

Table 26: Economic development priorities* (proportion of HEIs)

Area of activity	England	Northern Ireland	Scotland	Wales	UK
Access to education	55%	50%	79%	62%	59%
Research collaboration with industry	38%	0%	26%	38%	37%
Meeting regional skills needs	38%	50%	11%	38%	35%
Technology transfer	30%	100%	53%	38%	34%
Supporting SMEs	34%	50%	5%	31%	30%
Meeting national skills needs	30%	0%	21%	15%	27%
Developing local partnerships	19%	0%	26%	8%	19%
Attracting non-local students to the region	18%	0%	16%	8%	16%
Graduate retention in local region	15%	0%	21%	23%	16%
Support for community development	12%	0%	16%	31%	13%
Attracting inward investment to region	5%	0%	5%	0%	5%
Spin-off activity	2%	50%	11%	8%	4%
Management development	3%	0%	0%	0%	2%
Strategic analysis of regional economy	0%	0%	11%	0%	1%

* Respondents were asked to select the top three areas of economic impact.

Source: HE-BCI Survey, 2006

Lifelong learning:

Lifelong learning issues, are largely dealt with under the skills section above. The UK Government sees the provision of adult learning opportunities as an important contribution to addressing skills needs in the population.

Table 27: Indicators for Human Resources

Indicator	Value (date)	Source
Percentage of GDP spent on education		OECD
Percentage of working population with tertiary level education	29.2 (2004)	EIS
Percentage of working population in life-long learning	21.3 (2004)	EIS
S&E graduates as a percentage of the 20-29 age range	21.0 (2003)	EIS
Percentage of workforce in medium-high and high-tech manufacturing		EIS
Percentage of workforce in high-tech services		EIS
Science and engineering graduates as a percentage of working population		RTD
Researchers per 1000 workforce	5.92 (2003)	PSA
Percentage of GDP spent on tertiary education		3%AP
Share of R&D personnel in labour force by sector		3%AP
HRST core (25-64 years old) as % of labour force	18.4 (2003)	RTD
„ „ EU-25 comparison	*15.9 (2003)*	*RTD*

Key: OECD = Organisation for Economic Cooperation and Development; EIS = European Innovation Scoreboard; RTD = RTD Indicators Report; 3%AP = 3% Action Plan; PSA = PSA metrics report 2005

* There is some overlap with indicators relevant to other domains and between indicators from different sources.

Table 28: Human Resources SWOT analysis

Strengths	**Weaknesses**
• High output of S&E graduates (172% of EU average) • High participation levels in lifelong learning (215% of EU average) • Above EU average in terms of working population with tertiary education. • Relatively high proportion of workforce with SET degrees • High level of student mobility as measured by foreign student studying in UK	• UK has lower availability of highly skilled people with research training than its competitors (only 0.3% of population; 0.6% of labour force). UK ranks lowest in G8. • Poor performance in basic literacy and numeracy skills in workforce • Perception of poor management skills levels in some areas • Low proportion of its population qualified at the intermediate level, with concerns about the quality of vocational qualifications at the intermediate level.
Opportunities	**Threats**
• Scope for improvement of average performance in terms of % of population (aged 20-24) having completed at least upper secondary education • Improving entrance to and retention of S&E graduate output in innovation-relevant workforce could benefit overall industrial innovation performance	• Large proportion of population with low-level skills • Risk of loss of university departments teaching of S&E subjects in strategically critical areas of the economy (e.g. physics, chemistry, engineering) due to low student uptake of these subjects.

6.2 Governance

The main actor in this area is the Department for Education and Skills (DfES). The DfES is responsible for children's services, education and lifelong learning in

England. It also has wider responsibilities for a range of policies, some of which it shares with other government departments, such as the Sure Start programme (shared with the Department for Work and Pensions). It also interacts extensively with the DTI[55] in education issues of relevance to innovation (for example, on schemes such as the HEIF) and also the Department for Work and Pensions. The DfES also oversees the Learning and Skills Council[56] and the Higher Education Funding Council for England (HEFCE), which provide funding for staff and infrastructure in institutes of further and higher education respectively. Separate education departments operate in the devolved administrations in Scotland and Wales and also in Northern Ireland although there is of course very close liaison between all of these and there are several shared or mirrored policies, programmes and initiatives.

The aim of the DfES is "to help build a competitive economy and inclusive society by:

- creating opportunities for everyone to develop their learning;
- releasing potential in people to make the most of themselves; and
- achieving excellence in standards of education and levels of skills."

6.3 Policy Objectives

Underpinning the aim noted above, the DfES lists five objectives and fourteen Spending Review 2004 Public Service Agreement targets. Of particular relevance are:

Raise standards and tackle the attainment gap in schools

6. Raise standards in English and maths so that:
    - by 2006, 85% of 11-year-olds achieve level 4 or above, with this level of performance sustained to 2008; and
    - by 2008, the proportion of schools in which fewer than 65% of pupils achieve level 4 or above is reduced by 40%.

7. Raise standards in English, maths, ICT and science in secondary education so that:
    - by 2007, 85% of 14-year-olds achieve level 5 or above in English, maths and ICT (80% in science) nationally, with this level of performance sustained to 2008; and
    - by 2008, in all schools at least 50% of pupils achieve level 5 or above in each of English, maths and science.

All young people to reach 19 ready for skilled employment or higher education

10. By 2008, 60% of those aged 16 to achieve the equivalent of 5 GCSEs at grades A*-C; and in all schools, at least 20% of pupils to achieve this standard by 2004, rising to 25% by 2006 and 30% by 2008.

11. Increase the proportion of 19-year-olds who achieve at least level 2 by 3 percentage points between 2004 and 2006, and a further 2 percentage points

[55] Refer to Section 2 for more information on DTI activities in this area.

[56] The LSC is a non-departmental public body, established under the Learning and Skills Act 2000 which became fully operational in April 2001. It replaced the Further Education Funding Council and the 72 training and enterprise councils and was set up in response to the white paper Learning to Succeed (1999).

12. Reduce the proportion of young people not in education, employment or training (NEET) by 2 percentage points by 2010.

Tackle the adult skills gap

13. Increase the number of adults with the skills required for employability and progression to higher levels of training through:

- improving the basic skill levels of 2.25 million adults between the launch of Skills for Life in 2001 and 2010, with a milestone of 1.5 million in 2007; and
- reducing by at least 40% the number of adults in the workforce who lack NVQ2 or equivalent qualifications by 2010. Working towards this, one million adults in the to workforce achieve level 2 between 2003 and 2006.

14. By 2010, increase participation in higher education towards 50% of those aged 18 to 30 and also make significant progress year on year towards fair access and bear down on rates of non-completion.

Of particular relevance to the skills issue is the Skills Strategy White Paper; *Realising our Potential,* published by DfES in July 2003. This emphasised the relationship between skills, innovation and enterprise in raising productivity. The Skills Strategy underlined the UK's main strengths in the way in which skills, learning and qualifications are developed and noted favourable comparisons between the UK and German and US workers with regard to literacy, numeracy and science skills. However, the document highlighted areas for improvement, particularly among those with the lowest skills levels and this forms a focus for the Government's agenda for enhancing flexibility across the UK. The Skills Strategy sets out the Government's agenda for acting on both the demand for, and supply of, skills as a major contributor to improving levels of innovation and productivity. In particular it sets out plans for creating a more demand-led, responsive and flexible training system delivered through: the Skills Alliance, jointly chaired by the Secretaries of State for Trade and Industry and Education and Skills; the joint DfES and DTI Leadership and Management Unit; the joint DfES and DTI sponsored Skills for Business Network of Sector Skills Councils leading the development of Sector Skills Agreements; and Regional Skills Partnerships – which will bring together activities on regional and sectoral skills priorities, training, business support and labour market activity in support of regional economic strategies.

The more recent 2005 DfES White Paper[57] builds on the 2003 Skills Strategy, retaining the principles and direction of the original Skills Strategy and noting that good progress has already been made in implementing it. However, the skills challenge is still present and the White Paper set out how Government intend to tackle it with its partners. The White Paper developed a strategy for ensuring that employers have the right skills to support the success of their businesses. It also helps individuals gain the skills they need to be employable and personally fulfilled. In the Government's own words, for the first time, from 14-19 to adult skills, the

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[57] *Skills: getting on in business, getting on at work,* DfES White Paper, March 2005. Available at:
http://www.dfes.gov.uk/publications/skillsgettingon/

Government has set out a coherent lifelong learning strategy to tackle the UK's skill needs.

The most recent policy document produced by the Department is *The Five Year Strategy for Children and Learners: Maintaining the Excellent Progress*, released in September 2006. This provides a report on the progress, after two years, in delivering *The Five Year Strategy for Children and Learners* published in 2004. The report examines the rapid progress that has already been made and looks ahead at how the strategy would be taken forward to 2009 and beyond. It sets out five clear priorities for the Department and partners:

- Closing the gap in educational attainment between those from low income and disadvantaged backgrounds and their peers.
- While at the same time continuing to raise standards for all across the education system.
- Increasing the proportion of young people staying on in education or training beyond the age of 16.
- Reducing the number of young people on a path to failure in adult life.
- Closing the skills gap at all levels – from basic literacy and numeracy to postgraduate research – to keep pace with the challenge of globalisation.

On a broader level, concerning the more general UK innovation context, the Ten-Year Framework emphasised the importance of a strong supply of scientists, engineers and technologists to the long-term health of the science base and the wider UK economy, and set out the Government's aims to achieve a step change in:

- the quality of science teachers and lecturers in every school, college and university, ensuring national targets for teacher training are met;
- the results for students studying at GCSE level;
- the numbers choosing STEM subjects in post-16 education and in higher education;
- the proportion of better qualified students pursuing R&D careers; and
- the proportion of minority ethnic and women participants in higher education.

Building on these original framework proposals, the *Science and Innovation Investment Framework 2004-2014: Next Steps* document included a range of further commitments in this area:

- to raise further pupil attainment and the quality of school teaching in science and mathematics;
- to promote more collaboration between schools and higher education institutions in the teaching and learning of STEM subjects; and
- to review and evaluate the changes to the curriculum to ensure science continues to enthuse and inspire pupils.

Also, in the field of innovation policy, the UK's NRP 2005 mentions some areas with relevance to innovation including:

- Raising skills levels in the workforce by increasing participation in education at age 17 from 75% to 90% over the next 10 years, increasing participation in higher education for 18-30 year olds towards 50% by 2010, ensuring 2.25

million adults improve their basic skills, and reducing the number of adults in the workforce without a level 2 (upper secondary) qualification by 40%;

6.4 Policy Instruments

Clearly, the issue of Human Resources is complex, and addresses the entire educational experience of people from their first school days through to adult learning opportunities. Consequently, a range of policies and policy instruments are in place to meet the identified demands in human resources faced by the UK. Some of these are discrete instruments that can be clearly described whilst others encompass a broader range of policy actions. For example, the Government's efforts to improve the delivery of educational services at the primary and secondary levels incorporate a number of approaches, from the setting of curricula for state schools, norms and requirements for testing and examination, guidelines for the delivery of specific parts of the curriculum and assistance packages for disadvantaged pupils or additional help for those who excel, to provide just a limited number of examples. In addition, specific packages aimed at increasing skills in certain disciplines, such as mathematics and physics, have targeted the attractiveness of training programmes and the recruitment and retention of teachers in these areas.

In terms of the ability of the education system to produce the trained persons required by the demands of the knowledge society, the Government annually reviews the evidence on student participation and employment in shortage subjects in schools, further education and higher education, to judge the relative balance between supply and demand for those skills, and recommend whether there is a need for further action. All stakeholders including government central departments, the Learning and Skills Council (LSC) and the Sector Skills Development Agency (SSDA) work together to assess future market trends. Work is in progress to improve the quality of science teaching and support continual professional development (CPD) of science teachers. Regional Science Learning Centres have now been established in each region and are delivering CPD courses. There is evidence of significant effort to increase the science links to schools by supporting HEIs, industry and scientific societies in their outreach activities to schools and colleges in order to increase physical sciences and engineering participation in higher education.

As already noted, the Ten-year Science and Innovation Investment Framework highlights the fact that productivity and employability are hindered by poor skills and the UK is particularly weak in basic and intermediate skills. Differences across sectors are clear and the employment structure is, for instance, significantly less favourable in terms of employment in high-tech manufacturing than in terms of knowledge-intensive services. The UK Government has also specifically identified the issue of skills and training as a challenge within the SME sector and has introduced measures to address this as part of a wider policy mix. Amongst other initiatives, these include: the University for Industry (Ufi) now renamed **Learndirect**, which aims to work with partners to boost peoples employability, and organisations' productivity and effectiveness, by: "inspiring existing learners to develop their skills further; winning over new and excluded learners; and transforming the accessibility of learning in everyday life and work"; and the **Science and Engineering Ambassadors Scheme** (now the **Science Associates Scheme),** in which top science students are expected to form links with their old school or college to provide coaching and mentoring and inspire young people to take up studies and careers in science and engineering. Launched in September 2001, it brings together under one banner several existing private and public sector schemes. The Scheme places role models from businesses in schools and there are now over 12,000 Science and Engineering Ambassadors across the UK, representing over 700 different employers from a large range of multinationals and other organisations such as the NHS and the Environment Agency. On average, each ambassador works with schools on two to three occasions per year. The policy priority is therefore to improve collaboration between schools but also between schools and industry and the science base.

Also relevant is the **Manufacturing Advisory Service** (MAS). This offers assistance from experts to enable SME manufacturers to improve productivity, through a network of regional centres for manufacturing. The MAS delivers the following to companies: practical help; assistance for technology transfer; development of manufacturing skills; dissemination of best practice; and development of Networks of Expertise.

Other measures include the provision of assistance for companies to assess and review their demand for skills as part of overall business developments, including helping them to benchmark their own strengths and weaknesses against similar companies; equipping the managers of UK companies with the skills they require to foster innovative cultures and practices; the Design Council, in consultation with the Sector Skills Councils, has been working in partnership with UK universities and FE colleges to establish design learning for science, engineering and business management students to enable a better understanding of the role of design in translating science and technology into products and services.

The Government's **Skills Strategy** provides support to any adult without a good skills foundation to get access to training in order to achieve a 'Level 2' or 'Level 3' qualification; it also helps adults gain ICT skills and aims to ensure the provision of a wide range of learning for adults in all local areas[58]. In addition to measures to increase the supply of skills, the Skills Strategy recognises the importance of moving towards a more demand-led approach. It has been argued that demand for skills in the UK appears low in comparison to other industrialised nations, which may be because UK firms choose product market strategies that require the use of less skilled labour. The direction of this causal relationship is unclear, as production choices can themselves affect skills supply, but government initiatives to increase the availability of skills need to be supported by increased demand for skills by business.

The roll-out nationally from 2006/07 of the **National Employer Training Programme** aims to increase demand for skills and training to a more ambitious level. At the heart of the programme is a brokerage service. It will start by identifying, through a training needs assessment, the employer's skills needs at all levels, both those leading to qualifications and more informal development. It will then source training to meet those needs (generally at the employer's cost for training beyond the core of basic literacy, language and numeracy skills and Level 2), for delivery as part of a single, integrated training package. In return for free and flexibly funded training,

[58] DfES (2003), 'Skills strategy, White Paper'

employers will be expected to allow employees enough time at work to undertake the training successfully[59].

The recently launched (September 2006) **Train to Gain** scheme is a service to help businesses access the training they need to succeed. It offers employers impartial advice and easy access to quality training, matches training needs with training providers, and ensures that training is delivered to meet employers' needs. The service is now operational across England, and early evaluation findings and management information are very encouraging.

Some sector specific skills instruments are also worth mentioning as examples: in January 2006, a new Industry-Government Body was officially launched to help the UK fight climate change and address skills gaps[60]. Developed from an idea by HM Treasury, the **Energy Research Partnership** (ERP) brings together top energy industry executives, Whitehall officials and senior academics in an initiative designed to give strategic direction to UK energy research, development, demonstration and deployment. The partnership will initially focus a number of key areas, including addressing the high level skills shortages in the energy sector and communicating the opportunities that the energy sector offers. Part of the realisation of this strategy is the creation of an Energy Research Institute (see Section 7.2). In Scotland, the **Construction Skills Action Plan** is a national strategy, drawn up in partnership with industry bodies and public agencies, to prevent growth in Scotland's €14 billion construction sector being hampered by skill shortages. Scottish Enterprise has committed €50 million to the plan.

In order to deal with strategically important research areas that have been identified as 'at risk', the Government has launched its **Science and Innovation Awards** - large, long-term grants (typically £3-5 million over 5 years) supporting staff in a research group, with commitment from the host HEI(s) to continue support after the end of the grant. A pilot exercise was launched in 2004 and a total of 19 awards have now been made, the most recent being announced in December 2006. The awards are funded by the Engineering and Physical Sciences Research Council, and the Higher Education Funding bodies in England, Wales, Northern Ireland and Scotland. In addition, late in 2006, the UK Education Secretary asked HEFCE to inform him about department closures at UK universities, particularly in 'strategic subjects'. As a further element of its support for 'strategic subjects' – high cost subjects that are strategically important for the economy but subject to low student demand – HEFCE has recently announced £75 million of extra resources over three years to prevent closures to vulnerable university departments. The extra funding will increase HEFCE teaching grants for the vulnerable subjects by 20% (equivalent to £1000 per student).

6.5 Policy Effectiveness

Clearly, as Human Resources issues concern the entire educational progression of individuals, the effects of policies in this area will not become evident for several years. Even addressing short term skills shortages may not have any measurable

[59] DfES (2005), 'Skills: Getting on in business, getting on at work' White Paper
[60] See: http://www.gnn.gov.uk/environment/dti/

effects for a number of years. Thus it is quite difficult to judge the effectiveness of policy measures. However, some limited evidence is available.

For example, the Ten-Year Science and Innovation Investment Framework Annual Report 2006 notes the following main achievements in terms of the aim of ensuring the UK retains a strong supply of scientist, engineers and technologists:

- between 2004 and 2005, the overall percentage of pupils achieving grades A*-C in science GCSE and grades A-E in science A Level rose;
- in 2005, entries into A-level Biological Sciences were up by 1,427 students to 45, 662, Chemistry up by 1,034 to 33,164; with Physics down by 506 to 24,094.
- teacher recruitment in the STEM subjects has risen for the sixth year in succession, with over 7,500 recruits in these subjects in 2005/06, 70% more than in 1999/2000. This does not include the rising numbers of graduate career-changers following employment-based training routes;
- from September 2006, trainee teachers in mathematics and science will receive a higher bursary of £9,000, plus a £5,000 Golden Hello after they enter the classroom;
- in 2005/06, recruitment to conventional science initial teacher training was 91% of the allocated places available. This figure has risen from 88% in 2004/05;
- at January 2006, the number of unfilled teaching posts in secondary science, mathematics and technology were all at their lowest levels since January 2000;
- there have been around 130 recruits to a pilot scheme to train science specialist Higher Level Teaching Assistants. Next Steps are now being planned;
- findings of a survey on the recruitment and retention of post-16 staff commissioned by the DfES Standards Unit have informed the Government White Paper 'Raising Skills, Improving Life Chances';
- continuing success of the Research Councils UK Academic Fellowship scheme with 400 further awards being made;
- a database of practice launched by the UK GRAD programme to collect and share examples of good practice relating to skills development for researchers; and
- 38 schools involved in a new £1.5 million ethnic minorities STEM access grants initiative run by the Science Engineering and Technology Network (SETNET).

The number of undergraduate volunteers supporting pupils learning science under the Science Associates Scheme has continued to rise steadily. In 2003/04, around 1,000 placements were science-based; this increased to around 1,500 placements in 2004/05 and provisional figures for 2005/06 show a further increase to 2,000. In the 2006 Budget 2006, the Scheme received additional funding for 2006/07 and 2007/08 of £700,000 a year to increase the number of mathematics and science placements. It is believed that this could fund an additional 450 mathematics and science placements compared to 2005/06 levels.

The Government decided that the increased Golden Hello of £5,000 for teachers of science subjects taking jobs in FE colleges from September 2005 would be maintained for 2006/07. It was recognised that shortage subject areas attracting incentive support (Golden Hellos and Training Bursaries) needed to be more clearly defined. As a result of research into this issue by Lifelong Learning UK, maths and science have been defined within the shortage subject area list. The research findings were endorsed by Government and a revised list of shortage subject areas was published in June 2006.

In higher education, according to Higher Education Statistics Agency data[61], UK undergraduate qualifications in Physics and Chemistry rose by 5% and 1%, respectively. Biological Sciences increased by 8% but stabilised (0%) when not including Sports Science and Psychology. Engineering and Technology qualifications fell slightly (by 1%), Mathematical and Computer Sciences both decreased by 4%. Clearly, it is too early to judge the impact of the recently announced HEFCE funding for "at risk" science departments.

The minimum PhD stipend has been increased (from £5,295 in 1997 to £12,300 in 2006, and thereafter in line with the GDP deflator). A recent report[62] showed that overall numbers of studentships have been maintained and that higher stipends have had some positive impacts, although several issues, such as the inflexibility of postgraduate education, remain to be addressed. In addition, funding for transferable and careers skills training for researchers and PhD students has been successful in encouraging and supporting the work of skills practitioners in the HEIs. Although significant success has been achieved with postgraduate transferable skills there is still some way to go to enhance the level of career development skills for research-only staff. Lastly, a the UK Research Councils have put in place mechanisms to support PhDs of longer duration than 3 years.

The RCUK Academic Fellowship Scheme has been found to be successful in developing contract research careers and in building interdisciplinary bridges, whilst a review[63] of efforts by the Research Councils to increase doctoral stipends and researchers' salaries found that there were some positive outcomes, although the implications of a number of these required further elaboration.

In addition, as noted above, early indications are that the Train to Gain scheme is proving successful.

OECD work - on R&D determinants by the positive interaction between the stock of foreign R&D and the proportion of researchers in employment - suggests that one of the largest hindrances to innovation is insufficient capacity to absorb foreign knowledge. The UK has a lower proportion of researchers in the workforce than in the US, Japan, Finland or Sweden. Thus while, the UK benefits from strong FDI, its impact on local R&D could be negated by a lack of scientists. However, in theory, the low availability of trained researchers could reflect a lack of job opportunities in R&D activities and greater opportunities elsewhere, not least in finance. Thus, although the

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[61] Excludes figures for the Open University

[62] International Perceptions of UK Research in Physics and Astronomy 2005 (EPSRC, PPARC, Institute of Physics and Royal Astronomical Society - January 2006)

[63] Impact of the Roberts' Review Enhanced Stipends and Salaries for Researchers. Available at: http://www.rcuk.ac.uk/aboutrcuk/publications/policy/enhanced.htm

UK scores highly in terms of its supply of graduates in science, engineering and technology, it appears that the potential supply of researchers greatly exceeds the actual number of researchers[64] and large numbers of science graduates find the rewards of jobs in the City are more attractive than a career in research. Thus, employers continue to regularly report shortages in R&D and engineering jobs. Larger numbers of graduates in science and engineering would thus improve the ability of the UK to both foster and adopt innovations. Whether increases in tuition fees and research salaries and stipends will address this problem is not clear.

Overall, however, the ongoing problem seems to lie with the high share of the workforce having little or no formal qualifications beyond compulsory schooling: with 30% of the 25-34 year-olds classed as low-skilled, the UK scores poorly with many other OECD countries. A lack of basic literacy skills in adults is also a major issue which will take some time for ongoing efforts to improve education to address.

In conclusion, it seems that the UK has clearly identified the sets of human resources-related challenges faced by the economy and has set in train a variety of policy initiatives in an attempt to meet them. The degree to which they will be successful will only be realised in the longer term.

[64] Cotis, J-P, “Economic Growth and Productivity”, Address at the Annual Conference, Government Economic Service, Nottingham UK, 13-14 July 2006

7 Overall Innovation System

7.1 Challenges and Responses

As it was necessary to 'deconstruct' the UK's overall innovation policy agenda in order to address the component issues making up the structure of this report, it is a straightforward task to discuss the major policy challenges facing the system as a whole.

The three major challenges facing the UK economy and National Innovation System are:

4. To increase the intensity of innovation activity in enterprises;
5. To strengthen linkages between the public research base and business; and
6. To match future skills needs and improve the supply of high quality labour.

As noted in Section 2 above, these three challenges are identified and further elucidated in the *Ten-Year Science and Innovation Investment Framework 2004-14* together with subsidiary challenges. Thus, for a general overview of UK innovation policy and the UK NIS issues and challenges, the reader is directed to Section 2. However, on the face of available policy documentation and from the evidence presented in terms of policy responses, these represent the top three priority challenges

Obviously there are a range of policy options and interventions by which these challenges may be addressed. The UK Government's response to the challenges, as expressed in policy objectives and policy instruments, can be summarised as shown in Table 29. Whilst this analysis does not include many of the 'softer' policy interventions detailed in this report, it seems that there are no apparent gaps between the main challenges, objectives and priorities and the set of instruments in place. On the contrary, there does seem to be a high level of overlap between the various instruments, particularly those dealing with industry-academic collaboration, although the modalities and targets of these instruments do vary.

Table 29: UK innovation: Challenges, policy objectives and instruments

Challenges	Objectives/priorities	Measures and policies responding to the challenge
a) **increase the intensity of innovation activity in enterprises**	• **Increased business investment in R&D, and engagement with the Science Base**	• ***Defence R&D funding (private sector)*** • **Technology Programme (Knowledge Transfer networks and Collaborative R&D)** • **Knowledge Transfer Partnerships** • **Grants for R&D** • **R&D Tax Incentives** • **Enterprise Capital Fund** • **UKTI Strategy (aiming at FDI goals)**
	• **Support for high quality research and scientific productivity**	• **Micro and Nanotechnology Network** • **HEI Funding** • **CASE** • ***Funding for PSREs*** • **'Soft' dissemination, best practice**

		and networking initiatives
b) strengthen linkages between the public research base and business	• **Promotion of the flow of research results and ideas from the Science Base into the commercial environment and public services**	• **Technology Programme (Knowledge Transfer networks and Collaborative R&D)** • **Knowledge Transfer Partnerships** • **CASE** • **Faraday Partnerships** • **Foresight LINK** • **PSRE Fund**
	• **Increased business investment in R&D, and engagement with the Science Base**	• **Technology Programme (Knowledge Transfer networks and Collaborative R&D)** • **Knowledge Transfer Partnerships** • **CASE** • **HEIF** • **Faraday Partnerships** • **Foresight LINK**
c) match future skills needs and improve the supply of high quality labour (particularly in specialised scientific, engineering and technical skills areas)	• **Continued support for the Science Base infrastructure**	• **HEI Funding** • **Full economic costs for university conducted research** • **£500 million capital fund (SRIF)**
	• **Ensuring the supply of scientists, engineers and technologists**	• **HEI Funding** • **Education initiatives (schooling, teacher supplies, STEM subject provision, etc.)** • **Faraday Partnerships** • **Skills strategy and allied initiatives**

Note: instruments in italics denote measures which are not specifically designed in response to challenges, but which nonetheless contribute to meeting them.

7.2 Conflicts and Synergies

The purpose of this section is to draw out and comment on any conflicts and synergies between policies and instruments in different domains of the innovation policy mix and also similar interactions between innovation policies and policies in other socio-political domains.

Synergies within the innovation policy mix:

Ideally, in a well-designed policy mix, all policies should demonstrate some degree of synergy or complementarity. At worst, policies should neutral in regard to their interaction with other policies.

In the UK policy mix, it is clear that a number of measures and instruments are complementary. For example, measures to stimulate the creation of start-ups are reinforced with a set of incentives to promote related types of entrepreneurial activity, either at the general level or in a more focused context (such as through the promotion of incubators and similar activities in universities); such measures are also complemented by a range of measures intended to promote the availability of start-up capital and know-how, seed funding and other forms of early stage venture capital. In turn, there are a range of incentives and support measures for later stage funding and support tailored to the needs of SMEs.

The UK's policy mix is a product of an extended period of innovation support which has been shaped by a series of reviews of both the national innovation system or parts of it and by evaluation and monitoring of the performance and effects of instruments comprising the policy mix. Regarding the process of innovation in a systemic fashion, as has been done in the UK, seems to offer a logical approach for the design of complementary policy interventions.

Conflicts within the innovation policy mix:

Only one example of a conflicting measure can be identified. This concerns the mechanism by which, since 1992, the allocation of block grant funding has been made to HEIs by the higher education funding bodies in the UK – the Research Assessment Exercise (RAE). The RAE is a peer review process which produces 'quality profiles' for each submission of research activity made by HEIs. The UK higher education funding bodies use these profiles to determine their grant for research to the institutions which they fund. Any UK HEI that is eligible to receive research funding from one of these bodies can participate in the exercise. There have been three RAEs (in 1992, 1996, and 2001) and the next will occur in 2008. Once funding levels for institutions (which are actually made on a subject oriented 'cost-centre' basis and which may apply at a sub-departmental level) have been set, these are used for the annual allocation of funding until the next round of RAE.

The mechanism by which the assessment is made has changed over time and has been the subject of protracted debate and a number of extensive reviews. One of the major criticisms of the process is the enormous amount of staff time and resources that HEIs have to devote to the process of preparing RAE submissions.

In the 2006 Budget, the Government announced that, after RAE 2008, it would replace the Exercise with a less burdensome, metrics based approach. The new process will use, for all subjects, a set of indicators based on research income, postgraduate numbers, and a quality indicator. For subjects in science, engineering, technology and medicine the quality indicator will be a bibliometric statistic relating to research publications or citations. For other subjects, the quality indicator will continue to involve a lighter touch expert review of research outputs, with a substantial reduction in the administrative burden. Experts will also be involved in advising on the weighting of the indicators for all subjects.

The major issue concerning the RAE in the overall innovation policy mix concerns the fact that it is very much oriented towards the production of academic publications, indeed institutions may opt not to include in their submissions those academic staff who do not have a suitable number of publications that are significant at the international or world level. It has been argued that this focus on what might be termed the 'traditional' view of academics is outmoded in terms of the 21st Century model of universities and runs counter to the policy goal of stimulating greater interaction with business and, more recently, local communities. Whilst incentives are available for these latter activities, in terms of university income streams they are still very much secondary to the funding council allocations.

Whilst the intended replacement for RAE will be a metrics-based process and will include statistical indicators such as the amount of research income a department earns, it is not clear whether this will include research income from all sources (including industry and other funders) nor whether the publications data will include other measures of impact beyond citation counts (such as policy impact) or outputs such as grey literature and technical reports (or even non-published outputs) which may also have significant socio-economic impacts.

Thus, the academic focus of the current (and, possibly, future successors to the) RAE and measures to stimulate linkage between the higher education sector and business and the wider community provide a strong example of conflicting innovation policy measures in the UK.

Whilst the term 'conflict' is perhaps to strong in this case another potential example concerns the large numbers of policy instruments targeting the provision of venture capital and also those aiming at the promotion of interaction between the research base and industry. At first sight, it appears that there may be some degree of duplication within these two sets of measures which could lead to substitution or crowding out effects between their target groups. The DTI recently rationalised a number of its linkage measures following a detailed review and there may be scope for further rationalisation, particularly with regard to the various finance instruments that currently exist.

Synergies between innovation policy and other policy domains:
Of course the UK has a number of policy spheres that lie outside, but which may impinge on, the sphere of innovation policy – indeed it is difficult to define precisely the boundaries of the field of innovation, particularly in so far as it may extend beyond the narrow definition of technological innovation and encompass process, organisational, managerial, etc., innovation. Examples of related policy areas include those dealing with poverty and social inequality, national security, environmental issues, health and energy.

Several broad examples of complementary policy goals and instruments can be identified:

The issues of **poverty and social inequality** find prominence in the field of education. For instance, the first priority for the DfES in its 2004 report, *The Five Year Strategy for Children and Learners*, is

- "Closing the gap in educational attainment between those from low income and disadvantaged backgrounds and their peers…"

At a more general macroeconomic level, the Government believes that a strong, well-functioning economy with strong growth and productivity can better respond to the issue of poverty through enhanced employment and quality of life and through an efficient taxation system which allows government to support measures to alleviate social inequalities. Thus, the role of innovation cannot be dissociated from these other socio-political goals.

The issue of **security** is closely tied to defence, at the national level, and the Government is a provider of substantial funds to the defence sector, whilst safeguarding society from threats such as terrorism has been identified as a priority research and innovation challenge.

To give some specific details of the overlap with innovation policy, the Ministry of Defence (MoD) white paper *"Defence Industrial Strategy"* (2005)[65] places an emphasis on how the Ministry should work together more effectively with industry (including SMEs) and universities, to stimulate innovation and exploit research and technology to meet defence needs. In particular it identifies the need for greater utilisation of innovation, which may be achieved via the supply chain. Building on the White Paper, in October 2006 the MoD launched a Defence Technology Strategy (DTS), which set out the Ministry's plans for encouraging innovation to support the UK's defence needs. Specifically, the DTS identifies the areas of R&D that the MoD perceives to be key to the future provision of military capability to the UK's Armed Forces and can be viewed as a signal to UK industry on defence technology priorities. The MoD has an annual spend of approximately £2.6 billion and forms one of the largest government investors in R&D. The Ministry has also announced plans for a £10 million Competition of Ideas that is intended to 'encourage innovation by funding new research in prediction, protection, object recognition and networking' and which aims to attract original ideas from individuals, academia and SMEs. At the same time, information was released on University Research Fellowships (in cooperation with the Royal Society) to support research by graduates into emerging technologies.

Also in the context of security, the Technology Strategy Board, in its first Annual Report in November 2005, introduced the concept of Innovation Platforms. Two pilot Innovation Platforms have been announced. One of these covers the area of Network Security[66]. Each Innovation Platform has an initial £10 million earmarked in order to kick-start activities. Rather than focusing on sectoral issues, Innovation Platforms are intended to address broader challenges and to facilitate the integration of "a range of technologies and better coordination of policy and procurement, resulting in a step-change in UK performance, in the quality of public services and the ability of UK businesses to provide solutions"[67], through a risk-sharing approach by Government.

Amongst its responsibilities, the Home Office deals with the UK's internal policing and security issues. The Home Office's *Science and Innovation Strategy 2005-08* (2005)[68] emphasises closer cross-departmental collaboration across government on science and innovation issues to help inform policy design in the Home Office. One example includes liaison with the Technology Strategy Board. It also stresses collaboration with industry as an important driver for innovation, with Home Office scientists working with user communities to develop Home Office operational requirements and specifications. Consequently this would imply extensive links with

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[65] Ministry of Defence (2005), *Defence Industrial Strategy,* Defence White Paper, December 2005. Available online at: http://www.official-documents.co.uk/document/cm66/6697/6697.asp

[66] The other pilot is in the area of Intelligent Transport Systems and Services, thus providing an example of an overlap with the Transport policy sector.

[67] http://www.dti.gov.uk/innovation/technologystrategy/innovation_ platforms/index.html

[68] Home Office (2005), *Science and Innovation Strategy 2005-08,* November 2005. Available online at: www.scienceandresearch.homeoffice.gov.uk

industry in areas such as central intelligence policing, counter-terrorism, forensic science, etc.

With regard to the protection and improvement of the **environment**, the issue of sustainability forms a core cross-cutting issue in the development of Government policies. All departments have a commitment to produce Sustainable Development Action Plans (SDAPs) which are assessed by an independent sustainable development watchdog, the Sustainable Development Commission. Thus, the DTI's SDAP acknowledges that DTI's PSA targets include sustainable development and that much of the department's work can contribute to achieving a more sustainable economy. The department's energy policy, promotion of sustainable technologies and its involvement with the sustainable consumption and production agenda are some of the elements particularly explored in its plan[69]. In addition, a number of research programmes funded under DTI's Science Budget clearly address environmental concerns from a variety of perspectives.

The area of **health** policy also exhibits strong overlaps with R&D and innovation policy concerns. Some examples of these overlaps include steps being taken to increase research funding in public health in order to increase capacity. These include:

- Establishment of a strategic planning group by the UK Clinical Research Collaboration partners to develop a coordinated approach to funding public health research;
- The launch of a new Public Health Research Consortium with funding of £3.5m over five years by the Department of Health;
- Incorporation of the functions of the Health Development Agency by the national Institute for Clinical Excellence, to create a single organisation responsible for providing national guidance on the promotion of good health and the prevention and treatment of ill health;
- Setting up of a new Disease Prevention Panel to identify and prioritise health promotion and public health topics in NHS settings by the National Institute of Health Research Health Technology Assessment Research Programme.
- Total public funding for stem cell research will be up to £100m for 2006-07 and 2007-08, an additional investment of around £50 million. This additional investment is being overseen by the UK Stem Cells Funders Forum chaired by MRC. Several initiatives connected with stem cell research are in place.

As **energy policy** is a responsibility of the DTI, the interaction with R&D and innovation policy is also closely linked. Thus, for example, the DTI is working with the Carbon Trust through the Low Carbon Working Group to ensure that DTI and Carbon Trust programmes are complementary. In 2004/05 the Carbon Trust invested £11.5 million and committed an additional £5.3 million to the development of low carbon technologies and businesses. Schemes include: support of university research into low carbon technologies; investment alongside venture capital partners; support for early stage companies under the Low carbon incubator scheme.

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[69] http://www.sd-commission.org.uk/publications/downloads/dti_sdap.pdf

Also, as noted above, there is a collaboration between OSI, the DTI Energy Group, the UK Energy Research Centre and other major public and private sector players to raise the profile and improve the effectiveness of UK Energy R&D and facilitate the greater pull through of innovative technologies to commercialisation. A key vehicle will be the UK Energy Research Institute, which "brings together public and private funders of energy research to discuss strategic priorities and opportunities for collaboration, to provide leadership, and to enhance the coherence and impact of the total UK energy research and innovation activities". The Institute's remit is to accelerate the development of secure, reliable and cost-effective low-carbon energy technologies towards commercial deployment. It is anticipated that the Institute will play a major role in technology developments internationally in support of the UK's climate change goals. The Energy Research Partnership (co-chaired by the Chief Scientific Advisor), has committed itself to raising substantial sums of private investment for the Institute. EDF Energy, Shell, BP and E.ON UK have already announced their intention to be involved and the DTI has announced that it is prepared to provide £500 million, creating the potential for a £1 billion Institute over 10 years.

Conflicts between innovation policy and other policy domains:
At this level of interaction, it is more difficult to identify specific conflicts between policy instruments, not least due to the difficulty in recognising distinct policy instruments from areas outside of the innovation field. Clearly, and as highlighted in most UK Government statements on innovation and competitiveness, a stable macroeconomic climate is essential for many of the suite of micro-economic policy measures to function in an optimal manner. Thus, macroeconomic policies which destabilise the environment for R&D or those which create business uncertainty are very likely to have an adverse effect on the policy mix for R&D investment, particularly those which target the private sector.

OECD findings indicate the following broad impacts that other policy regimes may exert[70]:

- Macroeconomic volatility adversely effects innovation.
- Similarly, strict Product Market Regulation can have a negative effect on business R&D activity which is also detrimental to innovation.
- Strong (or rather, optimal) IPR regimes combined with liberal Product Market Regulation appears to be good for innovation.
- Strict Employment Protection Legislation can hinder the emergence and adoption of major and radical innovations, whilst favouring incremental innovation.
- Strong financial markets can support positive R&D investment decisions.
- Human capital investments can be correlated to increases in per capita GDP, although rates of return on tertiary education are already good in the OECD. Thus, private financing of tertiary education is advocated.

[70] "Economic Growth and Productivity", Address by Jean-Philippe Cotis, OECD Chief Economist at the Annual Conference, Government Economic Service, Nottingham UK, 13-14 July 2006

- Measures to raise the supply of S&T personnel may increase R&D but need to be spread out over time due to the inelasticity of supply. Likewise, they must be made at an appropriate level, and the supply of high level researchers should be balanced with supplies of skilled workers in industry.
- Higher public R&D investment boosts innovation both directly via patenting and through spill over effects on private R&D.
- Direct funding allows better targeting and provides better support to young firms, but returns small positive effects only when profits are low.
- Fiscal policies, such as R&D tax credits tend to be more effective than direct funding at boosting R&D and patenting.

Fiscal policies may also affect R&D tax credit schemes. For example if the general tax regime in a country is relatively benign, then R&D tax credits will need to be particularly generous in order to be attractive to potential R&D performers.

In the UK context, however, looking at the above set of generic examples, no obvious conflicts emerge.
Having said this, one particular specific example concerns the interaction of planning policy and research policy. This concerns the refusal, by the then Office of the Deputy Prime Minister, to allow the University of Cambridge to build an extension site for a new science park (which was focused on the priority area of biotechnology) due to planning restrictions based on broader environmental concerns. Whilst this is a specific case it illustrates how different policy domains may interact, although it requires the identification of a specific example to illustrate the type of interaction that may occur. In the absence of known examples, the determination of such interactions may be difficult or impossible.

7.3 Policy Orchestration

The issue of policy governance, the interaction and balance of innovation policy with the policy concerns of other ministerial and departmental actors and the Government's objective of pursuing a process of 'joined up government' are extensively dealt with in Section 3. A number of structures are in place to orchestrate policy formulation, implementation and evaluation activities across the innovation system as a whole, for example coordinatory bodies such as the Cabinet Committee on Science and Innovation and the system of lower level *ad hoc* and standing committees, whilst the designation of a lead body for innovation (the DTI, and the Innovation Group within OSI) offers a further means of orchestration. It is also noteworthy that important policy documents are often produced under joint authorship by more than one department or agency. The several innovation policy documents jointly produced by the DTI, HM Treasury and DfES, for example, bear witness to the coordinated approach to policy formulation.

The general development and evolution of the policy mix, which has taken place in the light of findings of a series of reviews, evaluations, consultations and other inputs to the policy making process suggests that policy makers take account of the perceived effects of the policy instruments upon the system of innovation rather than direct interactions between instruments. Thus any interactions are likely to be indirect (i.e. via their impact on the system/actors) rather than direct (i.e. resulting from the delivery contexts of other instruments).

Moreover, the modification and rationalisation of elements of the policy mix appear to have been implemented in response to the following outcomes:

- success of the instrument in adjusting the behaviour of the target actors (which might lead to its continuation, extension of scope or refinement)
- overlap with other instruments, i.e. similarity to other mechanisms in terms of objectives, targets, etc. (which might lead to the merging of complementary schemes or the simplification of bureaucratic or administrative requirements).

As some of the UK measures have been subject to reorganisation and rationalisation, it might be interesting to investigate the reasons behind this more deeply. However, those schemes that have been rationalised (for example, Grant for Research and Development and HEIF) have shared similar modalities and targets (SMEs and universities respectively). Thus, interaction between measures with dissimilar objectives, modalities and targets does not seem to have been examined. It is more likely that such rationalisation has been undertaken in the interests of bureaucratic and administrative simplification (both for the managing agencies and the recipients of these schemes).

7.4 Towards Lisbon

The main lessons that may be drawn from this review of the UK's innovation policies may be summarised as:

- The critical role played by coordinated approaches to policy formulation, with the presence of a clearly identifiable lead agency with responsibility for innovation concerns and with good coordination links to all other relevant policy actors.
- The setting of clear and realistic long-term targets and goals, together with the production of strategies which clearly communicate the Government's intentions to all actors in the innovation system.
- 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.

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Annex 1: Science Budget – 2005-2008

Table 1. Science Budget Allocations for 2004/05 to 2007/08.

(The amounts shown are the total allocations. The bracketed figures indicate capital element included in total allocation.)

£000's	04-05 allocation[2]	05-06 allocation	06-07 allocation	07-08 allocation	% age uplift in 2007/08 against 2004/05
Research Councils[3]	2,210,199 (166,630)	2,432,634 (164,085)	2,638,409 (179,327)	2,791,943 (155,067)	26% + 581,744
of which					
Arts and Humanities Research Council	67,746 (0)	80,536 (0)	91,379 (0)	97,092 (0)	43%
Biotechnology and Biological Sciences Research Council	287,571 (6,308)	336,186 (11,141)	371,644 (14,998)	381,829 (18,855)	33%
Council for the Central Laboratory of the Research Councils[4]	127,940 (19,262)	167,004 (19,853)	182,256 (30,105)	212,507 (40,356)	66%
Engineering and Physical Sciences Research Council	497,318 (6,457)	568,193 (13,229)	636,294 (13,248)	721,172 (13,268)	44%
Economic and Social Research Council	105,252 (1,780)	123,465 (3,250)	142,468 (3,250)	150,336 (3,250)	43%
Medical Research Council	455,279 (28,034)	478,787 (34,573)	503,461 (38,261)	546,514 (41,948)	20%
Natural Environment Research Council	314,256 (15,852)	334,047 (19,576)	359,367 (21,757)	367,248 (23,937)	18%
Particle Physics and Astronomy Research Council	274,037 (8,137)	293,916 (11,963)	306,540 (12,708)	315,245 (13,453)	15%
Diamond Synchrotron capital[5]	(80,800)	(50,500)	(45,000)	(0)	
Knowledge Transfer	78,960	91,440	103,500	108,500	37% + 29,540
of which					
Higher Education Innovation Fund	60,305	69,425	83,000	85,000	

2 Includes figures, for comparative purposes, for AHRB/BA which did not become the responsibility of the Science Budget until 1 April 2005

3 Figures from 06-07 include allocations made to enable Research Councils and Academies to pay a greater proportion of the Full Economic Cost of projects they support.

4 Excludes capital funding for Diamond synchrotron, which is shown separately below.

5 The Diamond synchrotron, announced in 2000, will be completed in 2006-07

Table 1. (continued)

Public Sector Research Establishment and other Knowledge Transfer initiatives	18,655	22,015	13,000	16,000	
RC Knowledge Transfer Fund	0	0	7,500	7,500	
Regional Development Agency and RC Capacity Building[6]	0	0	2,000	3,000	
Sustainability	**296,570**	**419,560**	**300,000**	**300,000**	
of which					
Science Research Investment Fund	296,570	300,000	300,000	300,000	
Full Economic Cost[7]	0	119,560	-	-	
Large Facilities	**53,628 (48,628)**	**45,406 (40,406)**	**60,414 (55,164)**	**104,681 (99,423)**	**95% + 51,053**
Academies[8]	**50,245**	**52,420**	**62,329**	**72,209**	**44% + 21,964**
of which					
Royal Society	31,045	32,520	36,359	41,072	32%
Royal Academy of Engineering	5,600	5,850	7,885	9,752	74%
British Academy	13,600	14,050	18,085	21,385	57%
Science and Society[9]	**7,175[10]**	**7,665[11]**	**9,975**	**11,395**	**59% + 4,220**
International Collaboration	**–**	**–**	**3,000**	**3,000**	
Restructuring and contingency	**37,700**	**38,011**	**56,957**	**60,014**	
Total	**2,734,477 (215,258)**	**3,087,136 (204,491)**	**3,234,584 (234,741)**	**3,451,742 (254,748)**	**26% + 717,265**

6 Regional Development Agency and RC Capacity Building funds are included in EPSRC's allocation

7 Sustainability funding of 120/200M in 06-07 and 07-08 folded into individual Research Council and Academies figures. Distribution of £120M to HEI's in 05-06 will be handled centrally by ESRC

8 Includes figures, for comparative purposes, for AHRB/BA which did not become the responsibility of the Science Budget until 1 April 2005

9 Science and Society includes work on public engagement, diversity in the science workforce and promoting science in schools (SETNET)

10 Includes £2.925m DTI funding for SETNET

11 Includes £2.925m DTI funding for SETNET

Source: DTI, Science Budget Allocations 2005-06 to 2007-08, May 2005

Annex 2: Overview of UK system of innovation (Source: Adapted from, *GOST*, *British Council 2005*).