

# **Innovation Nation**

**Background analysis: strengths  
and weaknesses of the UK  
innovation system**

## INTRODUCTION AND OVERVIEW

Innovation is important for national productivity and economic growth. Comparative studies of productivity growth typically explain at least some of the productivity gap between the UK and the US (the productivity leader in recent years) as being due to lower levels of investment in, or returns from, investment in R&D<sup>1</sup>. New analysis supports this view by providing evidence for a number of countries of a positive relationship between different strategies of business innovation, including R&D but also non-technologically based modes, and turnover per employee<sup>2</sup>. Innovation can also be a source of social, environmental and cultural benefits although evidence here tends to be qualitative rather than expressed in economic values<sup>3</sup>.

This document presents an assessment of the UK innovation system to support the DIUS Science and Innovation White Paper.

The analytical material is structured as an analysis of UK strengths and weaknesses. This can be – and was intended to be - a powerful tool in stimulating discussion. However it comes with some risk of simplification. Hence the following points need to be remembered in interpreting the material in this paper:

Designation of UK strengths and weaknesses are judgements even if shaped by robust evidence as far as possible. Where possible, comparisons are made between the UK and other countries or of trends over time. However, where these data exist they will not always lead to a definitive conclusion. Furthermore, while this distinction can be useful for strategy development, the underlying behaviour and the systemic patterns in the data are always more complex.

Some of the judgements are better supported by evidence (and in particular data) than others. In particular, there is little systematic data on innovation in the public sector and there are major gaps in understanding of the roles of users, consumers and other social actors in the innovation process. These gaps are discussed further in a concluding section. Some of the strategy's proposals are intended to address these gaps although the collection of adequate data will be a medium to long term endeavour<sup>4</sup>.

There is no automatic connection between areas of potential strength (or weakness) and policy actions. Some innovation policies aim to build on areas of strength to maximize economic and social returns; others will aim to address areas of weakness. In either case, decisions on investment of scarce public resources or other forms of policy intervention need to be based upon a coherent rationale and an assessment of expected costs and benefits.

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<sup>1</sup> OECD, "From R&D to productivity growth: do the institutional settings and the source of funds for R&D matter?" *Oxford Bulletin of Economics and Statistics*, 2004, 66(3).

<sup>2</sup> R Lambert and M Frenz, "Innovation Modes and Productivity in the UK", DIUS, 2008. Note, however, that innovation does not always increase (labour) productivity: a recent report highlights the retail sector where a business model innovation, the opening of small convenience stores by supermarket chains, reduces average productivity even though it is highly profitable and popular with customers (R Griffiths, "Technology, Productivity and Public Policy", *Fiscal Studies*, Vol. 28, No. 3, pp 273-291, 2007).

<sup>3</sup> DIUS, "Economic Impacts of Investment in Research and Innovation", July 2007, URN 07/1146.

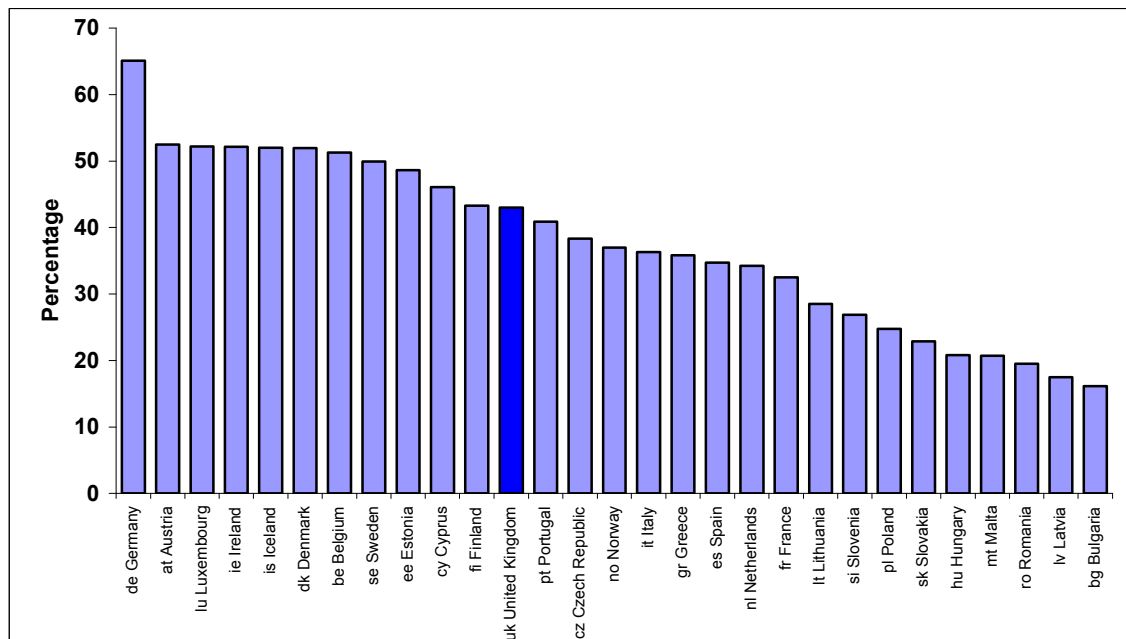
<sup>4</sup> The Science and Innovation White Paper proposals include an innovation research centre and an innovation index.

## Innovation performance is not easy to measure at a firm or whole economy level.

The most long-standing business innovation indicators are R&D expenditure and patenting, where on normalized measures the UK trails most G7 economies. The Government has set a challenging ambition for public and private sector R&D spending to reach 2.5 per cent of UK GDP by 2014. At the same time, however, it is becoming increasingly clear that traditional measures such as R&D have to be complemented by a broader range of innovation metrics in order to fully capture the UK's innovation performance. While technology generation and related IP protection are still very important for certain sectors, they have less meaning for large parts of the economy based upon services. Nor do they capture well innovations through changes to business models, marketing or organization.

Survey based measures of private sector innovation show the overall rate of business innovation in the UK to be at the European average (Figure 1).

**Figure 1: Comparable rates of innovation activity in EU member states**



Source: Community Innovation Survey 2005, based upon activity in the period 2002-04.

These survey data reflect a broad view of innovation, encompassing all product, service and process development. In addition, in line with the Oslo Manual<sup>5</sup>, the UK collects limited data on marketing, organizational and business model innovation.

The latest European Innovation Scoreboard goes a step further in producing a composite index of innovation used to rank all EU Member States<sup>6</sup>. On this measure the UK continues to be designated an EU “Innovation Leader” with one of the highest scores. Composite indices of this kind are contentious and there are powerful arguments against placing much reliance on them as a tool for tracking the impact of innovation policies<sup>7</sup>.

None of these data cover innovation in the public sector or those parts of the private sector most frequently providing services to the public sector or in competition with it (e.g. education and health). Nor do existing definitions and surveys capture satisfactorily user-led innovation where there are limited market transactions or firm creation.

Table 1 below presents a summary version of the analysis. The evidence on which these statements are based is set out in the remaining sections of this document.

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<sup>5</sup> The Oslo Manual is the OECD document that sets out an agreed and consistent set of guidance and recommendations for the conduct of innovation surveys. Its recommendations form the basis of the European-wide Community Innovation Survey (CIS), of which the UK Innovation Survey is the UK contribution. The latest published version of the Oslo Manual can be found at <http://www.oecd.org/dataoecd/35/61/2367580.pdf>

<sup>6</sup> “European Innovation Scoreboard, 2007: Comparative Analysis of Innovation Performance”, report by UNU-MERIT to European Commission, 2008.

<sup>7</sup> One problem with single number indices is that a decision has to be made on how to weight different variables; there is typically no obvious solution and this means that any aggregate score is to an extent arbitrary and can be increased or decreased by changing the weights. A second issue is that it can often be difficult to estimate why a composite indicator has moved in a particular direction.

**Table 1: Summary of UK strengths and weaknesses**

<b>Strengths</b>	<b>Weaknesses</b>
Research base	
Substantial public investment in high quality UK research base	Business investment in R&D (but possibly due to sector mix)
Increased exploitation of publicly funded research although limited technology diffusion from the research base	
Business innovation	
Some successful high tech sectors and a sizeable population of high tech SMEs	Significant minority of non-innovating businesses
Strong non technology based innovation in high value added sectors	Rate of business start-up and SME growth still lag behind US
One of world's leading financial and business services centres	Variability in innovation performance and capability across the UK
An open economy	
Effective framework conditions for innovation	
Innovation in public services	
Some world leading examples of new delivery of services and policy making	Incentives often work against innovation
Builds on strong culture of public management and efficiency	Insufficient skills to innovate successfully
	Weaknesses in spreading good practice
Innovative people	
Excellent universities with rising participation	Low business demand for skills in some parts of the economy
Strengthened public engagement	Overall skill levels of the UK population lag behind international leaders
	Increasing overall supply of STEM skills but concerns over numbers coming through in some disciplines
	Management skills and practices
Areas where further information is needed to assess UK performance	
Demand for innovation	
Barriers to user-led innovation	

## **RESEARCH BASE**

Investment in public and private research has historically been at the core of technology-based innovation policies. This reflects the public good characteristics of fundamental scientific research and the spillover externalities generally accepted to be generated from R&D even when performed in the private sector.

The UK's research base generates a broad and diffuse set of economic impacts that go much wider than the transmission and development of knowledge in technologically-intensive sectors of the economy or technology-based modes of innovation. As well as its contribution through the stock of codified knowledge, the research base has impact through its role in the supply of skilled people to all sectors of the economy as well as through new business start-ups, metrology, networks etc.<sup>8</sup>

### **UK Strengths**

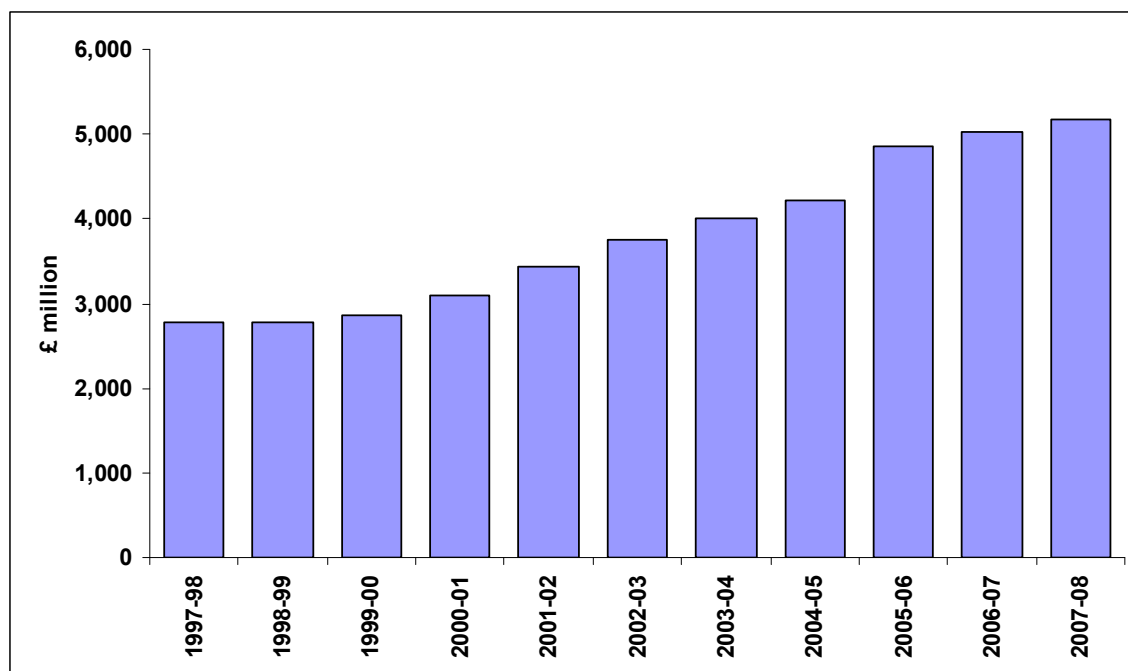
#### **Substantial investment in high quality research base**

Public investment in research through the Science Budget has increased substantially since 2000 and is set to increase in real terms in the period to 2010/11 (Figure 2).

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<sup>8</sup> B Martin and P Tang, "The Benefits from Publically Funded Research", 2006. For specific examples of research-based knowledge leading to innovation, see the DIUS report "Economic Impacts of Investment in Research and Innovation", *op cit*.

**Figure 2: Growth in real terms of the Public Spending on Science**



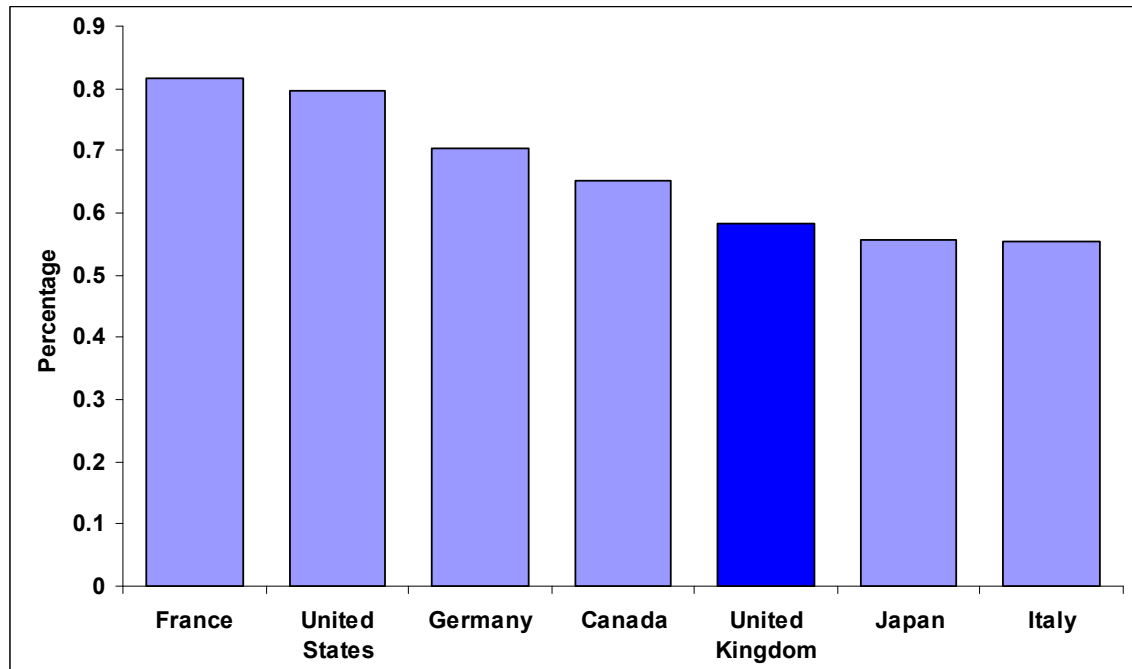
Note: Public spending on science comprises funding for research delivered through the Research Councils (UK) and QR funding for Higher Education Institutions in England distributed through HEFCE.

Source: DIUS. <http://www.berr.gov.uk/dius/science/science-funding/set-stats/index.html>

The growth in resources has meant that the funding of research within Higher Education has been placed on a more sustainable footing, including Research Councils now meeting 80 per cent of Full Economic Cost and investment in the capital infrastructure for research. The investment backlog in university research infrastructure is on course to be reduced to a manageable level, marking a major milestone in returning the research base to a sustainable condition.

International comparisons of public support for research are to an extent affected by the choices that different countries make about the institutional basis of research funding within their systems. Data are collected on Government funded R&D. This is a broader quantum of R&D expenditure; it will include research funded by all arms of Government as well as research performed in businesses but funded by government. The latest data show that, as a share of GDP, UK investment is broadly in line with other leading OECD economies (Figure 3). Over the period 1997-2005, there has been a slight increase in this ratio in the UK; over the same period the ratio has increased in Canada, Italy and Japan and fallen in the US, France and Germany.

**Figure 3: Government funded R&D expenditure as a share of GDP, 2005**



Source: OECD Main Science and Technology Indicators, 2007-2

The UK research base scores well on bibliometric-based measures of research quality. Scientific papers and citations are only one channel of economic impact but they provide an indication of scientific significance as judged by other researchers. The UK remains one of the leading producers of scientific papers – third in the world behind the US and China. It performs even better on more stringent measures of research impact such as citations in leading peer-reviewed journals per publication, where overall the UK lies second to the US. Another feature of UK research is its international nature with high rates of joint authorship across countries. The UK's share of internationally co-authored papers has increased more rapidly relative to domestic volume than for other G7 countries over the last five years<sup>9</sup>.

There is some variation across different scientific disciplines with, for example, the UK lying fifth in engineering behind the US, Japan, Germany and China<sup>10</sup>.

### **Increased exploitation of publicly funded research although limited technology diffusion from the research base**

The last decade has seen the introduction across the UK of funding streams specifically designed to encourage HEIs and PSREs to engage with businesses and community interests. In England this now takes place primarily through the Higher Education

<sup>9</sup> Evidence Ltd for the Office of Science and Innovation, DTI, "Patterns of international collaboration for the UK and leading partners," June 2007.

<sup>10</sup> Evidence Ltd for the Office of Science and Innovation, DTI, "PSA target metrics for the UK Research Base," March 2007.

Innovation Fund (HEIF)<sup>11</sup>. These funds have enabled HEIs and PSREs to build internal capability and provide visible incentives for institutions and the people working in them.

Systematic information on various forms of HEI-business interaction show an upwards trend for most indicators (Table 2).

**Table 2: Trends in selected indicators of HEI-business interaction, UK**

Indicator	2000/2001	2002/03	2005/06
Income from business (contract research and consultancy) (£ million)	362	457	536
Number of spin-outs	248	197	187
Number of graduate start-ups	516	974	1172
Number of patents granted	250	377	577
Licensing income (£ million)	18	37	58

Source: Higher Education-Business and Community Interaction Surveys.

There are insufficient data to judge whether there is a similar trend in business engagement among PSREs<sup>12</sup>.

It is very difficult to judge how effective UK HEIs are in engaging business relative to HEIs elsewhere in the world because of limited data<sup>13</sup>. Few UK institutions appear to match the depth and breadth of engagement seen in the leading US institutions; however, there is not a homogeneous pattern across the very large number of HEIs in the US<sup>14</sup>.

To put these research base activities in context, data from the UK Innovation Survey<sup>15</sup> show that businesses most often use other businesses – customers, suppliers, collaborators and competitors – as information sources for their innovation activities

<sup>11</sup> Similar arrangements have been introduced by the funding bodies for the Devolved Administrations. Predecessors of HEIF included HEROBAC, SEC and UC. In England Regional Development Agencies may also fund similar activities (not separately identified).

<sup>12</sup> A similar survey has been carried out for PSREs but only three years' data are available and comparisons are more difficult given the differences across surveys in coverage and response. For further details see pages 48-49 of DIUS, "Economic impacts of investment in research and innovation," July 2007.

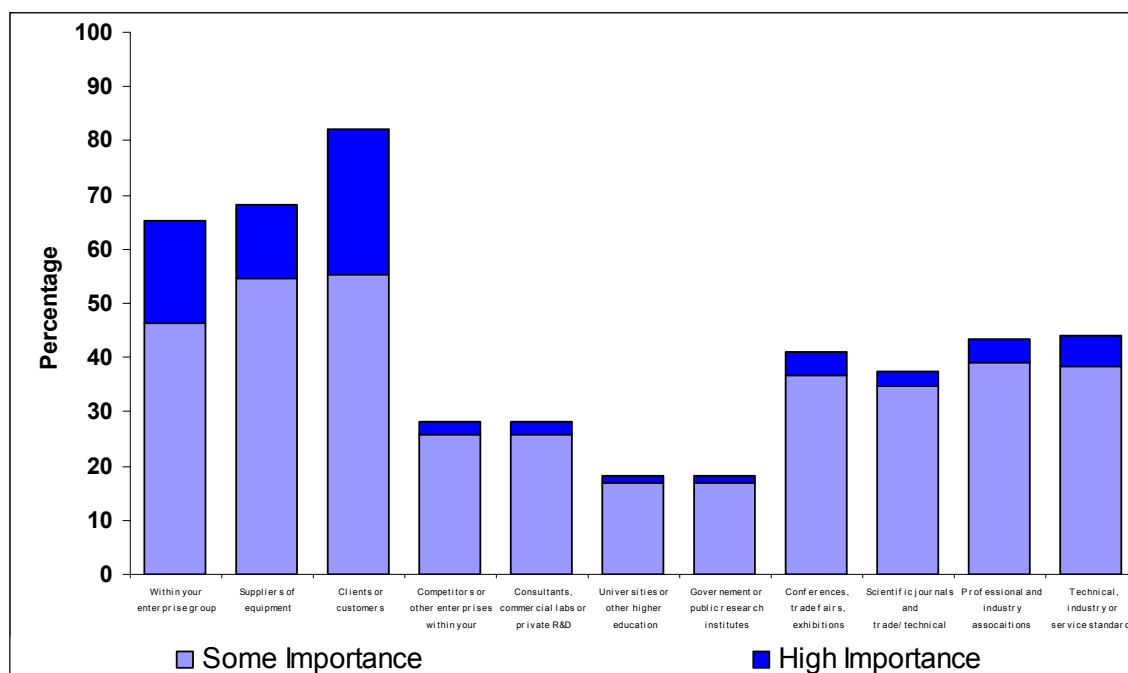
<sup>13</sup> For example, data from North America tend to be focused on traditional technology transfer and commercialisation activities (patents, licenses, etc.), see D Bostrom and R Tieckelmann (eds), "AUTM Licensing Survey. FY 2005 Summary", AUTM, 2007.

<sup>14</sup> A Cosh et al, "International Innovation Benchmarking Study", 2006. <http://www.cambridge-mit.org/project/home/default.aspx?objid=1446>

<sup>15</sup> This paper includes some early results from the 2007 UK Innovation Survey. An article is scheduled for the April edition of the Economic and Labour Market Review, providing an account of the main findings.

(Figure 4). HEIs and government research institutes etc. were each mentioned by just over a fifth of businesses.

**Figure 4: Information sources regarded as important by innovating businesses**



Source: UK Innovation Survey 2007.

However, the proportion of businesses stating that universities or HEIs were of high importance as an information source was just 1 per cent in 2007 (whereas 27 per cent of businesses rated clients or customers of high importance). Comparable data from other European countries for 2005 show a similar pattern: a relatively small proportion of businesses have very high levels of knowledge exchange with HEIs, research institutes and other similar providers of scientific expertise<sup>16</sup>.

These findings do not necessarily point to a failing in the innovation system. The proportion of businesses requiring access to leading edge scientific knowledge may be limited at any point in time<sup>17</sup>. Furthermore, these data measure the direct transmission of knowledge and underestimate the total contribution of research-based knowledge to business innovation. This is because of additional indirect flows through publications, the operation of consultancies, codified standards and the movement of people<sup>18</sup>.

<sup>16</sup> See “Economic Impacts of Investment in Research and Innovation”, *op cit*, page 47. The UK data show no significant changes in patterns of inter-action between the 2005 and 2007 surveys.

<sup>17</sup> Data from the UK Innovation Survey suggests that novel innovators are more likely to regard the research base as a useful source of information.

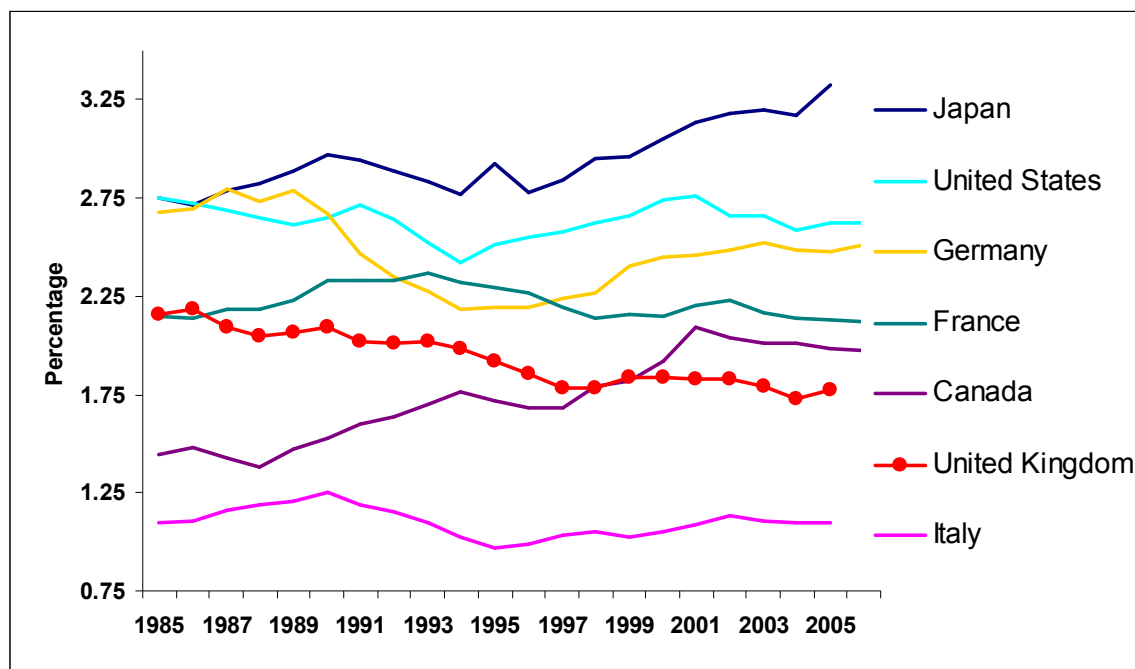
<sup>18</sup> For example, 6 per cent of businesses in 2007 rated technical, industry or service standards of high importance as an information source. These standards may often incorporate research-based knowledge. For a more general treatment see the Chapter by Peter Swann in DTI Economics Occasional Paper No. 6, 2006, *op cit*.

## UK weaknesses

### Business investment in R&D (but possibly due to sector mix)

The latest OECD data show that total R&D expenditure as a share of GDP in the UK is sixth in the G7 and close to the OECD average (Figure 5). Furthermore there has been no increase over the past decade. To contribute to narrowing this gap, Government set, in the Ten Year Framework, an ambition for the UK's share of R&D in GDP to reach 2.5% by 2014<sup>19</sup>.

**Figure 5: International comparisons of R&D expenditure**

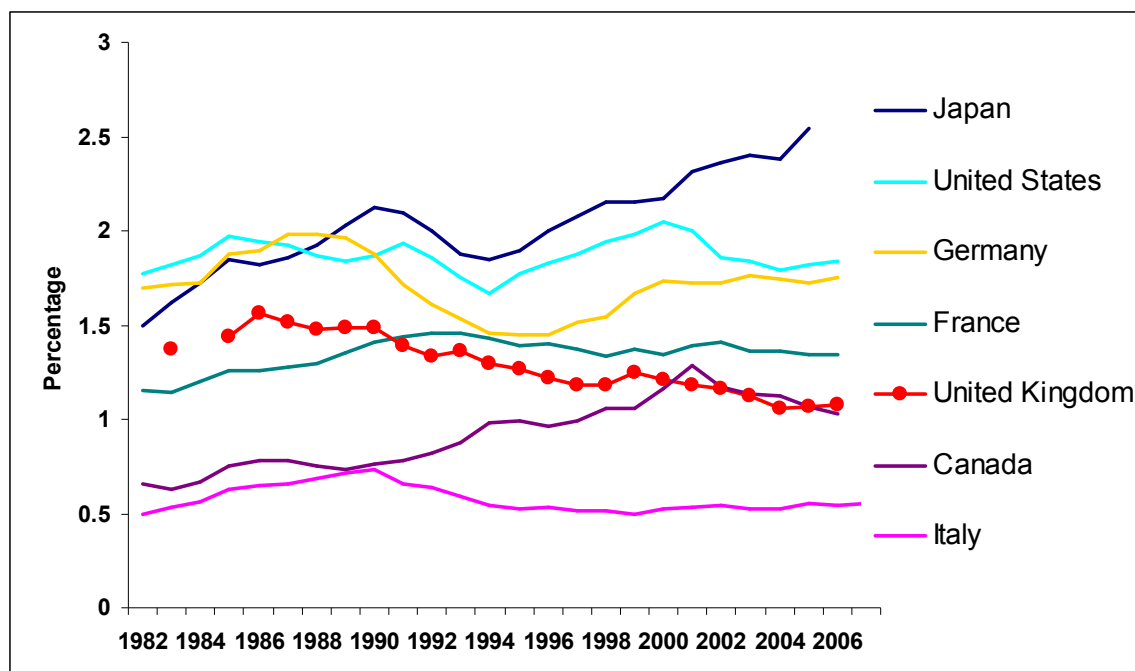


Source: OECD.

The R&D gap is primarily due to a lower share of GDP spent on R&D performed by businesses in the UK (Figure 6).

<sup>19</sup> H M Treasury, "Science and Innovation Investment Framework, 2004-2014" [http://www.hm-treasury.gov.uk/spending\\_review/spend\\_sr04/associated\\_documents/spending\\_sr04\\_science.cfm](http://www.hm-treasury.gov.uk/spending_review/spend_sr04/associated_documents/spending_sr04_science.cfm)

**Figure 6: International comparisons of business R&D expenditure**



Source: OECD.

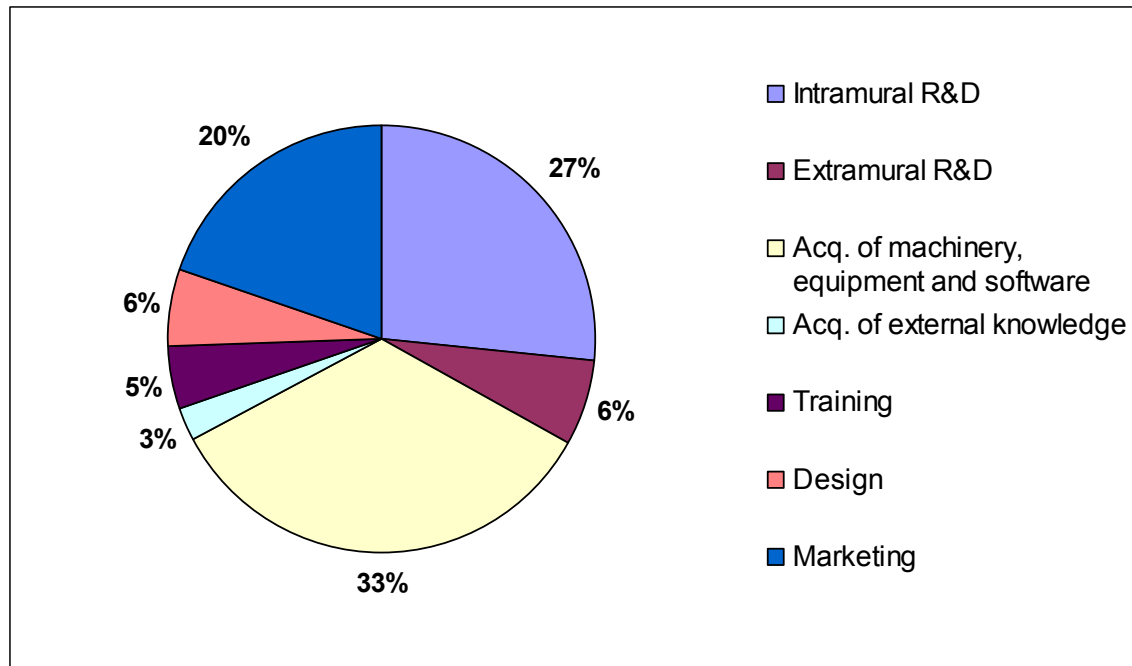
However a number of analyses in recent years have suggested that at least part of the gap between the UK and other European countries may not be due to under-investment in R&D on the part of UK companies; the sector mix of the economy plays an important role in explaining these patterns<sup>20</sup>. The latest data continue to support this interpretation<sup>21</sup>. Business R&D in the UK is low as a share of total output because R&D intensive industries account for a smaller share of UK output than they do in some other leading economies. Data from company accounts show that UK companies in R&D intensive sectors invest at a comparable level to their competitors.

This analysis demonstrates the need to supplement simple whole economy indicators with a more detailed understanding of disaggregated trends. More fundamentally, while R&D is an important input to technology-based innovation in some sectors, it is not the only or indeed dominant category of business investment in innovation. According to the 2007 UKIS, UK businesses spend about £40 billion a year on innovation; of this only a third is R&D. Investment in machinery, computer hardware and software – largely reflecting the take-up of technology - accounts for a similar proportion and marketing related expenditure represents a fifth of all innovation expenditure (Figure 7).

<sup>20</sup> See DTI Economics Paper No. 11 “R&D Intensive Businesses in the  
[“HTTP://WWW.BERR.GOV.UK/FILES/FILE9656.PDF](http://www.berr.gov.uk/files/file9656.pdf); Report by Lord Sainsbury of Turville, “The Race to the Top”, Chapter 2, [http://www.hm-treasury.gov.uk/media/5/E/sainsbury\\_review051007.pdf](http://www.hm-treasury.gov.uk/media/5/E/sainsbury_review051007.pdf); A Mathieu and B van Pottelsberghe, “A Note on the Drivers of R&D Intensity”, CEPR Discussion Paper No. 6684, 2008..

<sup>21</sup> S. Bulli, “Business Innovation Investment in the UK”, DIUS, 2008

**Figure 7: Business expenditure on innovation**



Note: Businesses with 10+ employees.  
Source: UK Innovation Survey 2007.

There are substantial differences in the composition of innovation expenditure across different business sectors. R&D accounts for about a tenth of innovation expenditure in the primary sector, construction, retail and other services. However, it accounts for over half of total expenditure in engineering-based manufacturing and two fifths in knowledge intensive services. In contrast, nearly half of all retail sector expenditure on innovation goes on marketing.

These expenditure patterns also differ considerably across countries. While about a third of innovation expenditure by business over the period 2002-04 in the UK and Italy was spent on R&D, the proportion in France and Norway was about four fifths. Across the EU as a whole, over this period, 54 per cent of innovating firms engaged in R&D<sup>22</sup>. The proportion, however, varied from 92 per cent in Denmark to 9 per cent in Bulgaria with the UK having a slightly higher than average share of non-R&D innovators (54 per cent). Again sector mix may be a significant explanation for these patterns, although differences in questionnaire design, definitions and quality of response may also have an impact.

## **INNOVATION IN THE PRIVATE SECTOR**

Business innovation entails a wide range of activities. Most familiar are new market offerings – products or services – but innovation can also include the introduction of new

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<sup>22</sup> “European Innovation Scoreboard 2007”, *op cit*.

processes, business models or changes to managerial or marketing activities. Surveys of business leaders suggest it is regarded as an increasingly important long-term driver of business success<sup>23</sup>. Equally the desire to innovate often lies behind the creation of new business start-ups<sup>24</sup>.

The 2007 UK Innovation Survey reports that, on a comparable basis, 68 per cent of UK businesses were innovation active, a similar proportion to the 2005 survey (63 per cent) and much higher than in 2001 (49 per cent)<sup>25</sup>. The largest enterprises, those with 250 or more employees, were more likely to be innovation active (76 per cent).

These data capture business perceptions of their activities based upon questionnaires that include a definition of innovation. This does not imply that businesses use these definitions or measures in their internal management of innovation. Only R&D expenditure is captured systematically in company accounts. Measures of value added can also be constructed from company accounts but changes in value added arise from factors other than innovation.

Individual companies use many different measures of innovation: one study found no less than 241 in use across a small number of companies<sup>26</sup>. Business surveys suggest that the metrics used by companies track inputs and outcomes as well as activities although one survey found that 60 per cent of companies used five or fewer metrics to track innovation<sup>27</sup>.

A review of the literature and qualitative findings from recent studies of a number of business sectors<sup>28</sup> suggest some common patterns:

- Most businesses do not systematically measure or manage innovation as defined in the Oslo Manual.
- Businesses often use broader performance measures; tight management of these acts as an incentive to innovate.
- Some of these measures are generic (such as revenue per employee) whereas others are very sector specific<sup>29</sup>.

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<sup>23</sup> IBM "Expanding the Innovation Horizon: the Global CEO Study 2006". <http://www-935.ibm.com/services/uk/bcs/pdf/g510-6259-01-the-global-ceo-study-2006.pdf>.

<sup>24</sup> Small Business Service, "Annual SME survey."

<sup>25</sup> Innovation activity includes business that introduced new products, services or processes in the three year reference period (2004-06 for the 2007 survey). It also includes businesses that had on-going innovation activities (e.g. R&D or horizon scanning), businesses that had abandoned attempts to innovate, and businesses that had invested in innovation. The proportion reported here is significantly higher than the UK figure presented in Figure 1. This is because the data in Figure 1 collated by Eurostat have to use a more restricted definition of innovation activity that, in particular, excludes innovation activities that did not result in a tangible innovation during the three year reference period.

<sup>26</sup> T. Mcroft, Innovation Measurement Project Report, Internal Paper, DTI, 2007

<sup>27</sup> Boston Consulting Group Innovation Survey 2007  
[http://www.bcg.com/publications/files/Innovation\\_Aug\\_2007.pdf](http://www.bcg.com/publications/files/Innovation_Aug_2007.pdf)

<sup>28</sup> Sources: A Ghani, "How do Businesses Measure Innovation?", BERR unpublished literature review; NESTA "Hidden Innovation" report 2007.

<sup>29</sup> For example, in the retail sector, sales or profit per square foot of floor space is used as a key performance indicator whereas this would make little sense in many other industries.

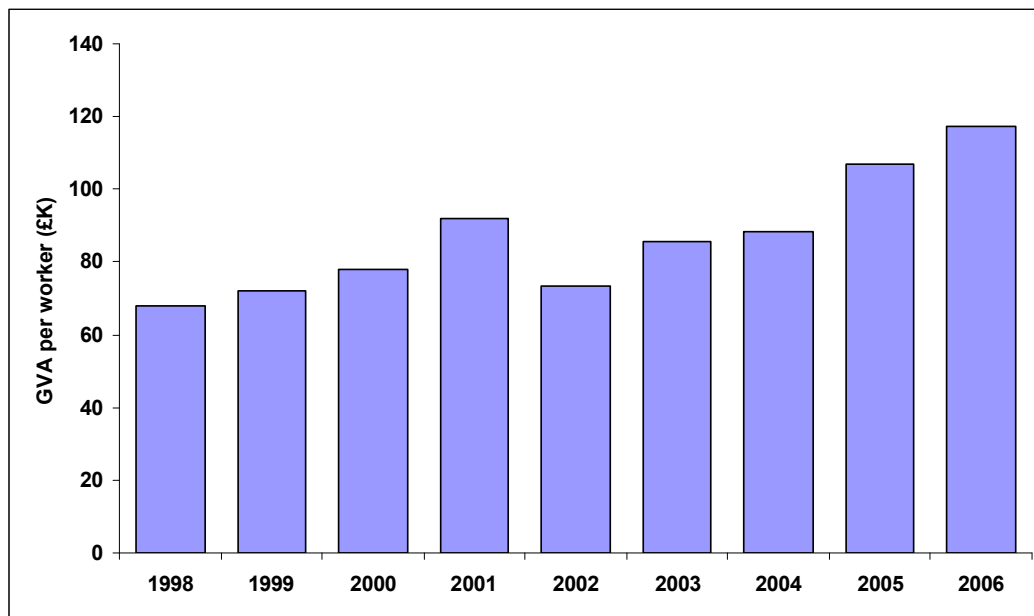
## UK Strengths

### Some successful high tech sectors and a sizeable population of high tech SMEs

A number of technology and R&D intensive business sectors continue to show strong levels of performance in internationally traded markets, principally pharmaceuticals and aerospace<sup>30</sup>.

BERR estimate that the pharmaceutical sector is running a significant positive balance of payments – exports of £12 billion in 2005 and a net trade balance of £3.4 billion – and is generating high value added employment (see Figure 8). Of the 73,000 people employed in the industry in 2003, 27,000 were employed in R&D. Two of the largest companies in the world – AstraZeneca and GSK – are UK head quartered and the UK benefits from the R&D and production presence of a number of other global leaders. Pharmaceutical companies spent £3.3 billion on R&D in the UK in 2005, accounting for 9 per cent of global R&D expenditure<sup>31</sup>.

**Figure 8: GVA per worker (£k) Pharmaceuticals SIC 24.4**



Source: DIUS calculations on ONS ABI data

One reason for this relative concentration of R&D activity in the UK is the strength in relevant scientific research (biology and the pre-clinical and clinical medicine fields).

<sup>30</sup> Source: BERR unpublished analysis based on revealed comparative advantage measure.

<sup>31</sup> Source: PICTF Indicators, 2005.

The UK aerospace industry currently comprises 13 per cent of turnover in the world aerospace market, second only to the US<sup>32</sup>. Like pharmaceuticals, aerospace is R&D intensive (accounting for 11 per cent of all manufacturing R&D) and has high GVA per employee due to high capital intensity and a relatively highly qualified skills base (one third of all employees in the sector are graduates).

It is not possible to estimate with precision the number of high tech SMEs in the UK. Nevertheless the R&D Scoreboard shows that relatively small firms are investing in R&D and over 4,800 small firms claimed the small firms R&D Tax Credit in 2005/6.

## **Strong non technology based innovation in high value added sectors**

The UK economy also shows considerable strength in a number of large business sectors where R&D is less significant or critical to the innovation process. In these sectors, a broader mixture of investments may be required, for example, in building and maintaining brands, in software development, or in the adaptation and exploitation of ICT developed elsewhere in the economy.

The UK has built up a substantial and increasing trade surplus in knowledge-based services. For example, the UK is the global market leader in financial services exports (24 per cent of world exports) and computer services (14 per cent of world exports)<sup>33</sup>. Knowledge based services also have a relatively high rate of innovation activity even though most businesses covered by this category are not R&D intensive<sup>34</sup>.

Recent years have seen significant productivity improvements in computer and R&D related services (Figure 9).

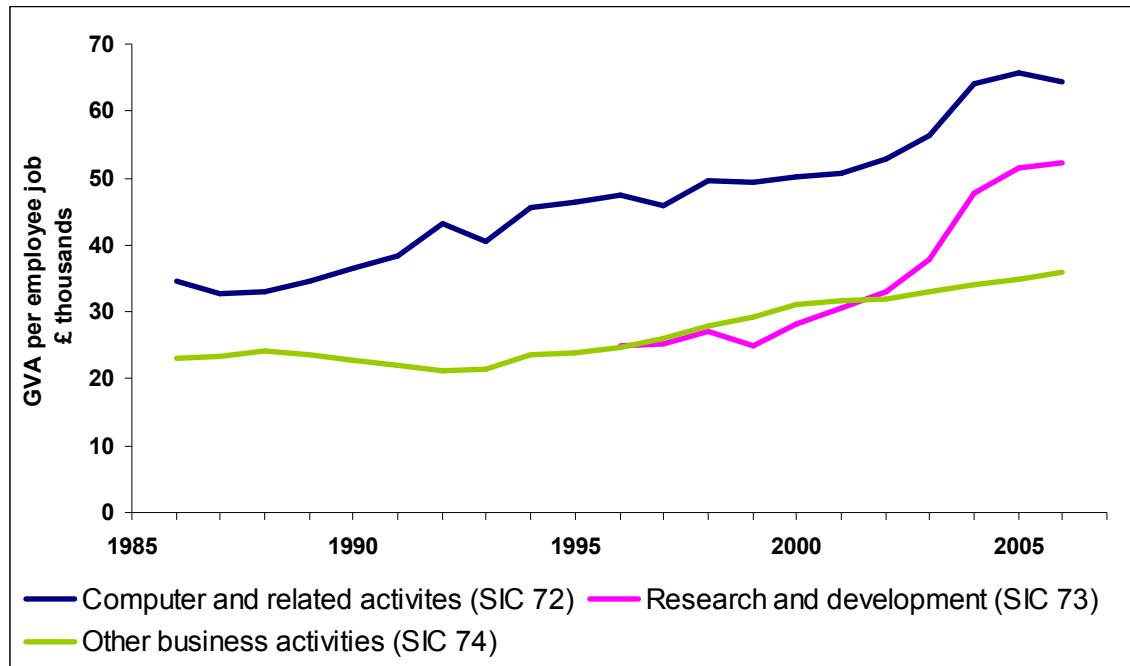
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<sup>32</sup> Source: Flight International.

<sup>33</sup> BERR, "Globalisation and the Changing UK Economy", 2008.

<sup>34</sup> This category in the UK Innovation Survey includes computer software and R&D services. However, it also incorporates a much broader range of financial and business advisory services where formal R&D is less prevalent. Nevertheless the overall rate of innovation in financial services in 2005 (74 per cent) was the same as for manufacturing. Other categories of expenditure such as design or software are often more relevant than R&D.

**Figure 9: Productivity in Business Services (SIC 72, 73, 74), 1986-2005**



Source: GVA constant price output indices and employee jobs series, ONS

The Value Added Scoreboard suggests the UK also has concentrations of successful companies in the energy sector. This is also an area where formal R&D is low but where both business model and technology based innovations have been evident<sup>35</sup>.

Although their outputs are in some cases less widely traded, and international comparisons are difficult because of definitional and data restrictions, the UK has been cited as having possibly the world's largest creative industries sector<sup>36</sup>. DCMS estimates suggest it has also been growing more quickly than the economy as a whole. While these industries are increasingly significant in their own right, people in creative occupations such as design, architecture and advertising are much more widely spread across the economy<sup>37</sup>.

The effect of the UK's sector structure can be seen in businesses' use of formal methods of intellectual property protection. Measures of patent applications per head of population show the UK lagging behind its major competitors and are consistent with R&D data. However, data on EU applications for trademarks and registered designs show the UK in a more favourable light<sup>38</sup>. Data on the use of copyright are not available

<sup>35</sup> The move by some energy companies towards a service based model can be seen as an example of business model innovation. The NESTA "Hidden innovation" report highlights the role that adaptation of research and technologies has played in oil exploration.

<sup>36</sup> Work Foundation, "Staying Ahead: The Economic Performance of the UK's Creative Industries", July 2007.

<sup>37</sup> P Higgs, S Cunningham and H Bakhshi, "Beyond the Creative Industries: Mapping the Creative Economy in the United Kingdom", NESTA Technical Report, 2008.

<sup>38</sup> "Economic Impacts of Investment in Research and Innovation", *op cit.*

because there is no administrative process required to obtain this protection. Trademarks, designs and copyright are of course the types of formal IP protection that are seen as most important by the UK service sector<sup>39</sup>.

## **One of the world's leading financial and business services centres**

The strength of the financial services sector in the UK is of course connected with London being one of the world's two leading financial centres (alongside New York)<sup>40</sup>.

UK businesses therefore have proximity to a large financial market. The venture capital sector, for example, may not match the size and depth of the US but is by far the largest in Europe<sup>41</sup>. A recent report has ranked the UK third best in the world for financing business needs<sup>42</sup>.

The concentration of world class businesses stretches wider than the financial services sector. Four of the world's top ten law firms are based in the UK. The UK also possess large accountancy firms with the capacity to provide cross-border and international services. UK expertise and strength in supporting areas like advertising and design means that the UK has a concentration of the capabilities that global businesses need for success and growth.

Nevertheless, while the general financing situation for existing businesses is good, there is evidence that difficulties remain for a minority of viable businesses. For businesses with very high growth potential, access to modest amounts of equity of between £250,000 and £2 million might be problematical because of a tendency to increased deal size. Difficulties in raising finance, however, might not arise simply because of barriers in the market place. Some smaller businesses might lack the skills and knowledge to develop and present attractive propositions to investors.

## **An open economy**

Value chains and innovation systems are becoming increasingly international. The UK is relatively open for an economy of its size and stage of development.

One indicator of its attractiveness as a business location is the relatively high flow of foreign direct investment. The UK has the largest FDI inflow of any OECD economy<sup>43</sup>. This pattern is accentuated in technology-based markets and for knowledge flows. The UK has by far the highest proportion among the G7 of its business R&D funded from overseas<sup>44</sup>. Although the data are not so systematic, they also suggest that UK-based

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<sup>39</sup> Tether and Massini, in "Innovation in Services", DTI Economics Occasional paper No. 9, 2007.

<sup>40</sup> Source: "The Global Financial Centres Index 2007", City of London and Z/Yen Group Ltd.

<sup>41</sup> Eurostat estimates of early stage venture capital as a percentage of GDP excluding management buy outs etc. reported in the European Innovation Scoreboard, 2007. Compared to an average estimate of 0.05 per cent of GDP for the EU as a whole, the relevant UK estimate was 0.22 per cent of GDP.

<sup>42</sup> Milken Institute: Capital Access Index, 2006.

<sup>43</sup> BERR, "Globalisation and the Changing UK Economy", 2008.

<sup>44</sup> S.Bulli, 2008. op cit.

companies are prominent investors in R&D overseas. UK firms patenting pharmaceuticals and chemicals were more likely to be exploiting inventions developed overseas than similar firms in France or the US<sup>45</sup>

## Effective framework conditions for innovation

Businesses that choose to protect intellectual property using formal means need access to a regulatory system that is effective in striking a balance between the interests of the generators of knowledge and those who benefit from its diffusion. The UK-IPO attracts high levels of satisfaction from those using its services with 97.9% of respondents to a recent customer survey stating that overall they are satisfied with the performance of the Office<sup>46</sup>. Compared to some other similar institutions, lags in the patenting process are relatively low, with 93% of search reports being issued within 5 months of request in 2007<sup>47</sup>. This compares very favourably to other regimes such as the EPO, which issued only 50% of search reports within 6.6 months in 2006<sup>48</sup>. Comparison may also be favourably drawn with the US PTO, where the average time to first action by examiner was 25.3 months for the fiscal year 2007<sup>49</sup>. It should be noted however that this last figure is not a direct equivalent due to the procedural differences between the US and European systems.

Standards have been shown to be a powerful vehicle for the transmission of business knowledge and innovative practices and there is a strong statistical association with productivity growth<sup>50</sup>. Similarly the outputs of the UK National Measurement System<sup>51</sup> have been shown to be an important source of advances in knowledge relevant to innovation across most production sectors<sup>52</sup> and also provide the underpinnings for advances in emerging technologies such as biotechnology. The National Physical Laboratory is regarded as one of the world's leading measurement facilities.

Design often complements R&D and other forms of innovation expenditure<sup>53</sup>. A new study has shown its significance as a discipline in organizing and facilitating open innovation<sup>54</sup>. Over the period 2004-06, 17 per cent of innovating businesses said they spent at least some money on design directed at product or process innovation. While international comparisons are difficult because of differences in data sources and definitions, the UK would appear to have a relatively successful design sector<sup>55</sup>.

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<sup>45</sup> R Griffiths, "Technology, Productivity and Public Policy", *op cit*.

<sup>46</sup> UK IPO Customer Satisfaction Survey 2007

<sup>47</sup> UK IPO Annual Report 2007

<sup>48</sup> EPO Annual Report 2006

<sup>49</sup> [http://www.uspto.gov/web/offices/com/annual/2007/100\\_summary.html](http://www.uspto.gov/web/offices/com/annual/2007/100_summary.html)

<sup>50</sup> DTI Economics Paper No. 12. "The Empirical Economics of Standards" 2005

<http://www.berr.gov.uk/files/file9655.pdf>

<sup>51</sup> This refers primarily to the National Metrological Laboratories: NPL, LGC and NEL.

<sup>52</sup> Provisional results from research on measurement knowledge and its impact on innovation.

<sup>53</sup> DTI Economics Paper No. 15. "Creativity, Design and Business Performance".

<http://www.berr.gov.uk/files/file13654.pdf>

<sup>54</sup> V Acha, "Open by Design", DIUS 2008.

<sup>55</sup> DTI Economics Paper No. 15. *op cit*.

OECD analyses suggest that the UK has relatively liberal product and labour market regulations<sup>56</sup>. This is likely to facilitate the overall adaptability of UK businesses and reduce lock in to established markets and ways of doing things.

More specifically, regulatory regimes that promote competition and empower consumers are likely to create incentives for innovation although the relationship is subtle and suggests the need for a sophisticated approach to policy making<sup>57</sup>. Benchmarking studies have been conducted and suggest that regulation in the UK compares well with other leading OECD economies in many respects, although not across all dimensions<sup>58</sup>.

Other types of regulation (e.g. environmental or health and safety regulation) can have powerful effects on innovation: by creating incentives for businesses to innovate or indeed by blocking particular innovation pathways. The key principles have been widely disseminated and built into regulatory guidance: regulations that set down required outcomes and give businesses some freedom in how they meet them are likely to stimulate innovation. It is not clear whether the UK has been more or less successful than other countries in using regulations in this way. A review of the literature concluded that it is not possible to come to firm conclusions on the overall impact of environmental and health and safety regulations on the rate of innovation<sup>59</sup>.

The broader macroeconomic environment has in recent years also been conducive for investment. Compared to other advanced economies, output growth has been both relatively high and stable.

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<sup>56</sup> OECD country studies, UK

<sup>57</sup> Recent studies have suggested that the relationship between competition and innovation is U-shaped; too much competition in a market can also drive out innovation P. Aghion, et al, "Competition and Innovation: an Inverted- U Relationship", Quarterly Journal of Economics, May 2005.

<sup>58</sup> Benchmarking reports on UK competition and consumer policy regimes.

<http://www.berr.gov.uk/files/file34673.pdf> and <http://www.berr.gov.uk/files/file32812.pdf>

<sup>59</sup> S Mahdi, P Nightingale and F Berkhout, "A Review of the Impact of Regulation on the Chemical Industry", Final Report to the Royal Commission on Environmental Pollution, 2002.

## **UK weaknesses**

### **Significant minority of non-innovating businesses**

From the 207 Innovation Survey, 64per cent of businesses<sup>60</sup> were innovation active. This leaves 36 per cent of businesses that were not engaged at all in innovation over a three year period. As the UK Innovation Survey excludes business with less than 10 employees, this result is not simply due to very small firms without the capacity, incentive or desire to innovate. Over a quarter (26 per cent) of businesses with more than 250 employees said they were not innovation active.

There are concentrations of non-innovators in some sectors notably “Other Services” (hotels and catering, transport, real estate and other business services) where nearly half of smaller firms and 30 per cent of firms with 250 or more employees were not engaged in innovation activity.

### **Rates of new entrepreneurial activity and business growth still lag the US**

Innovation often happens through the creation and growth of new firms as well as through change in existing firms. Indeed this is almost an essential ingredient of disruptive innovations that transform or create markets.

The SME base in the UK continues to grow. On average around 180,000 businesses have registered each year for VAT since 2000 and VAT registrations have exceeded de-registrations for twelve years in a row. However, new entrepreneurial activity as a whole still lags behind a number of key competitor countries including the US and Canada<sup>61</sup>.

### **Variation in innovation performance and capability across the UK**

**The geographical patterns of innovation in the UK are complex.**

Sub-national data are most commonly collected by region<sup>62</sup>. The UK Innovation Survey suggests relatively small differences between regions in rates of innovation activity (Figure 10).

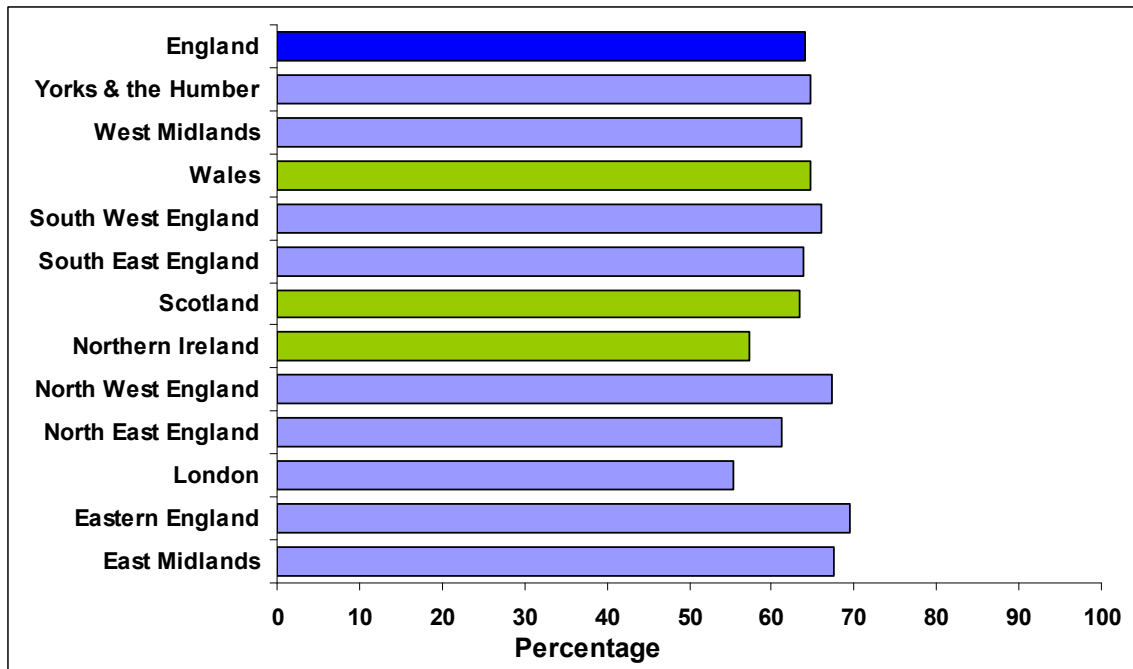
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<sup>60</sup> This differs a little from the figure of 68% quoted above, as the comparisons over time reported there have been calculated using the sector coverage common to all three surveys.

<sup>61</sup> Measured by the percentage of businesses active for less than 42 months. Source: Global Entrepreneurship Monitor.

<sup>62</sup> The term “region” is used here to refer to the English Regions and the countries with Devolved Administrations.

**Figure 10: Innovation activity by region, 2004-06**



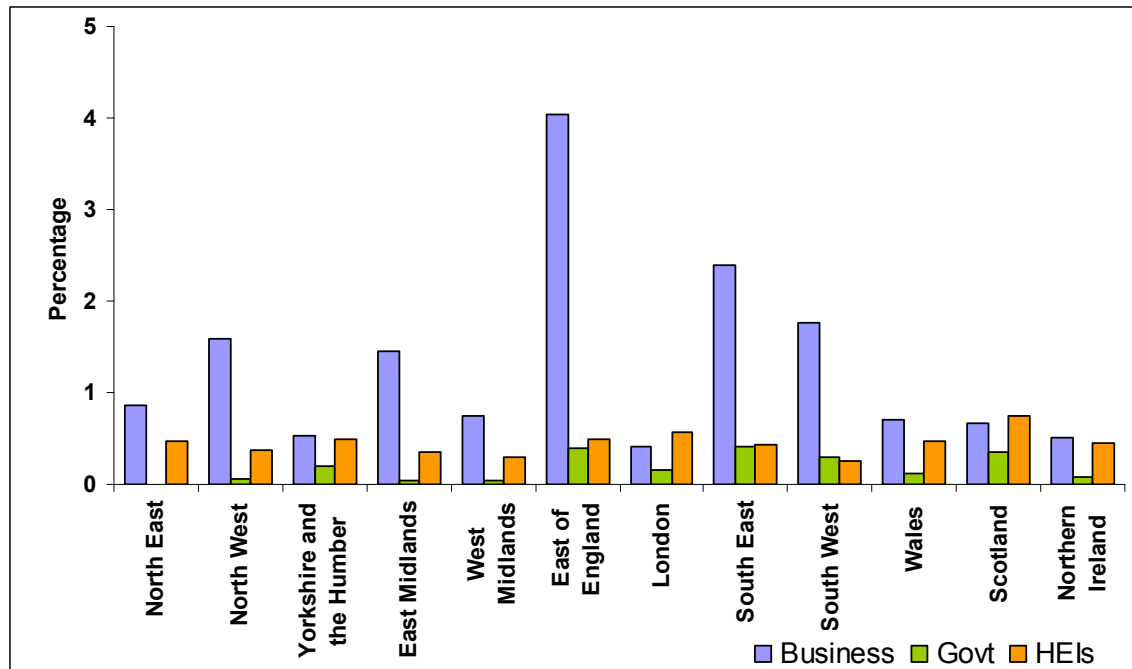
Source: UK Innovation Survey 2007.

There are sharper differences between regions in some of the building blocks of innovation. Thus rates of R&D intensity differ greatly across the UK with a concentration in the south eastern regions (Figure 11). For business R&D, these patterns reflect the location decisions of a relatively small number of R&D intensive companies long ago<sup>63</sup>.

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<sup>63</sup> Although there has been a small amount of convergence with higher growth of R&D in Scotland, Wales and Northern Ireland.

**Figure 11: R&D intensity by region, 2003**

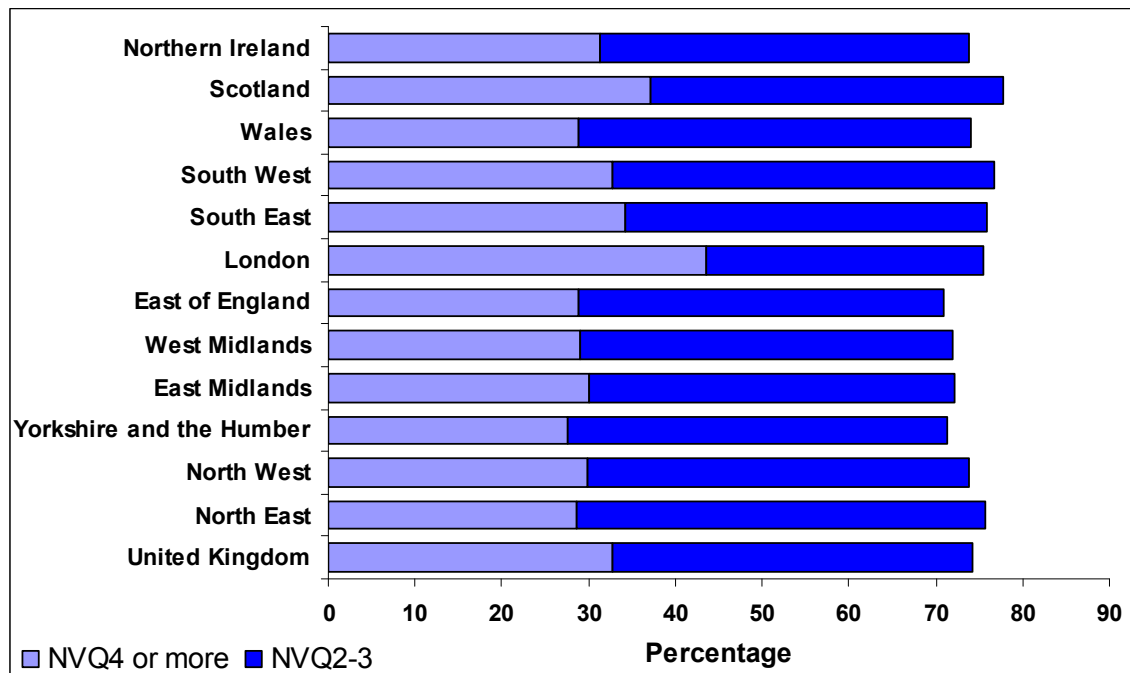


Notes: The chart shows R&D performed by business, government departments and HEIs, as percentages of regional Gross Value Added.

Source: ONS

There are also less marked but significant differences between regions in workforce skills as measured by academic and vocational qualifications. The proportion of economically active adults with a NVQ Level 2 or higher varied in 2006 from 71 per cent in the East of England to 78 per cent in Scotland. There was greater variation for those with at least NVQ4 where London attracts a relatively high share of the highly qualified population (Figure 12).

**Figure 12: Highest qualification by region, 2006**



Notes: Economically active adults are men aged 18-64 and women aged 18-59.

Source: Labour Force Survey, 2006 Q4.

New research suggests that differences between regions in capacity to absorb knowledge can be explained primarily in terms of historic location patterns of businesses and differences in other factors such as skills<sup>64</sup>.

Firms of course innovate across statistical (and national) boundaries. This can be seen at one level through the operation of clusters that span regional boundaries (e.g. motorsport) and where the challenge for policy makers is to facilitate and avoid creating unintentional barriers to co-operation and knowledge flows. An attempt to systematically map clusters by government, based primarily on patterns of regional employment concentration, found over 150 industrial clusters in the UK, often on a limited scale. Nevertheless it concluded that the UK did not have a heavily clustered economy<sup>65</sup>. Recent analysis of ONS employment and business data shows that some industries are highly concentrated geographically, often for access to natural resources or, in the case of many services, in London<sup>66</sup>. The data also indicate that these patterns once established are highly persistent.

Equally there is evidence that some businesses locate their innovation activities close to relevant university Departments although this effect only applies to certain firms and kinds of Department (e.g. innovating firms in the chemicals industry tend to be located

<sup>64</sup> M Kitson et al, "Absorptive Capacity and Regional Patterns of Innovation", Centre for Business Research, University of Cambridge, 2008.

<sup>65</sup> Department of Trade and Industry, "Building Clusters in the UK: A First Assessment", 2000.

<sup>66</sup> H Simpson, "An Analysis of Industrial Clustering in Great Britain", report to the Department of Trade and Industry, 2007.

near leading materials science Departments)<sup>67</sup>. Cities are also important as hubs for knowledge exchange, national and international communications and as dense markets.

Whether these geographical patterns identify a significant point of weakness in the UK innovation system is difficult to determine. There is a spatial dimension to all economic activity. Sub-national differences in innovation performance are not unique to the UK.

## INNOVATION IN PUBLIC SERVICES

The public sector accounts for around 20 per cent of UK employment. Productivity and innovation in the public services is thus important both in economic terms and because of the potential for improved services to citizens.

There is – in comparison to the business sector – very little systematic evidence on the prevalence or characteristics of innovation. Much of the evidence is piecemeal and/or qualitative. It is very difficult to judge the extent to which information and opinion collected in a range of case studies and research into specific parts of the public sector can be generalized. Probably the nearest to an estimate of prevalence can be found in an Audit Commission survey where 43 per cent of responding local authorities and fire authorities said that they innovated a “great deal” and 52 per cent reported “some” innovation<sup>68</sup>.

The difficulties are in the first place conceptual. Ideas and definitions used to describe and categorise innovation in profit-seeking businesses may not translate seamlessly across to public services (see Table 3 for a typology produced by one researcher in the field which illustrates the dimensions that a public service innovation can incorporate).

**Table 3: Dimensions of innovation in public services**

<b>Description</b>	<b>Type</b>	<b>Public sector example</b>
New products	Product	New instrumentation in hospitals
New ways in which services are provided, new “scripts”	Service	Online tax self-assessment
New procedures, organizational systems, structures	Process	Administrative reorganisations
New contexts, customers or partner	Position	Connexions service for young people

<sup>67</sup> L. Abramovsky et al, “Analysing business-university innovation linkages using the 4th Community Innovation Survey”, research report, 2007. A recent report by Library House (“An Analysis of UK University Technology and Knowledge Transfer Activities”, report to Gatsby Charitable foundation, March 2007) found that innovative venture capital-based R&D based companies tend to be located near universities with high research assessment ratings.

<sup>68</sup> Audit Commission, “Seeing the Light”, 2007.

New goals, purposes or values	Strategic	Community policing, foundation hospitals
New democratic institutions and forms of participation	Governance	Area forums, devolved government
New language, concepts and definitions	Rhetorical	Congestion charging, carbon taxes

Note: Any single attempt to innovate can contain one or more of these dimensions.  
Source: Reproduced from Hartley (2005).

Most public services have multiple and sometimes qualitative performance indicators. Few public services have the sharpness of focus provided by profit-loss accounting. Thus it can be difficult to evaluate the outcomes of attempted innovations.

## UK strengths

### Some world leading examples of new delivery of services and innovative policy making

Public service innovation has been made to happen in the UK. A widely cited and documented example is NHS Direct<sup>69</sup>. A recent report for the work Foundation identifies a number of others (e.g. Companies House electronic incorporation scheme, HM Land Registry e-conveyancing)<sup>70</sup>. Many of these to some extent involve the use of ICT to produce new services or new means of delivering existing services.

What cannot be established with any accuracy or generality is whether the “success rate” of major innovation projects in UK public services is any higher or lower than for similar administrations elsewhere.

### Builds on strong culture of public management and efficiency

The UK has been one of the earliest and most prominent adopters of the New Public Management and its associated emphasis on generating a culture of strong management and efficiency. Efficiency was reported by local authorities to be the most powerful driver of innovation<sup>71</sup>.

At one level this creates the conditions and organizational incentives to innovate. However, some commentators have suggested that this approach to public services management can reduce innovation by driving out the slack resources often required for low-key experimentation<sup>72</sup>.

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<sup>69</sup> See P Cunningham et al. “NHS Direct, an Innovation in Social Trust” 2005.

<http://www.step.no/publin/reports/d12-3ukum.pdf>

<sup>70</sup> R Lekhi, “Public Service Innovation”, report by Research Republic LLP to Work Foundation.

<sup>71</sup> Of local authorities and fire authorities responding to the Audit Commission survey (reported in Audit Commission, “See the Light”, *op cit.*), 79 per cent stated they were under pressure to be efficient for some or all of the time.

<sup>72</sup> C Sabel, “Beyond Principal-Agent Governance: Experimentalist Organisations, Learning and Accountability”, WWR, not dated.

## UK weaknesses

### Incentives often work against innovation

A feature of many public service organizations would appear to be an imbalance between risk and reward for innovating.

An organization (or a manager within an organization) often has a choice whether to innovate or not. Typically the costs of deciding not to innovate are small or non-existent: the status quo is usually a defensible option because the costs of not innovating may not be visible. In contrast, if an attempt to innovate is made, the consequences of failure can be severe whereas the consequences of success to the manager or organization are often very limited<sup>73</sup>. If these conditions apply it would be unsurprising if innovations with a high degree of risk were rarely attempted.

### Insufficient skills to innovate successfully

Commentators have claimed that the UK public services often lack the skills to innovate. Again it is difficult to evaluate such claims. Circumstantial evidence might include the following:

- A number of reviews of public procurement have concluded that capability needs to be strengthened<sup>74</sup>.
- In the absence of price mechanisms, there may be areas where there is a misalignment between investment in innovation and the benefits of potential improvement.
- A common problem with service innovations, including in the private sector, is that they are difficult to “switch off” and re-design. This difficulty, however, is likely to be especially acute for many public services. The knowledge and experience required to “simulate” services may be lacking. Service innovation in general requires deep tacit knowledge and skills stored in “communities of practice”<sup>75</sup>.

### Weaknesses in spreading good practice

The processes for diffusing knowledge and spreading knowledge differ between public and private sectors. Markets provide powerful incentives for firms to adopt practices and techniques developed elsewhere – either from their competitors or elsewhere – not least through the threat arising from new firms entering the market. In the absence of direct market competition, policy makers have to design regulatory or delivery structures that produce similar incentives for efficiency such as contestability of provision or inspection

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<sup>73</sup> Certainly in financial terms. Rewards to innovating organisations may be primarily enhanced reputation and staff morale and possibly a relaxation of central controls. For individuals, it may be professional reputation.

<sup>74</sup> For references see [http://www.hm-treasury.gov.uk/media/E/6/government\\_procurement\\_pu147.pdf](http://www.hm-treasury.gov.uk/media/E/6/government_procurement_pu147.pdf)

<sup>75</sup> R Lakhni, “Public Service Innovation”, *op cit*.

and audit. The complexity of many public services can make it difficult to implement effective mechanisms for spreading good practice without creating unanticipated or perverse effects. Equally, a lack of competition from new entrants can also mean that unsuccessful innovation projects are not closed down as swiftly as in the market economy.

This complexity also means that spreading good practice is often a matter of adaptation rather than imitation<sup>76</sup>. A recent study of Local Authority beacon schemes found that, where local authorities tried to implement a change as a result of visiting a beacon, in most cases (63 per cent) this was done by attempting to adapt good practice to the circumstances of the particular Local Authority rather than through direct adoption of what they had seen<sup>77</sup>. This of course requires a degree of sophistication and skill on the part of those seeking to make the adaptation.

## **INNOVATIVE PEOPLE**

Human capital is vital to understanding innovation activity and capability. Highly skilled people are needed to generate the frontier knowledge that drives many new technological developments. Tacit knowledge or know-how is embodied in people and moves with them from firm to firm and from place to place. Innovation can be a complex task to co-ordinate and manage. The execution of innovation projects will depend on the capabilities and motivation of the workforce.

There are a number of skills that are necessary for innovation:

- Technical knowledge (including but not restricted to the STEM subjects).
- The cognitive and creative skills required to solve problems.
- The managerial skills required to innovate.
- The basic skills, competencies and attitudes required by a flexible and adaptable workforce.

All of these broad categories are likely to be required to some degree although their relative significance may differ according to the nature of the innovation being attempted and other factors such as industrial sector, size of business etc. Not all of these skills need to be possessed internally by an innovating organisation; scarce and specialized skills may be bought in through contract research, consultancy or sub-contracting.

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<sup>76</sup> J Hartley in J Hartley and A Pike (eds), "Managing to Improve Public Services", Advanced Institute of Management, 2005.

<sup>77</sup> J Hartley and J Benington, "Copy and Paste, or Graft and Transplant? Knowledge Sharing Through Inter-Organizational Networks", *Public Money and Management* 26 (2), 2006.

## UK strengths

### Excellent universities with rising participation

Universities have a number of functions important to innovation:

- As generators of frontier research-based knowledge;
- As suppliers of trained people;
- As bridges between researchers and the business and broader community;
- Through their connections into global knowledge networks;
- As significant economic actors in their local areas.

As demonstrated above, the UK performs strongly in terms of the scientific quality of its publicly funded research base. A large part of this knowledge is of course generated by HEIs. UK researchers have a high rate of co-production with researchers from other countries and UK HEIs are highly successful in obtaining funding for research from the European Framework Programme.

In 2004/05, just over half (52 per cent) of masters students were non-UK domiciled with the proportions being 39 per cent for doctorates and 12 per cent for first degrees<sup>78</sup>. Hence it is not surprising that leading UK universities feature prominently (after US universities) in existing international rankings. For example, 19 UK universities feature in the top 100 of the THES world rankings.

Participation of UK-domiciled students in higher education has increased significantly over the past decade as part of a longer term trend. The current higher education initial participation rate is 43 per cent<sup>79</sup> although it needs to rise further to meet the longer term goals for 2020 set out in the Leitch Review. The UK Innovation Survey shows a positive relationship between the share of the workforce that are graduates and the likelihood that a business innovates<sup>80</sup>.

### Strengthened public engagement

Public confidence and engagement in research is crucial for individuals to engage in the science and innovation system, from encouraging individuals to undertake further training or to work as a researcher, to those in business considering investing in innovation. Public confidence and engagement is also important to help build understanding and appreciation of the economic and social impacts of research and innovation.

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<sup>78</sup> Royal Society, "A Higher Degree of Concern", 2008.

<sup>79</sup> Provisional figure for 2005/06.

<sup>80</sup> DTI Economics Occasional Paper No. 6."Innovation in the UK: Indicators and Insights" 2006

The 2005 MORI survey<sup>81</sup> showed that 86 per cent of adults think that science makes a good contribution to society and 82 per cent of adults think that science will make our lives easier. There are some issues concerning trust in science and scientists: 14 per cent trust government scientists to provide accurate information about scientific facts, which is considerably lower than those working for charities and universities (around 40 per cent), but around the same level of trust as for industry scientists (13 per cent).

## **UK weaknesses**

### **Low business demand for skills in some parts of the economy**

Employer investment in training would appear not to match the levels of the highest skilled economies. Labour Force Survey data indicate a relatively high incidence of job-related training in the UK compared to other countries but other surveys suggest that employer-provided training in the UK is often of relatively short duration and hence may not be of the intensity required to upgrade workforce competencies in line with the goals of the Leitch Review. Indeed the latest data suggest a third of employers provided no training at all over the course of a year<sup>82</sup>.

These data suggest a weakness in demand. As skills are a derived demand this may connect to more general issues concerned with business and innovation strategies. Research suggests that, in some parts of the economy, low demand for skills is connected to low ambitions for the business and business strategies of cost-based competition in low value segments of product markets<sup>83</sup>. These may also be firms who do not seek to innovate. Such firms are sometimes described as being trapped in a low skills equilibrium because of the difficulties that they can face in changing their business model. The risk is that such strategies become unsustainable with increasing global competition.

### **Overall skills levels of the UK population lag behind international leaders**

Although international comparisons need to be treated with a degree of caution, data on qualifications suggest that the UK population of working age is not as well qualified as in a number of other OECD countries (Figure 13).

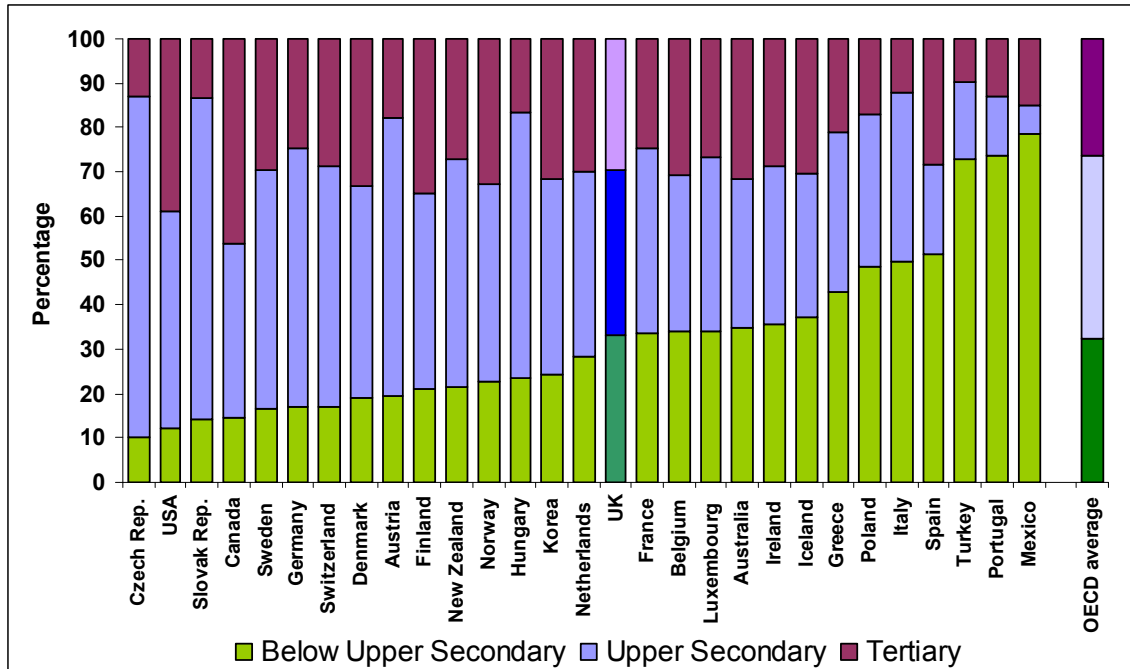
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<sup>81</sup> Market and Opinion Research International, "Science and Society: findings from qualitative and quantitative research conducted for the Office of Science and Technology, DTI," March 2005.

<sup>82</sup> National Employers Skills Survey 2007.

<sup>83</sup> For example: G. Mason, *Enterprise product strategies and employer demand for skills in Britain: research evidence from the Employers Skill Survey*, NIESR Working Paper 50. 2004

**Figure 13: International comparisons of qualification profiles**



Source: OECD Education at a Glance 2007

The gap is most apparent at intermediate level due to the significant proportion of people in the UK with few or no qualifications. This will in part be a reflection of low levels of demand from some employers. It also reflects historic weaknesses in the provision of education and training.

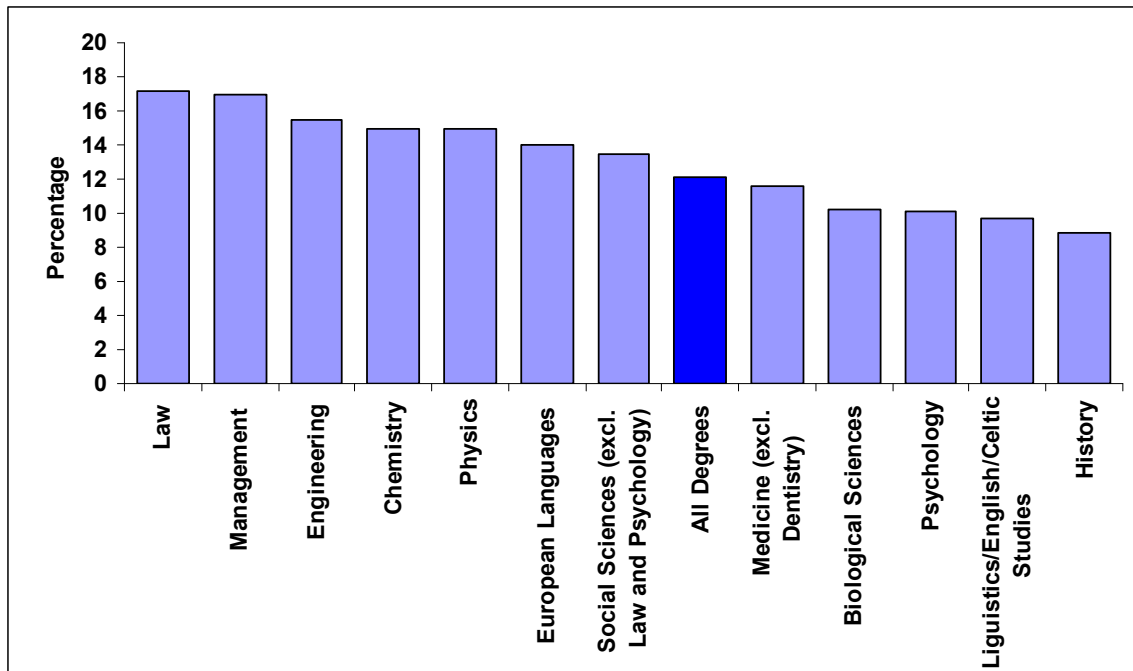
**Increasing overall supply of STEM skills but concerns over numbers coming through in some disciplines**

High level technical knowledge – including in STEM subjects – can be important for many forms of innovation. There is some evidence from innovation survey data that employment of R&D workers is associated with increased innovation in manufacturing. More generally there is an association between employment of STEM graduates and certain forms of innovation<sup>84</sup>.

STEM graduates are – and probably always have been - employed across a wide range of industries and occupations. Some will be using their technical knowledge as active researchers in the publicly funded research base or in business. Others will be drawing on their research expertise to interpret knowledge and apply it to their business needs. STEM and indeed other graduates will also be valued for their general problem solving skills as well as for their technical knowledge. The (private) wage returns to first degrees in some STEM subjects are relatively high (Figure 14).

<sup>84</sup> Kitson *et al.*, *op cit.*

**Figure 14: Wage returns to first degrees by subject**

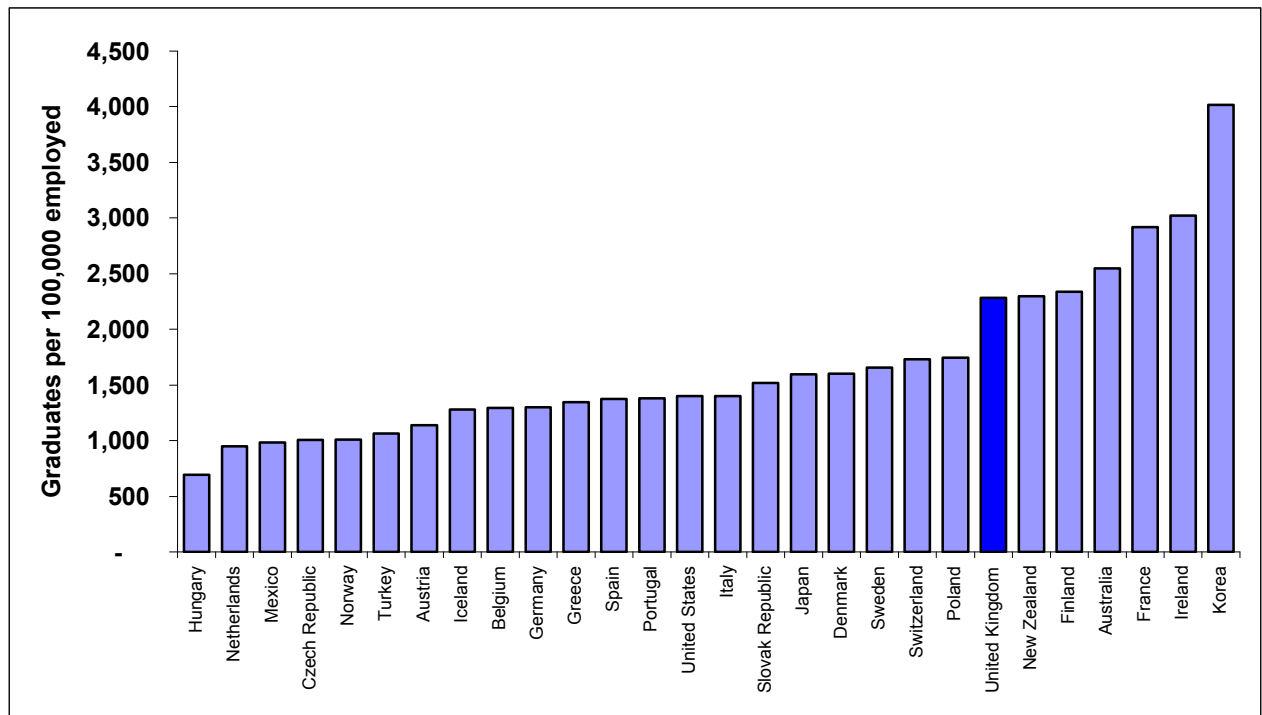


Source: PWC (2005): "The economic benefits of higher education qualifications".

Labour Force Survey data show that overall numbers of STEM graduates and PhD holders in the adult workforce have increased over time<sup>85</sup>. The UK has one of the highest proportions of STEM graduates in its workforce among the OECD (Figure 15).

<sup>85</sup> DTI Economics Paper No. 16."Science, Engineering and Technical Skills in the UK", 2006

**Figure 15: Comparisons of science graduates per 100,000 employed population aged 25-34, 2005**

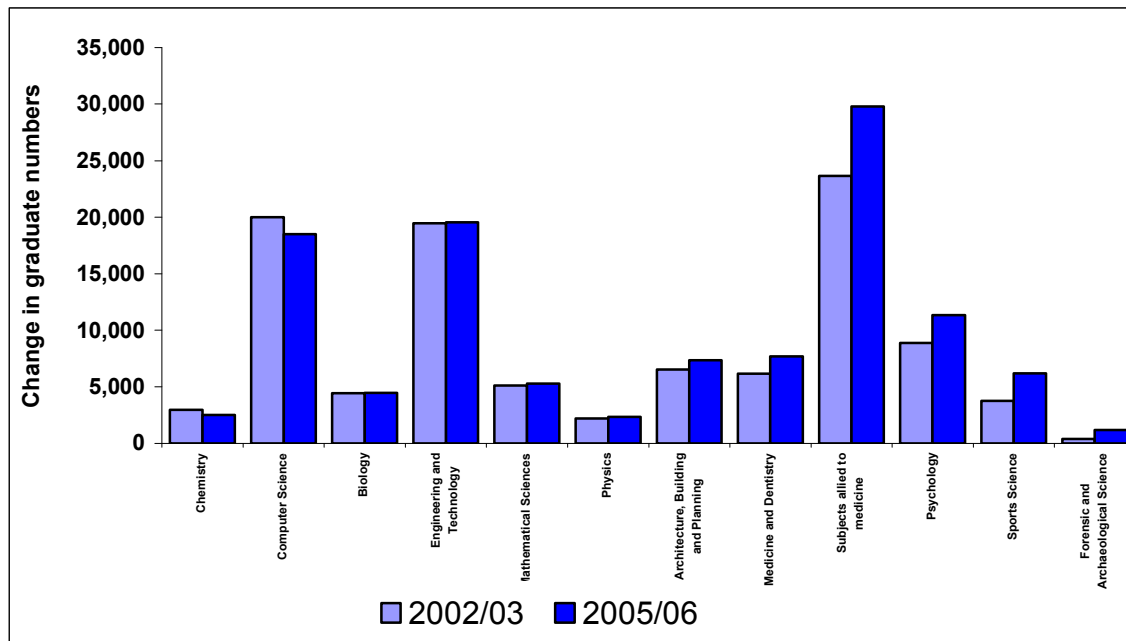


Source: OECD Education at a Glance 2007

Graduate numbers in STEM disciplines as a whole have increased in recent years. In 2005/06 about 42 per cent of all first degrees were in STEM subjects, a proportion that has been relatively stable. The pattern has not been uniform across subjects and since 2002/03 there have been falling graduate numbers in chemistry and computer science (Figure 16)<sup>86</sup>.

<sup>86</sup> Exact comparisons are only possible since 2002/03 because major changes were introduced then to subject coding systems and to the way students on joint degrees were apportioned.

**Figure 16: Changes in graduate numbers in STEM subjects, 2002/03-2005/06**



Note 1: Change in Computer Science since 2003/04

Note 2: Excludes Open University

Source: Higher Education Statistical Agency.

Trends in first degrees are in part shaped by the numbers of young people taking A Levels in STEM subjects. The most recent data on A Levels taken for England show an upward movement in a number of STEM disciplines (e.g. mathematics and chemistry).

Similarly numbers of postgraduates in both STEM and non-STEM subjects have increased in recent years. However, the Royal Society have drawn attention to some apparent falls over the past decade in the number of UK-domiciled postgraduates in subjects such as physics and chemistry<sup>87</sup>.

## Management skills and practices

New research shows that implementation of different management practices is associated with business innovation and that management training is associated with service sector innovation<sup>88</sup>.

UK managers appear to be less well qualified and trained than their counterparts in other countries (Table 4)<sup>89</sup>.

<sup>87</sup> Royal Society, *op cit*.

<sup>88</sup> Kitson *et al.*, *op cit*.

<sup>89</sup> A comparative survey of businesses in the UK and the US leads to similar conclusions (see Cosh *et al*). See also data on expenditure on management development quoted in "BERR's role in raising productivity: new evidence", BERR Economics Paper No. 1.

**Table 4: Training of managers in selected countries**

	UK	USA	Japan	Germany	France
Average terminal educational age	19.5	22	21	21	22
Graduate (%)	49	74	78	72	61
Off-the-job training (days/year)	4	7	5.5	5.5	6
On-the-job training (days/year)	4.5	8	6.5	6.5	6

Source: Keep and Westwood, (2003)<sup>90</sup>

The CEP/McKinsey studies of management practices in manufacturing across a range of countries considerable variation in the effectiveness of management practices between firms within countries. On average management practices in UK firms were less rigorously applied than in the leading countries, the US and Sweden, although more consistently than in China and India.

These issues matter for performance: further analysis suggested a relationship between management practices and company performance<sup>91</sup>.

## **AREAS WHERE FURTHER INFORMATION WOULD BE NEEDED TO ASSESS UK PERFORMANCE**

Recent years have seen an increased focus on the role of users and consumers in the innovation process. In part this has been because of the open innovation paradigm and more “democratic” models of innovation. It also reflects the significance of aggregated consumer demand in shaping innovation. This can take place through early adopters of technology either in the private sector or in the public sector (where public procurement plays an important role).

These are also areas where existing information is incomplete and where in particular it is not possible to judge the comparative performance of the UK innovation system.

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<sup>90</sup> E Keep and A Westwood, “Can the UK learn to manage?”, Work Foundation, 2003

<sup>91</sup> N Bloom and J van Reenan, “Measuring and explaining management practices across firms and countries”, 2006.

## Demand for innovation

It has been suggested that lead users and lead markets can drive forward the development of new products and services and help take promising ideas through from inception to the point where economies of scale can be reaped by selling into larger markets domestically and internationally<sup>92</sup>. Government can be a lead user and sometimes create lead markets through its procurement or regulatory activities.

It is not possible to determine with authority how well this process works across the entire UK economy. Recent Eurobarometer surveys suggest an overall level of public readiness for innovation above the EU average<sup>93</sup> although the proportion falls when asked more focused questions on readiness to substitute new products and services for tried and tested alternatives.

The UK Innovation Survey asks businesses about potential constraints on innovation. In 2007, around two thirds of businesses said that “uncertain demand” was of no importance as a barrier to innovation, whereas 5 per cent of businesses said it was of high importance; to put this in context, the most commonly cited constraining was high costs of innovation (10 per cent). Hence demand conditions appear to be part of – but not the only – factor that might discourage a business from innovating.

Note that demand conditions may vary over the business cycle. Nor is it always undesirable that businesses may cancel or abandon innovation projects because they perceive a lack of effective demand for the end result.

## Barriers to user-led innovation

A number of studies have documented the significant role that users – as opposed to manufacturers – have played in a number of specific innovations and fields. For example, it has been suggested that four fifths of novel innovations in scientific instrumentation were developed by users<sup>94</sup>.

Business innovation surveys do not routinely capture users as a distinct community. Thus it is difficult to determine from current data how widespread these examples of user-led innovation are. However, the example of open source software suggests that its role is likely to be of economic significance<sup>95</sup>.

This lack of general data also means that barriers to user-led innovation – and whether they represent a market failure - are difficult to identify in a general sense. The public infrastructure for knowledge sharing is likely to affect the degree of user-led innovation

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<sup>92</sup> L Gheorgiou, “Demanding Innovation”, 2007, [http://www.nesta.org.uk/informing/provocations/luke\\_georghiou.aspx](http://www.nesta.org.uk/informing/provocations/luke_georghiou.aspx)

<sup>93</sup> NESTA, “User-led innovation and Innovative Consumers”, 2008.

<sup>94</sup> Riggs and von Hippel, 1994, cited in NESTA “User-led Innovation and Innovative consumers”, *op cit*. BERR Economics Paper No. 1, *op cit*.

<sup>95</sup> The UK Innovation Survey does not include a “user” category. Probably the nearest it gets is a question that asks businesses about their innovation partners. In 2007, two thirds (68 per cent) said that “clients or customers” were innovation partners. Not all of these will have been “users”.

by affecting the ability of diffuse user communities to exchange information. Hence the intellectual property framework and provision of ICT infrastructure may speed up or impede user-led innovation. Users may respond quite differently from companies to financial incentives. Businesses themselves are investing in interactive ICT<sup>96</sup>. However it is not clear whether conditions in the UK produce a significant departure from the optimal level of user-led innovation.

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<sup>96</sup> NESTA, "User-led Innovation and Innovative consumers", *op cit.*

## **PRIORITIES FOR IMPROVING THE EVIDENCE BASE**

The analysis above has in a number of places identified limitations in the evidence base, especially statistics, in moving away from models of innovation based on businesses, R&D and technology.

This section identifies those aspects of the evidence base where there is a clear need for improvement. These are broad areas and cannot be addressed in one step by any one Government Department or indeed by any single national authority. DIUS will seek to make concrete progress in improving the evidence base in collaboration with other Government Departments, Research Councils and the research community, delivery partners and business organizations. There is also an important international dimension working with other Governments, the OECD and the EU.

The themes below are for improvement in the medium to long term. Some of them will be addressed in the development of an innovation index and the programme of the Innovation Research Centre announced in "Innovation Nation".

### **Innovation, productivity and economic performance**

There is still a need for a better understanding of the relationships between innovation and productivity at the whole economy level and at the firm level, the latter building on current OECD work. Data linking through the ONS Virtual Micro-data Laboratory will provide new opportunities for analysis as time series of innovation surveys build up.

### **Non-technology centred innovation**

There is a continuing need for better measures of business innovation, especially for forms of innovation that do not involve R&D or the creation and development of new technologies and for non-R&D intensive sectors. This includes marketing, business model and managerial innovations. More value can be obtained from existing innovation survey data, for example by the application of sophisticated analytical techniques. There might be scope for refining measures of inputs, for example through extending recent analysis of business investment in a range of intangible assets<sup>97</sup> to incorporate a wide range of design and creative inputs. This would need to be accompanied by work to test whether there are knowledge or other spillovers from these categories of investment that are not captured by the businesses making the investment.

### **Non-economic effects of innovation**

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<sup>97</sup> M Marano, J Haskel, G Wallis, "Treasury Economics Paper 1," Intangible Investment and Britain's Productivity", 2007.

Innovation can improve health outcomes, produce a better environment, a better informed and more cohesive society. While a number of these outcomes are in principle capable of economic valuation, they tend not to be reflected in GDP and hence in productivity estimates. At present, the evidence base here is largely qualitative, based on exemplar case studies<sup>98</sup>. There may be scope for more systematic examination of these effects using quantification and (possibly) valuation techniques already developed in disciplines such as health and environmental economics.

## **Public services innovation**

At present it is difficult to assess the innovation performance of the public sector as a whole – or even of organizations within it – because of a lack of systematic data. Progress on this is likely to be very challenging. It is likely to require work on developing concepts and definitions as well as raising difficult issues of practicality and methodology such as the appropriate unit of analysis and sampling frames.

## **Users and innovation**

Consumers and users need to be brought more firmly into innovation measurement and research. This might be possible in part through refinements to existing surveys and other instruments. However it might require new data collection. As well as documenting the phenomena and their nature and prevalence, there is a need to identify more precisely the barriers to user-led innovation and demand driven innovation.

## **Skills and innovation**

DIUS will consider how the connections between skills and innovation summarised in this report might affect current and future analysis and data gathering activities.

## **Factors that encourage and discourage innovation**

There is some data available from innovation surveys on firms' perceptions of barriers to innovation. There is a need to understand better the relationship between internal factors (strategy, capability) and external factors (market structures, regulations etc.). This will also help to determine whether and when policy interventions may be of benefit.

A cross-cutting theme will be place and the role of businesses and other innovation actors within local, sub-national, national and international innovation networks and value chains.

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<sup>98</sup> "Economic Impacts of Investment in Research and Innovation", *op cit*.