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NESTA Making Innovation Flourish

The Innovation Gap

Why policy needs to reflect the reality of innovation in the UK

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Foreword
Innovation is vital to the future economic prosperity and quality of life of the UK. The word innovation has become an important one in contemporary policymaking but, as this report demonstrates, innovation is frequently found in unlikely places. It is rarely based on traditional understandings of linear, 'pipeline' research and development that lead only to new products, drugs or technology. If that were the case, where, for example, would there be room for the retail innovation of IKEA, Zara and eBay, or the role of the City of London as a centre for financial services? What would we make of the UK's advertising and music industries, or of social innovation from the National Cycle Network and NHS Direct to the BBC and the Open University?

We need a deeper understanding of innovation based on where it actually happens, and we need to develop our approach to innovation policy based on this understanding. The current emphasis on traditional research and development is necessary, but not sufficient. It has grown from a concern over the UK's unimpressive performance on traditional innovation metrics. But these metrics measure inputs more than outcomes and are inherently biased against the make-up of the UK economy. The result has been an over-emphasis on a very small sector of our economy and the exclusion of the vast majority.

We need to build from the rhetoric around a national mission for innovation toward making that vision a reality. To do this, we will need to develop a firm understanding of what the UK wants from innovation. We need to accurately appraise our capacity in those sectors, and imaginatively build policy accordingly. This is why NESTA is focused not just on increasing the number of innovations that the UK produces, but on transforming the UK's *capacity* for innovation. We focus across all sectors on the factors (financial, human and policy) that maximise our country's ability to innovate and to capture the value from that innovation.

This report is intended to drive forward the discussion and practice of innovation policy in the UK. NESTA will seek to promote and support this through its research, its programmes and its investments. We welcome your involvement and your views.

Jonathan Kestenbaum
CEO, NESTA

October, 2006

NESTA is the National Endowment for Science, Technology and the Arts.

Our aim is to transform the UK's capacity for innovation. We invest in early stage companies, inform innovation policy and encourage a culture that helps innovation to flourish.

Executive summary

This is not, at heart, a complex argument. Traditionally, any reference to an 'innovation gap' with regard to the UK is assumed to mean the UK's deficit in innovation performance compared to other leading nations. However, traditional indicators of innovation performance are heavily biased toward investments in scientific and technological invention and so do not capture innovation in those sectors that represent the vast majority of the UK economy. Moreover, even within those sectors that they do represent, traditional indicators poorly reflect the true level of innovative activity. This gulf between practice and measurement is the real innovation gap. Understandably, policy built to remedy our historical poor performance on these indicators has focused on scientific and technological invention. This has been necessary but partial, because it has under-represented other sectors that are valuable to the UK economy. This emphasis now needs to be balanced against a wider agenda around the skills and attributes required to create, absorb and exploit innovation in the rest of the economy.

The UK underperforms on traditional innovation indicators and has built policy and structures to remedy this

The traditional headline data that informs the innovation debate shows that the UK performs poorly on business expenditures on research and development (R&D) and on the production of patents. For example, overall per capita expenditure on R&D in the UK is just half that in some other countries: the UK spends $566, the US $1,005, Sweden $1,154 and Finland $999. Similarly, the UK has a triadic patenting rate of 36.7 patents per million population, while Germany achieves a rate of 90.7 and Japan reaches 92.3. As a result, policymakers across the UK have sought to drive improvements in these areas, and have focused on incentives for scientific and technological R&D, support for high-tech manufacturing firms, increasing public investment in the science base and improving links between universities and industry.

Traditional indicators ignore major sectors of the UK economy

With innovation seen as fundamental to developed economies in an increasingly interconnected world, a paradox is apparent in the continued economic expansion of the UK despite its supposed under-performance. The resolution of this paradox lies in the way in which innovation has typically been measured.

Traditional indicators have captured only a limited amount of the innovation and innovative potential that exists in the UK. First, they are more relevant to some sectors than to others. For example, formal R&D is much less important in many service sectors than in high-tech manufacturing. The decline in some manufacturing sub-sectors therefore helps to explain much of the UK's relative under-investment in business R&D. Similarly, although universities have been a focus of much innovation policy based on the traditional 'pipeline' view of innovation (where pure knowledge is created and then commercialised in industry), they actually produce only a small amount of the innovation relevant to the modern UK economy.

Second, the Organisation for Economic Co-operation and Development (OECD) definition of some indicators neglects some of the UK's strengths, for example exploration activities in petroleum, one of the UK's most valuable sectors. Third, traditional measures unhelpfully aggregate data from many sectors into single indicators. For example, the UK pharmaceutical sector, where the development of new drugs in traditional laboratory settings is crucial, outperforms its competitors in investment in R&D but this performance is obscured when crude economy-wide indicators are compiled. If these factors are taken into account in the traditional metrics, the UK's performance significantly improves against our international competitors. The gap in business R&D intensity between the UK and France closes by 80 per cent, and between the UK and Germany by 73 per cent.

Understanding 'hidden innovation' is vital to the UK's future prosperity

Uncovering the innovation that is hidden by traditional indicators will be a defining issue in the development of successful innovation policy. We have begun this process by using five in-depth case studies to examine how innovation actually occurs. For example, the development of new genetic tests through the 'hidden research system' in the NHS suggests that informal and iterative development and research (D&R) is often more significant than formal R&D, even in scientifically advanced sectors. In engineering consultancy, we witness multiple forms of innovation that deliver substantial economic and social benefits being driven by interactions between businesses and their clients. In social housing, we are seeing the transformation of an underperforming sector by creative interventions such as new regulations and awards.

Together, these case studies emphasise how innovation relies on interactions between a wide diversity of actors. They indicate how innovation reaches far beyond the production of products and into the development of new services and organisational models to meet social as well as economic challenges.

The extension of our understanding of hidden innovation, and the development of new metrics that more accurately represent sectors such as these, might allow us to be more confident about the UK's ability to generate and exploit innovation. It could also allow us to identify those sectors where insufficient innovation is currently taking place.

The wide distribution of high quality skills is crucial to the development of hidden innovation and the absorption of innovations developed outside of the UK. This means that the traditional focus on the supply of people with advanced science, engineering and technology (SET) skills into jobs in formal R&D, needs to be balanced by a recognition that SET graduates working in other sectors also make an important contribution to innovation. However, greater levels of innovation might be limited by the UK's poor performance in intermediate skills, which at their current levels inhibit our ability to take advantage of technological developments and to cope flexibly with the changes brought by globalisation.

Building the policy agenda that the UK needs to meet the national challenges of the 21st century

Our research has six implications for policy:

- We need a **broad** view of where innovation comes from and where it applies. In other words, we need to look beyond science and technological invention and the obvious forms of innovation that result in new materials or products. We need to think of innovation as a process that is of vital importance to all sectors of the UK economy, and build innovation policy that reflects this.

- We should consider the importance of the **drivers** of this new and broader definition of innovation. In particular, policy should focus on an education system that is able to develop foundation analytical and problem-solving skills, creativity, imagination, resourcefulness and flexibility. These will support our collective capacity to initiate, absorb, support, organise, manage, and exploit innovation in its many forms. While current policy may over-estimate the importance of academic research as a source of innovation, it may under-estimate the damage that low per capita investments in public research have had on the production of skilled scientists and engineers who can apply their skills in the wider economy.

- We need a **textured** innovation policy that recognises one size does not fit all sectors. The recipe in the pharmaceuticals sector will not work for financial services or for public services. This leads to a requirement for us to gather sounder intelligence and analysis of the sources and contribution of innovation across different economic sectors. We need a much better understanding of the dynamics driving innovation in areas such as the City of London, popular music and construction.

- Innovation policy needs to be **imaginative** and encompass a wide range of interventions that are relevant to stimulating and supporting innovation. It would be useful to focus more on the multi-directional flows within and between science and technology, architects and developers, designers and producers, government and industry, management and engineering, universities and industry, and customers and suppliers.

- We should create an innovation policy that is **appropriate** to UK conditions. A striking feature of most innovation policies around the world is their similarity. A distinctive UK innovation system would focus on sectors that play a marginal role in the policies of countries with larger manufacturing sectors.

- We need greater clarity regarding the **outcomes** of innovation (rather than just the outputs). The focus of the UK's innovation policy should be determined by what we as a nation want from innovation, rather than focusing on innovation as an end in itself.

Toward a national mission for innovation

The UK is not alone in grappling for the understandings, metrics and policies that will effectively capture and stimulate the reality of innovation in the 21st century. Moreover, the UK has some considerable strengths as it faces up to the challenge. We have a strong background in innovation studies and policymakers across the UK are increasingly realising that policy and measurement have fallen out of sync with the reality of innovation. What is needed is the articulation of a national mission around innovation, one that encompasses the complexity of innovation while remaining a simplified guide to action.

The UK is well-placed to be a leader of an international shift in innovation policy. Aside from the intrinsic benefits of becoming a more skilled, more innovative country, the creative, open nature of our society combined with our developed system of regional and national government means that the UK is well-positioned to take advantage of innovations developed elsewhere. The ability to generate knowledge and to be able to exploit the knowledge of others is a powerful combination and represents what it means to be a hub in the future global economy. By embarking upon a considered, concerted drive toward a national mission for innovation, the UK will be well-positioned to lead the world in the application of knowledge, enterprise and creativity and to meet the national challenges of the 21st century.

Acknowledgements

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Methodology

The first strand of the research comprised a form of 'synthesis research'. This combines findings from a wide range of credible research sources in order to produce new insights and to develop an integrated understanding of an issue. It also identifies the implications for policy, practice and research. In this instance, this report examines empirical data relating to innovation from a variety of well-known surveys, and also the academic research literature on the nature of innovation and innovation policy. The second strand of the research focused on five new case studies of innovation in specific sectors of the UK economy. These case studies are based on interviews with individuals and representatives of relevant organisations, as well as reviews of the research literature relating to these sectors.

Contents

Part I: The UK underperforms on traditional innovation indicators and has built policy and structures to remedy this

1.1. Innovation is vital to meeting the national challenges of the 21st century

Innovation is regarded as the major source of competitive advantage for mature economies such as the UK in an increasingly competitive global economy.[1] As the economist Baumol put it: "Under capitalism, innovative activity – which in other types of economy is fortuitous and optional – becomes mandatory, a life-and-death matter."[2] More recently, innovation has been closely associated with the concept of the 'knowledge economy', that is, the theory that advanced economies are increasingly based on the production, distribution and use of knowledge, and that their future competitive advantage lies in how efficiently and effectively they are able to engage in these activities.[3]

At a national level, variations in levels of innovation are related to economic growth and trade performance.[4] At the level of individual businesses, investments in innovation enable enterprises to outperform their competitors. Innovations in processes, products, services and expansion into new markets are crucial if UK enterprises are to thrive in a globalised economy, and so benefit UK society by contributing to wealth creation and employment.[5]

Further, there is a broader need for innovation in order to find new solutions to seemingly intractable social problems, to improve the quality of life and to provide greater economic and social opportunities for more UK citizens. In particular, the challenges of an ageing population, healthy living, social cohesion and the need for greater environmental sustainability will require innovative solutions

However, as the OECD has noted: "Innovation policy in OECD countries has mostly been seen as an extension of R&D [research and development] policy. As such it has been linked to research and technological development. This remains the case, even though the systemic approach developed under the label 'National Innovation Systems' (NIS) during the 1990s expanded this perspective to include interactive linkages in the innovation system."[6]

1.2. The UK performs poorly on traditional innovation indicators

The notion that the UK performs poorly in innovation tends to rely on traditional indicators of innovation, such as public and private investment in R&D, private sector engagement in innovation activity, and the number of patents registered.[7]

1.2.1. Low investment in science base, but relatively high scientific productivity

Public sector R&D expenditure remains comparatively low despite significant increases in the UK's science budget in the last few years (net government expenditure in science, engineering and technology by UK central government departments has risen in real terms from £1.55 billion in 1994-5 to an estimated £2.55 billion in 2004-5). According to the Office of Science and Innovation, government internal expenditure on R&D in 2003 was 0.18 per cent of GDP, up from 0.17 per cent in 2002, compared to the US at 0.33 per cent, the EU average of 0.24 and the G7 average of 0.26 per cent.[8]

However, this low spend does at least appear to be highly productive: the UK consistently scores highly in the numbers of scientific papers and citations per capita compared to the US, France and Germany.[9] Despite having

1. The Department of Trade and Industry (DTI) defines innovation as the successful exploitation of new ideas, see Department of Trade and Industry (2003), Innovation Report, Competing in the Global Economy: The Innovation Challenge, (DTI, London).

2. p.1, Baumol, W. J. (2002), The Free-Market Innovation Machine: Analyzing the Growth Miracle of Capitalism, (Princeton University Press, Princeton).

3. For example, see Organisation for Economic Co-operation and Development (1996), The Knowledge-Based Economy, (OECD, Paris).

4. See Metcalf, J. S. (1998), Evolutionary Economics and Creative Destruction, (Routledge, London). Also Fagerberg, J. (1987), 'A Technology Gap Approach to Why Growth Rates Differ', Research Policy, 16, pp.87–99, and Fagerberg, J. (2002), Technology, Growth and Competitiveness: Selected Essays, (Edward Elgar, Cheltenham).

5. For example, see the discussion in The Young Foundation (2006), Social Silicon Valleys, A Manifesto for Social Innovation, (The Young Foundation, London).

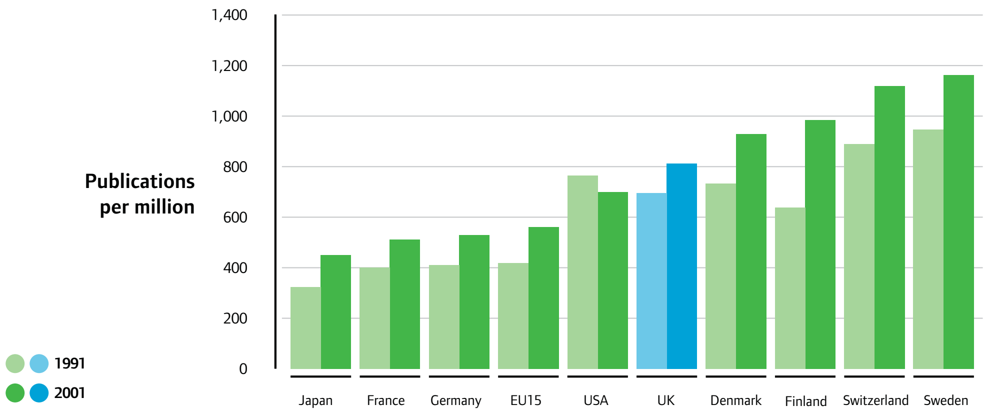
6. p.7, Organisation for Economic Co-operation and Development (2005), Governance of Innovation Systems, Synthesis Report Volume 1, (OECD, Paris).

7. International comparative surveys tend not to provide breakdowns within countries, hence data specific to the UK nations is not available from these surveys.

8. Office of Science and Technology (2003), Science, Engineering and Technology Indicators, (OST, London).

9. Organisation for Economic Co-operation and Development (2005), Main Science and Technology Indicators (MSTI): 2005/2 Edition, (OECD, Paris).

Figure 1: Science and engineering publications per million population (1991, 2001)



Source: Institute for Scientific Information (ISI) Science Citation Index (SCI).[11]

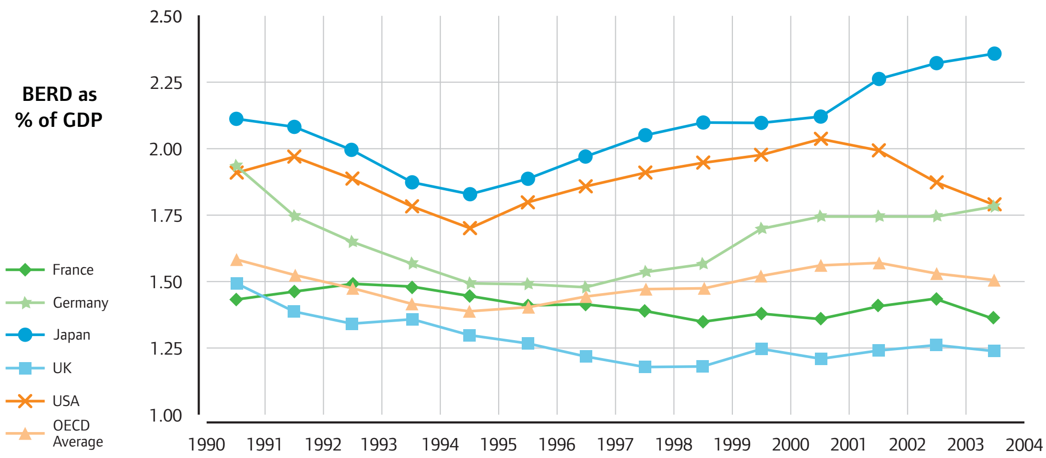
only one per cent of the world population, the UK is responsible for five per cent of world science, publishes more than 12 per cent of all cited papers and nearly 12 per cent of papers with the highest impact.[10] But the UK does not perform as well as some other European countries such as Switzerland, Sweden, Finland and Denmark (see Figure 1).

Further, the UK science system represents a smaller investment per capita than many of its competitors. In 2000, a study found the UK was ranked sixteenth in the OECD in its per capita investments in Higher Education Investments in R&D (HERD).[12] This is about half the amount of Sweden and Switzerland, just under two-thirds that of the US and slightly less than in Germany and France.

1.2.2. Only average private sector expenditure on R&D

Firms need to engage in complementary internal research in order to take advantage of public sector research.[13] However, the UK performs only averagely in business expenditure on R&D (BERD).[14] The UK is below the OECD average[15] and below its peer group of EU countries (Belgium, Netherlands, Austria, France and Italy).[16] This is a longstanding issue; business expenditure on R&D (BERD) has been below that of competitors such as the US, France and Germany for many years (as illustrated in Figure 2), and has been identified repeatedly as a major issue for innovation in the UK.[17] Similarly, overall per capita expenditure on R&D (GERD)[18] in the UK is just half that in some other countries; the UK spends $566, compared to $1,005 in the US, $1,154 in Sweden, and $999 in Finland.[19]

Figure 2: Business R&D (BERD) as a percentage of GDP (1990-2003)



Source: OECD.[20]

10. HM Treasury/Department of Trade and Industry (2006), Productivity in the UK 6: Progress and New Evidence, (HM Treasury/DTI, London).

11. See: http://scientific.thomson.com/products/sci/.

12. According to a study published in 2000, see Salter, A., D'Este, P., Martin, B., Geuna, A., Scott, A., Pavitt, K., Patel, P., and Nightingale, P. (2000), Talent, Not Technology: Publicly Funded Research and Innovation in the UK, (Science and Technology Policy Research, University of Sussex, Brighton).

13. Ibid. Also Cohen, W., and Levinthal, D. (1990), 'Absorptive Capacity: A New Perspective on Learning and Innovation', Administrative Science Quarterly, 35, pp.123–33.

14. According to the definition that is used for tax purposes in the UK, R&D is defined as any project to resolve scientific or technological uncertainty aimed at achieving an advance in science or technology (advances include new or improved products, processes and services), see Department of Trade and Industry (2004), Guidelines on the Meaning of Research and Development for Tax Purposes, (DTI, London). This definition is based on the OECD's Frascati Manual, see Organisation for Economic Co-operation and Development (2002), Frascati Manual 2002, (OECD, Paris).

15. Organisation for Economic Co-operation and Development (2005), OECD Science, Technology and Industry Scoreboard 2005, Briefing Note for the United Kingdom, (OECD, Paris).

16. European Commission (2005), Annual Innovation Policy Trends and Appraisal Report, United Kingdom 2004-2005, (European Commission, Brussels).

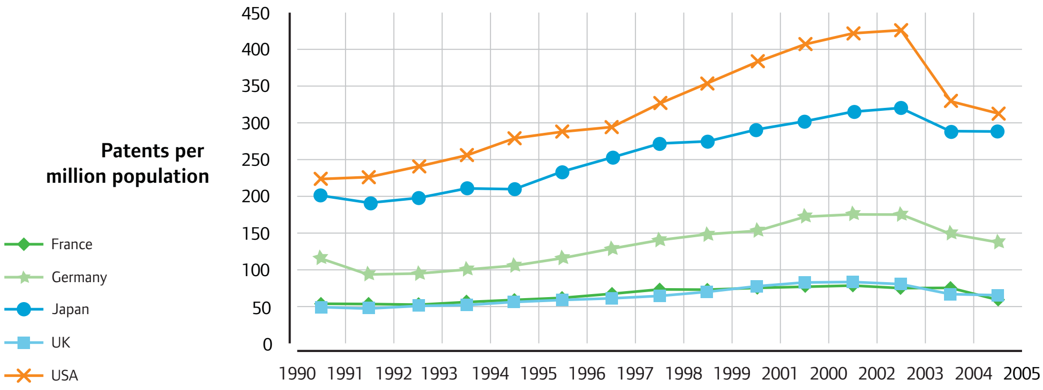
17. For example, Department of Trade and Industry (2003), Innovation Report, Competing in the Global Economy: The Innovation Challenge, (DTI, London).

18. Gross domestic expenditure on research and development (GERD) is the total intramural (government and business funded) expenditure on research and development performed on a national territory during a given period, see Organisation for Economic Co-operation and Development (2002), Frascati Manual 2002, Proposed Standard Practice for Surveys on Research and Experimental Development, (OECD, Paris).

19.Organisation for Economic Co-operation and Development (2005), Main Science and Technology Indicators (MSTI): 2005/2 Edition, (OECD, Paris).

20. Ibid.

Figure 3: US patents granted per million population (1990-2004)



Source: OECD, US Patent Office.[25]

Another measure is that of 'R&D intensity' (total expenditure on R&D as a percentage of national GDP). The UK's R&D intensity, at 1.9 per cent of GDP in 2003, is below that of its competitors. It is lower than Japan (3.2 per cent), Germany and the United States (2.6 per cent), France (2.2 per cent), and the EU-15 average (2.0 per cent).[21] Further, the UK's current level of R&D intensity is below that of the early-1990s, when it spent about 2.1 per cent of GDP on R&D.[22]

1.2.3. UK businesses display low levels of innovative activity

According to the Third Community Innovation Survey (CIS 3) only 38 per cent of UK enterprises were engaged in 'innovation activities'; three percentage points below the EU average and well below Germany (61 per cent) and Sweden (47 per cent) and the Netherlands and Finland (45 per cent).[23] The picture is even worse when more radical forms of innovation are considered: only 21 per cent of UK enterprises were engaged in product innovation (firms that reported the introduction of new or significantly improved goods or services in the three-year period 1998–2000), compared to an EU average of 31 per cent, and well behind the equivalent figures for Iceland (46 per cent) and Germany (42 per cent).

Similarly, according to the OECD, UK SMEs are well below the OECD average in the percentage innovating in-house (less than 23 per cent compared to an EU average of nearly 32 per cent and nearly 55 per cent of Swiss businesses), and below the average in being involved in innovation co-operation (just over 22 per cent compared to an EU average of nearly 32 per cent and nearly 55 per cent of Swiss SMEs).[24]

1.2.4. UK lags behind Germany, US and Japan on patenting

Patenting in the US is often used as a proxy for overall patent activity because most economically significant innovations are likely to be patented in the world's largest market. Given the UK's comparatively low investment in innovation, it might not be a surprise that it lags behind Germany and Japan in patenting activity (based on the number of patents granted in the US, as illustrated in Figure 3).

Lastly, according to a study conducted for the DTI by Michael Porter and Christian Ketels, UK patenting in the US is characterised by a low representation of universities and other public institutions.[26] By comparison, France, a country with a roughly equal level of overall US patenting, registers a significantly larger role for universities and research institutions. This suggests that UK universities are less active in commercialisation efforts than their peers in other advanced economies.[27]

21. The US has such a high GDP that this means that it spends more on R&D than the rest of the G7 combined, with its huge subsidies to university and SME research and large internal business R&D.

22. All data from Organisation for Economic Co-operation and Development (2005), OECD Science, Technology and Industry Scoreboard 2005, (OECD, Paris).

23. Department of Trade and Industry (2004), International Comparisons of the Third Community Innovation Survey, (DTI, London). 'Innovation active' here indicates that the firm reported the introduction of a new product or process and/or had innovation activities that were incomplete or abandoned in the period 1998-2000. Comparative international data is not yet available from the more recent survey covering 2002-2004, but the UK-only figures indicate an increase in the percentage of businesses that are involved in innovation activities to 57 per cent, see Department of Trade and Industry (2006), Innovation in the UK: Indicators and Insights, DTI Occasional Paper No. 6, (DTI, London).

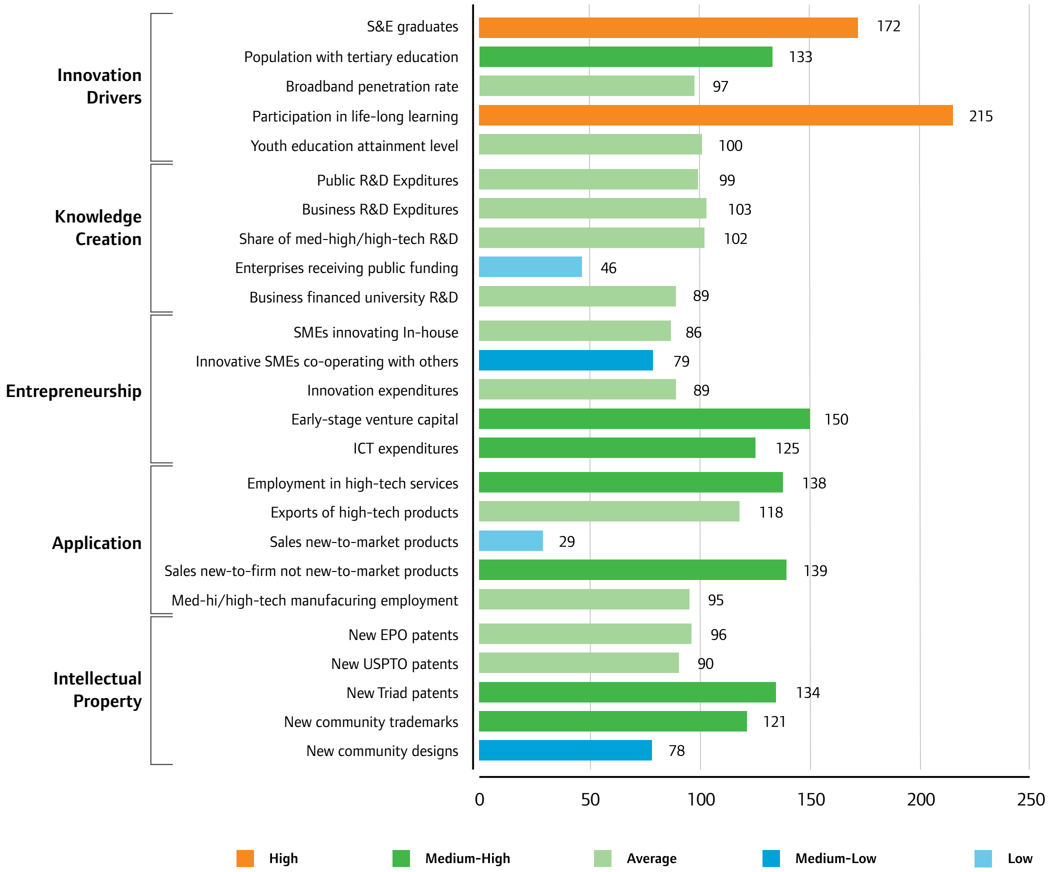
24. Organisation for Economic Co-operation and Development (2005), OECD Science, Technology and Industry Scoreboard 2005, (OECD, Paris).

25. Organisation for Economic Co-operation and Development (2005), Main Science and Technology Indicators (MSTI): 2005/2 Edition, (OECD, Paris); US Patent Office (2005), Patent Counts by Country/State and Year, All Patents, All Types, (USPTO, Alexandria VA).

26. p.24, Department of Trade and Industry (2003), UK Competitiveness: Moving to the Next Stage, (DTI, London).

27. Ibid.

Figure 4: European Innovation Scoreboard – UK performance relative to EU average



Source: European Commission.[28]

1.2.5. Poor performance on European Innovation Scoreboard (EIS)

The European Innovation Scoreboard (EIS) is a composite index of innovation (see Figure 4). It illustrates the UK's performance relative to the EU average, across a range of indicators (the EU average in this chart is represented by the value 100).[29] It shows that the UK has variable performance across these metrics, and in particular it appears to confirm that the UK declines in performance as it gets closer to the exploitation of innovation. This survey suggests that Sweden, Finland and Switzerland are the leading innovative countries in Europe

So, for example, the UK performs above the EU average in the number of science and engineering graduates that it produces, but below average in the percentage of university-based R&D financed by businesses, and well below average in the public funding of innovation (defined as the proportion of firms that have received any public financial support for innovation from at least one of three government levels, namely local, national or EU).

1.2.6. In sum, a distinctly poor performance

The general implication created by these indicators is that the UK wastes its innovative potential by failing to invest in innovation, particularly the commercial exploitation of ideas, despite its strengths in developing ideas in the first place. Business under-invests in innovation, does not sufficiently support university-based R&D, and under-protects the outputs of innovation through the use of patents. Similarly, public sector investment in innovation is well below that of our competitors (although this does generate high quality science). This picture suggests that the UK lags behind its competitors, and in particular is failing to turn high quality science into innovation, suggesting the need for greater links between university and industry. The implication is that by not producing enough knowledge, the UK is sowing the seeds of future prolonged economic decline.

28. European Commission (2005), European Trend Chart on Innovation, Innovation Strengths and Weaknesses, (European Commission, Brussels).

29. The EIS measures innovation performance across the European Union. It uses 26 indicators under five themes relating to innovation performance and compares performance against a European average, by combining data from the Community Innovation Survey with related data compiled by the OECD and EUROSTAT.

1.3. Public policy interventions have focused tightly on improving the UK's poor performance against traditional indicators

For additional detail, please see Appendix B.

1.3.1. Innovation has been recognised as a priority by the UK and EU

As a result of an increasing awareness of the importance of innovation and in response to figures such as those quoted above, the last 10 years have seen innovation become a high priority for UK policymakers.

Unsurprisingly, policy has focused around improving poor performance against the measures outlined above. Compounded by analyses that have pointed to the persistence of the productivity gap with main competitors,[30] the result has been a range of central strategies and initiatives that have focused on Science, Engineering and Technology (SET) areas.[31] The UK nations have reflected a similar emphasis on SET, R&D in advanced technologies, and university-business collaborations, as have the initiatives of the English regions.

The UK's concerns regarding its innovation performance have been mirrored at the European level. There is a large gap in R&D investment between the EU and the US and Japan. As a result, since the mid-1990s a succession of measures to increase R&D spend have been introduced, including the fifth Research and Technological Development (RTD) framework programme, adopted in 1998. This included a programme for the promotion of innovation and the role of SMEs in particular. More recently, in March 2000, the Lisbon Council committed the EU to the objective of becoming the "most competitive and dynamic knowledge-based economy in the world" by 2010.[32] In 2002 the EU established the goal of increasing its R&D expenditure to three per cent of GDP by 2010 (it was 1.81 per cent in 2003).

1.3.2. UK central government policy and structures reflect this priority but with a clear focus on SET

The Department of Trade and Industry (DTI's) *Innovation Report* (2003) stated that the government wanted "the UK to be a key knowledge hub in the global economy… In terms of business R&D and patenting we will aim to be the leading major country in Europe within ten years."[33] It went on to make a number of general recommendations, including for the development of a Technology Strategy.

The following year (2004), the *Lambert Review* of business–university collaboration made several recommendations to improve links between universities and businesses, which the Government accepted.[34] This was prompted by the recognition that while UK firms have many network relationships, relatively few cite universities or public research institutes as partners in these networks. The Review gave support to two existing schemes, LINK and Knowledge Transfer Partnerships (KTPs) and suggested an extension to the Higher Education Innovation Fund (HEIF) as ways of allocating funding for business-relevant research. The *Science and Innovation Investment Framework 2004-2014*, published jointly by HM Treasury, the DTI and the Department for Education and Skills (DfES) in July 2004, set out a series of goals for public and private sector R&D activity, for interactions between business and the publicly-funded research base, and improvements in SET skills.[35] It further established a target to increase the UK's R&D intensity from 1.9 per cent in 2003 to 2.5 per cent by 2014.

Because of its heritage in science and technology policy, the DTI has emerged as the focal point for the governance of the current UK system of innovation. Within the DTI, the Office of Science and Innovation (OSI) evolved out of the Office of Science and Technology (OST) and is responsible for the funding of basic university research largely via the research councils. The Technology Strategy Board (TSB) is a high-level forum for interaction between business, government and other stakeholders that advises the Secretary of State for Trade and Industry on business research, technology and innovation priorities for the UK. Following the publication of the *Innovation Report*, the Steering Group on Innovation in the Knowledge Economy (chaired by the Secretary of State for Trade and Industry) meets on a quarterly basis with the intention of coordinating the work of all Government departments on the science, innovation and wealth creation agendas.

30. For example, the review conducted by Michael Porter and Christian Ketels, Department of Trade and Industry (2003), UK Competitiveness: Moving to the Next Stage, (DTI, London).

31. For example, Department of Trade and Industry (2003), Innovation Report, Competing in the Global Economy: The Innovation Challenge, (DTI, London); Department of Trade and Industry/HM Treasury/ Department for Education and Skills (2002), Investing in Innovation, A Strategy for Science, Engineering and Technology, (DTI/HM Treasury/DfES, London); and HM Treasury/Department of Trade and Industry/Department for Education and Skills (2004), Science & Innovation Investment Framework 2004-2014, (HM Treasury/DTI/DfES, London).

32. See European Commission (2003), Innovation Policy: Updating the Union's Approach in the Context of the Lisbon Strategy, (European Commission, Brussels), and European Commission (2003), More Research and Innovation - Investing for Growth and Employment: A Common Approach, (European Commission, Brussels).

33. p.3, Department of Trade and Industry (2003), Innovation Report, Competing in the Global Economy: The Innovation Challenge, (DTI, London).

34. HM Treasury (2003), Lambert Review of Business–University Collaboration: Final Report, (HM Treasury, London).

35. HM Treasury/Department of Trade and Industry/Department for Education and Skills (2004), Science & Innovation Investment Framework 2004-2014, (HM Treasury/DTI/DfES, London).

These policies and structures have resulted in a number of specific initiatives, a few of which are highlighted here (for additional detail, see Appendix B). KTPs provide financial support for collaborative projects between businesses and individuals from public or private research organisations. Knowledge Transfer Networks provide grants to set up networks in specific technology areas. The Higher Education Innovation Fund (HEIF) is spending £187 million for knowledge transfer activities in 2004–06.

Perhaps the most prominent policy is the R&D tax credits scheme. These credits are a company tax relief which can either reduce a company's tax bill or, for some SMEs, provide a cash sum. Their aim is to encourage greater R&D spending in order to promote investment in innovation. Between April 2000 and April 2005, around 17,000 claims for R&D tax credits were made with around £1.3 billion of support claimed.[36]

1.3.3. Scotland prioritises a broad innovation agenda, but initiatives focus on SET and knowledge-transfer

The Scottish Executive has a dual role, in having responsibility for policy formulation but also in administering a number of schemes designed to enhance innovation in Scotland.[37] Scottish Enterprise, the main economic development agency for Scotland, plays a leading role in the direction and implementation of policy on R&D and innovation. These priorities have largely grown from the analyses set out in the *Framework for Economic Development in Scotland, A Science Strategy for Scotland and the Smart, Successful Scotland Strategy*.[38] The last of these identified four core themes: productivity (and the 'productivity gap' with other leading competitor nations); entrepreneurship (in particular, raising the rate of new firm formation); the skills required for a flexible labour market; and 'digital connections.' This has led to several initiatives: the Scottish Funding Council's Knowledge Transfer Grant (doubled in size to at least £12 million for 2005-06); a newly-revamped Technology Ventures Scotland (TVS) to advise on policies and projects relating to commercialisation and technology transfer and the SCORE (SME Collaborative Research programme); and SEEKIT (Scottish Executive Expertise, Knowledge & Innovation Transfer grant scheme) initiatives intended to boost interaction between industry and the science base.

1.3.4. Northern Ireland's policy closely resembles that of the DTI

In Northern Ireland, the innovation strategy was developed in parallel with the DTI *Innovation Report*. This strategy, *Think, Create, Innovate*, was published in 2003, with an emphasis on the better integration of public, private and higher education R&D efforts as well as the need to increase levels of R&D expenditure throughout the region.[39] In the more recent Action Plan there are six areas for action (all of which display a familiar emphasis): resourcing R&D; supporting knowledge and technology transfer; developing a greater awareness of intellectual property management; leading a regional innovation system (including establishing a Regional Science-Industry Council); promoting cross-sectoral collaborations; and enhancing interregional collaborations (across the UK, Ireland, the EU and beyond).[40]

Similar to England, the lead department in innovation has been the Department of Enterprise, Trade and Investment (DETI). Invest NI was established in 2002 as the main economic development organisation in Northern Ireland and promoting innovation is one of its core objectives (especially higher R&D spending and knowledge transfer). Together, as part of the Regional Innovation Strategy, a Higher Education Innovation Fund for Northern Ireland has been established, along with a Pilot Proof of Concept Fund and 18 Research & Technological Development (RTD) centres of excellence (in areas such as nanotech, genomics and integrated aircraft technology, where the region has the skills and institutions to be internationally competitive). These are in addition to Invest NI's complementary pre-competitive research, near-market and technology transfer programmes that seek to ensure the participation of SMEs and micro-businesses in the region's R&D.[41]

36. Department of Trade and Industry website, accessed 10th July 2006.

37. See the study commissioned by the Scottish Executive, Roper, S., and Love, J. (2006), The Scottish Innovation System: Actors, Roles and Actions, (Aston Business School/Cardiff University, Birmingham/Cardiff).

38. Scottish Executive (2001), A Smart, Successful Scotland, Ambitions for the Enterprise Networks, (Scottish Executive, Edinburgh), Scottish Executive (2004), A Smart, Successful Scotland, Strategic Direction to the Enterprise Networks and An Enterprise Strategy for Scotland, (Scottish Executive, Edinburgh).

39. Department of Enterprise, Trade and Investment (2003), Think, Create, Innovate, (DETI, Belfast).

40. Department of Enterprise, Trade and Investment (2005), The Regional Innovation Strategy for Northern Ireland, Action Plan September 2004 to August 2006, (DETI, Belfast).

41. These programmes include Compete, START, SMART, Product & Process Development (PPD), and KTP. Increasingly, this support is being focused on services, for example. Invest NI has made nearly £4 million available for developing and adapting ICT under the Compete programme in 2004-2006.

1.3.5. In Wales, a linked innovation and entrepreneurship agenda

In Wales, the Assembly Government's *Innovation Action Plan* (2003) established five broad themes for establishing a stronger culture of innovation in Wales: communicating the importance and benefits of innovation to business; supporting high growth businesses; better equipping people to innovate; building the best innovation support provision; and encouraging technology development, transfer and commercialisation, and closer links between academia and businesses more generally.[42] This was followed in 2005 by the Assembly Government's Strategic Framework for Economic Development consultation document, *Wales: A Vibrant Economy.*[43]

In Wales, the innovation agenda was initially led by the Welsh Development Agency through the 'Innovation Works' campaign and has now been taken over by the Welsh Assembly Government's Department of Enterprise, Innovation and Networks. Support for high growth businesses has been delivered in particular through the network of Technium centres that provide high-tech incubator space and links to research and expertise in higher education institutions. Support for innovation is further provided through the Knowledge Bank for Business to provide tailored advice and support to businesses with high growth potential. The service includes diagnostic review and benchmarking, and training on finance, innovation management, and performance improvement. Other important science and technology facilities include the Institute of Life Sciences in Swansea, The Centre for Advanced Software Technology in Bangor and ECM2 in Port Talbot.

1.3.6. Innovation is a priority for the English regions, but again a focus on SET and knowledge-transfer

The nine Regional Development Agencies (RDAs) are the main vehicles for the delivery of the DTI's innovation policies in the English regions and as such hold the lion's share of budget and responsibility for the innovation agenda. The RDAs develop Regional Innovation Strategies (RIS) in consultation with a wide range of regional and local actors. These typically prioritise regional networks that foster collaboration, the exchange of good practice, and the level of interaction between universities/research institutions with local/regional businesses, particularly SMEs. The RDAs have also established Science and Industry Councils (SICs) or similar arrangements, to bring together science, technology and business representatives from the private sector and universities.

Collectively, the RDAs are putting an increasing focus on innovation as a driver of economic development. In 2001-02, the DTI established a £15 million Innovative Clusters Fund (ICF) for RDAs to promote cluster development and business incubation. A further £35 million was provided by the DTI as part of the then Regional Innovation Fund (RIF).[44] Other regional innovation support mechanisms include the Regional Venture Capital Funds (RVCFs) and the Centres of Industrial Collaboration (CICs). Further, the three northern RDAs have committed to promoting Science Cities as part of their £100 million investment in university-business collaboration over the next six years. This has already started with Manchester, York and Newcastle. The March 2005 budget confirmed that three further Science Cities are to be developed in Bristol, Birmingham and Nottingham.

42. Welsh Assembly Government (2003), Wales for Innovation, The Welsh Assembly Government's Action Plan for Innovation, (WAG, Cardiff).

43. Welsh Assembly Government (2003), Wales: A Vibrant Economy, (WAG, Cardiff).

44. The RIF has now been subsumed within the 'single pot' funding arrangements for the RDAs, increasing their flexibility to mix funds to promote regional economic development

Part II: Traditional indicators ignore large and important sectors of the UK economy

2.1. The UK Paradox: economic success 'without innovation'

The notion of the 'European paradox' has been widely discussed. This refers to the notion that allegedly better European science is not translated into innovations at the same rate as in the US.[45] However, another paradox exists with regards to the UK. This is that the UK apparently fails to invest in innovation and yet has retained its position as one of the largest, most advanced and most successful economies in the world.

The UK is the fifth biggest economy in the world and has one of the strongest economies in Europe. The UK's GDP growth in 2005 was above that in the Euro area as a whole for the tenth consecutive year, with average growth since 1997 only behind that of the US amongst the G7 economies. More than two million new jobs have been created since 1997, yet economic volatility is at historically low levels and is now the lowest in the G7. Inflation, interest rates, and unemployment remain comparatively and historically low. The UK came first in a recent OECD review of 30 countries for macro-economic performance between 1998-2004 and second for liberal product market regulation.[46]

How can such an economy, such a country, appear to perform so poorly in innovation and yet still be so successful? The resolution of this paradox lies in flaws in the traditional indicators of innovation, and this has important implications for innovation policy in the UK.

2.2. The understanding of innovation on which the traditional indicators are based is out-dated

2.2.1. The nature of innovation has changed – and so have academic understandings of innovation

New and distinct forms of innovation are constantly emerging, related to new industrial sectors and forms of organisation. This is reflected in the increasing complexity of industrial innovation processes.[47]

Necessarily, academic models of innovation are historically contingent. Between the 1950s and 1980s innovation was understood by focusing on discrete events such as discoveries and inventions, especially within universities and firms. This view, the so-called 'linear model,' assumed a central role for formal (especially scientific or technological) R&D in the development of new products or processes, and that research in universities is followed directly by its application in industry.[48]
This reflected the form of industrial organisation based around the scale-intensive mass-production of consumer goods and new science-based industries such as chemicals that began to emerge in the US in the late nineteenth century. These firms developed R&D laboratories and employed increasing numbers of scientists and engineers, to ensure that the complex production systems to generate consumer goods were efficiently managed.

45. However, this supposed paradox has been heavily criticised. Dosi et al. have highlighted that the paradoxical result that more European science is not translated into more technology is based on a deeply flawed understanding of relative performance of the EU and US science systems that fails to take into consideration the larger population of the EU. While it is true that the EU now produces more scientific papers in absolute numbers, that is not true per capita and the US has substantially better performance in terms of citations and highly cited papers. The problem with the EU is not due to a lack of linkages to industry from universities or a lack of networks, but a lack of high quality academic research. See Dosi, G., Llerena, P., and Labini, M. (2005), Science-Technology-Industry Links and the "European Paradox": Some Notes on the Dynamics of Scientific and Technological Research in Europe, working paper 2005/2, (Laboratory of Economics and Management (LEM), Sant' Anna School of Advanced Studies, Pisa, Italy).

46. Organisation for Economic Co-operation and Development (2005), Economic Survey of the UK, (OECD, Paris).

47. For example, see Granstrand, O., Patel, P., and Pavitt, K. (1997), 'Multi-technology Corporations: Why They Have 'Distributed' Rather than 'Distinctive Core' Competencies', California Management Review, 39, pp.8–25.

48. Kline and Rosenberg highlighted two problems with the linear model. First, that it generalises a chain of causation from R&D to innovation that is true only of a minority of innovation processes. Second, it ignores all the feedback loops involved in the process of innovation by under-estimating the uncertainties involved. See Kline, S. J., and Rosenberg, N. (1986), 'An Overview of Innovation', pp.275–304, in Landau, R., and Rosenberg, N. (eds.), The Positive Sum Strategy: Harnessing Technology for Economic Growth, (National Academy Press, Washington DC).

49. Nightingale, P., Brady, T., Davies, A. C., and Hall, J. (2003), 'Capacity Utilisation Revisited: Software Control and the Growth of Large Technical Systems, Industrial and Corporate Change, 12 (3), pp.477-517.

50. p.12, Fagerberg, J. (2005), 'Innovation: A Guide to the Literature', pp.1-26, in Fagerberg, J., Mowery, D., and Nelson, R., (eds.), The Oxford Handbook of Innovation, (Oxford University Press, Oxford). Also Lundvall, B., (1988), 'Innovation as an Interactive Process: From User–Producer Interaction to the National System of Innovation', pp.349–69, in Dosi, G., Freeman, C., Nelson, R., Silverberg, G., and Soete, L. G. (eds.), Technical Change and Economic Theory, (Pinter, London).

For these firms, innovation involved both product innovation driven by design teams and R&D laboratories, and process innovations produced by internal production engineering or sourced from external capital goods suppliers. The wider contexts and consequences of innovation were rarely considered in the initial post-war period of high consumer demand. This linear model may have been accurate in the 1950s, but was less so in the 1970s, and is not universally applicable now.

Another shift in industrial organisation occurred towards the end of the twentieth century with the wider application of IT, which has transformed a range of industries particularly in services such as finance, media and telecommunications.[49] In these sectors, product, service and process innovations are often bundled together and frequently depend on sophisticated software systems. Much of the innovation in these sectors takes place outside of formal R&D (this also means that much of the innovation in these sectors is not patented, although it is sometimes protected by copyright). In this context, innovation depends heavily on external sources of knowledge, and this systemic nature of innovation is increasing.[50]

Academics have adapted their understandings of innovation to reflect the prevalent forms of innovation that have emerged. For example, progressively, attention has been placed on how innovation is generated within the firm (organisational innovation), the factors that shape innovation (such as regulation), and the distribution of innovative labour and intelligence in networks. The networked model of innovation was developed predominantly in studies of software and IT (although it originated in studies of the Danish dairy industry in the 1980s), but it has now been applied across many sectors as a way of studying the interdependencies between actors.

R&D remains important to innovation, but its importance and nature differs between sectors.[51] Even in R&D intensive sectors, the majority of R&D focuses on development rather than research,[52] and knowledge often flows from development to research (as development work generates questions that require scientific analysis).[53] It is therefore misleading to privilege scientific research, particularly within universities, as a source of innovation. When firms are asked about the sources of knowledge for innovation, university research tends to come a long way down the list, suggesting that its importance is being over-estimated within current policy thinking.[54] R&D intensive firms in the UK typically generate as much scientific output as a medium sized university such as Sussex.[55] Similarly, approximately a quarter of the scientific publications with multiple authors produced in the UK have an author located within the NHS.[56]

Further, it is now recognised that much of the economic benefit from innovation occurs when knowledge and technology are diffused widely and other incremental innovations develop as a result.[57] The development and diffusion of discoveries and inventions can take many decades, as incremental innovations that improve on and adapt the original 'radical innovation' are generated.[58] This aspect of innovation is substantially more economically important than the initial introduction of the discovery or invention.[59] For example, the first internet was built in 1968 for United States Defense Department by the firm Bolt, Beranek and Newman, but it was only with the invention of the World Wide Web by Tim Berners-Lee in the 1990s that the internet as we know it began to transform society. Similarly, the first successful low-cost airline was Pacific Southwest Airlines in the United States, whose first flight was in 1949, many decades before the highly publicised success of EasyJet, Ryanair and JetBlue. In this sense, most innovation is not new. One well-known study of product development surveyed 13,000 'new' products introduced by 700 companies and found that 'new to the world' products represented only 10 per cent of the sample; many of the products were in fact line extensions, improvements or revisions.[60]

The problem is that a gap has opened up between the practice, the theory, the measurement (and subsequently policies) of innovation. This is the true 'innovation gap,' and it can produce a misleading view of national innovation performance.

51. A number of taxonomies have been developed that show different patterns of innovation. For example, Pavitt's taxonomy highlighted two high-tech sectors: 'science based', where innovation involved strong links to research and heavy investments in R&D; and 'specialised suppliers', involving lots of interaction with users and capabilities in specialised engineering. There was also a 'scale intensive' sector that innovated in production engineering and 'supplier dominated' that innovated by drawing on technology from suppliers. See Pavitt, K. (1984), 'Patterns of Technical Change: Towards a Taxonomy and a Theory', Research Policy, 13, pp.343-74.

52. National Science Foundation (2000), Science and Engineering Indicators 2000, (NSF, Arlington, VA).

53. This pattern can be picked up in patent and scientific publication data that shows that the relative performance of post-War science in the UK, Japan and Germany has lagged rather than led relative performance in technology, see Pavitt, K. (1999), Technology, Management and Systems of Innovation, (Edward Elgar, Cheltenham).

54. For example, a Cambridge-MIT study shows that in both the US and the UK universities rank well down the list of sources of knowledge for firms (and this study focused disproportionately on high tech manufacturing and services). See Cambridge-MIT Institute (2006), Measuring University-Industry Linkages, (Cambridge-MIT Institute, Cambridge).

55. Hicks, D. (1995), 'Published Papers, Tacit Competencies and Corporate Management of the Public/Private Character of Knowledge', Industrial and Corporate Change, 4, pp.401-424.

56. Hicks, D. M., and Katz, J. S. (1996), 'Hospitals: A Hidden Research System', Science and Public Policy, 23 (5), pp.297-305. Given that the measure here is publications, this data is likely to continue to over-estimate the relative importance of universities compared to other institutions and industry.

57. For example, in the industrial revolutions of steam and electricity, see Crafts, N. (2004), 'Steam as a General Purpose Technology: A Growth Accounting Perspective', The Economic Journal, 114, pp.338-351, and von Tunzelmann, G. N. (1978), Steam Power and British Industrialization to 1860, (Clarendon Press, Oxford), and more recently on IT, David, P.A. (1990), 'The Dynamo and the Computer: An Historical Perspective on the Modern Productivity Paradox', The American Economic Review, 80 (2), pp.355-361. See also Rosenberg, N. (1979), 'Technological Interdependence in the American Economy', Technology and Culture, 20 (1), pp.25-51.

58. Rosenberg, N. (1982), Exploring the Black Box, (Cambridge University Press, Cambridge), and Freeman, C. (1982), The Economics of Industrial Innovation, (Pinter, London).

59. p.283, Kline, S. J., and Rosenberg, N. (1986), 'An Overview of Innovation', pp.275–304, in Landau, R., and Rosenberg, N. (eds.), The Positive Sum Strategy: Harnessing Technology for Economic Growth, (National Academy Press, Washington DC). Also, Mowery, D., and Rosenberg, N. (1998), Paths of Innovation, Technological Change in 20th-Century America, (Cambridge University Press, Cambridge), and p.8, Fagerberg, J. (2005), 'Innovation: A Guide to the Literature', in Fagerberg, J., Mowery, D., and Nelson, R. R., The Oxford Handbook on Innovation, (Oxford University Press, Oxford).

60. Booz, Allen and Hamilton (1982), New Product Management in the 1980s, (Booz, Allen and Hamilton, New York).

61. Office for National Statistics (2005), United Kingdom Input-Output Analyses, (HMSO, London). GVA measures the contribution to the economy of each individual producer or sector.

62. Organisation for Economic Co-operation and Development (2005), OECD Science, Technology and Industry Scoreboard 2005, (OECD, Paris).

63. Office for National Statistics (2005), United Kingdom Input-Output Analyses, (HMSO, London).

64. Organisation for Economic Co-operation and Development (2005), The Service Economy in OECD Countries, (OECD, Paris).

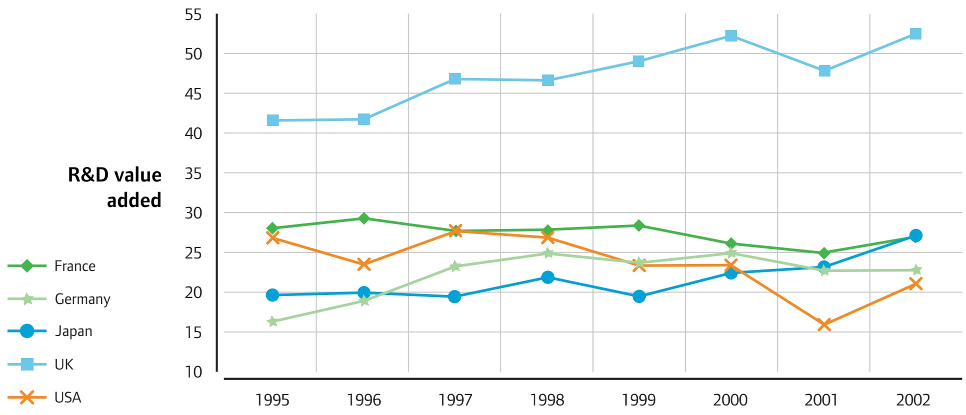
65. These figures relate to 1990-2000. See Griffith, R., and Harrison, R. (2003), Understanding the UK's Poor Technological Performance, (Institute for Fiscal Studies, London).

66. Godin, B. (2002), 'The Number Makers: Fifty Years of Official Statistics on Science and Technology', Minerva, 40 (4), pp.375-397.

67. For example, from the classic SAPPHO project: Rothwell, R. (1972), Factors for Success in Industrial Innovations from Project SAPPHO – A Comparative Study of Success and Failure in Industrial Innovation, (SPRU, Brighton); Rothwell, R., Freeman, C., Horsley, A., Jervis, V. T. P., Robertson, A. B., and Townsend, J. (1974), SAPPHO Updated – Project SAPPHO Phase II, (Harvard School Press, Cambridge, Massachusetts).

68. p.165, Smith, K. (2005), 'Measuring Innovation', chapter six in Fagerberg, J., Mowery, D., and Nelson, R. R., The Oxford Handbook on Innovation, (Oxford University Press, Oxford).

Figure 5: R&D as a proportion of value added in the pharmaceutical sector



Source: SPRU calculation based on OECD data.

2.2.2. Traditional indicators are weak measures for contemporary innovation, particularly in the UK

Traditional indicators neglect the extent and diversity of innovation in the UK, and so produce an unfairly negative analysis. They conceptualise innovation primarily as a new product or process developed through technological advancement (more akin to the linear model of innovation described above). This is relevant to high-tech manufacturing but far less so for other sectors that are vastly more important to the UK economy.

Manufacturing now accounts for less than 15 per cent of total GVA in the UK, and its contribution has fallen every year since 1998.[61] This is less than half that of the business and financial services sector, which forms the largest single sector of the UK economy, accounting for 31.7 per cent of the total GVA of the economy in 2003. High-tech manufacturing sectors account for only 2.5 per cent of the UK economy (medium-high tech manufacturing sectors account for a further 3.6 per cent of the economy).[62] Business and financial services are continuing to increase in importance, growing by more than 8.4 per cent from 2002-2003, faster than the overall growth in GVA of 5.5 per cent.[63] Comparative data from the OECD suggests that the growth of the UK's services sectors has been particularly pronounced compared to other countries.[64]

Since most innovation in the UK therefore occurs outside of manufacturing, it follows that most innovation is not based on traditionally-defined formal R&D; informal development activities (that is, more iterative and recursive processes of design, building and testing of new products, processes and services) are more significant and more common in most sectors. This has important implications for the interpretation of the traditional indicators of innovation.

2.2.2.1. The UK's sectoral composition accounts for much of its poor showing on business expenditure on R&D (BERD)

The UK's relatively poor showing on traditional indicators of investment in formal R&D is primarily down to business sectors. During the 1990s, compared to the US, the fall in industry-funded BERD in the UK accounts for the whole of the UK's poor relative performance in gross domestic expenditure on R&D (GERD) (while government-funded R&D made a positive contribution).[65]

However, R&D spend is a poor indicator of innovation for UK business. R&D statistics first emerged in the 1930s in countries such as the UK, the US, and Canada, but their subsequent development and adoption internationally owes much to the OECD, in particular the *Frascati Manual* which established a standard methodology for data collection.[66]

Yet numerous studies have shown that firms create new knowledge from a variety of sources such as their expertise in production, quality control and testing, and experience in marketing and feedback from customers.[67] Both non-R&D spending and spending on capital goods represent a larger proportion of investment in innovation than R&D (especially in small businesses, which tend not to have a formal R&D division).[68] Taking this into account, the picture is considerably different and much more positive. For instance, the UK performs very strongly in comparative spending on R&D in the pharmaceutical sector, a major sector of the UK economy where formal R&D is critical to new product development (Figure 5).

Table 1: Percentage share of GVA by sector and country (2002)

	US	UK	France	Sweden	Japan	Germany	Finland
Services	76.9	74.1	72.9	70.6	70.1	70	65.4
Industry	17.3	19.3	19.7	23.1	21.9	24.3	25.7
Construction	4.8	5.7	4.9	4.4	6.7	4.5	5.4
Agriculture	1.0	0.9	2.6	1.8	1.3	1.1	3.5

Source: OECD.[69]

Table 2: Technology-intensive sectors' percentage share of GVA by country (2002)

	Finland	Japan	Sweden	US	UK	Germany	France
High technology manufacturing	5.6	3.1	3.0	2.8	2.5	2.4	2.4
Medium-high technology manufacturing	4.6	6.0	6.5	3.4	3.6	9.6	5.0
Low technology sectors	89.8	90.9	90.5	93.8	93.9	88.0	92.6

Source: OECD.[71]

More generally, the UK's aggregate R&D intensity is lower than many other countries largely because the composition of its industries is skewed towards industries (particularly services and oil and gas) where R&D intensity is lower and away from sectors such as information technology and electronics with high R&D intensities. The prominence of service sectors in the UK economy is second only to that of the US amongst a selected group of OECD countries, as Table 1 shows.

However, since most advanced economies are undergoing some degree of transition towards being more service-oriented as opposed to manufacturing-based, this does not explain all of the UK's poor relative performance in spending on formal R&D. Similarly, it is not because the UK specialises in low-technology manufacturing (it does not). Rather, it is because the UK is poorly represented in some areas of medium-high tech manufacturing (such as mass car production) where R&D expenditures are typically high.[70] For example, medium-high technology manufacturing comprises only 3.6 per cent of the UK economy, compared to 9.6 per cent in Germany and 6.5 per cent in Sweden. The UK's lack of reliance on high and medium-high technology manufacturing is shown in Table 2.

The relative decline in UK manufacturing (especially in sub-sectors related to machinery, equipment and transportation) helps to explain the majority of the UK's poor relative performance in business R&D.[72] For example, almost 45 per cent of the gap in BERD between the UK and Germany is due to the UK's poor relative performance in communications equipment, nearly as much is due to the countries' different industrial mix. The rest is due to its performance in car production, chemicals excluding pharmaceuticals, transportation equipment and computing machinery.[73] As such the traditional data less reflects that Germany has a more innovative economy than the UK, but rather that it specialises in sectors in which traditional innovation and traditional measures of innovation are more appropriate. The UK's performance is distorted because it has a very strong presence in both the highest and lowest R&D intensity sectors (such as oil and gas, food and telecoms), while it has a smaller presence ('performs poorly') in automotive, IT hardware and electronics R&D.

69. Organisation for Economic Co-operation and Development (2005), OECD Science, Technology and Industry Scoreboard 2005, (OECD, Paris).

70. The issue of what constitutes 'high-tech' sectors has been the focus of some (necessary) discussion in the academic literature. Some researchers focus on sectors with comparatively high R&D intensity (such as aerospace, pharmaceuticals and computers), while others such as Pavitt have extended the concept of 'high-tech' beyond science-based industries to include specialised suppliers that base their innovations on engineering and interactions with users; see Pavitt, K. (1984), 'Patterns of Technical Change: Towards a Taxonomy and a Theory', Research Policy, 13, pp.343-74. However, it has been suggested that the extent of the variance in R&D intensity across industries makes high-tech, medium-tech and low-tech misleading as terms, see Hughes, K. (1988), 'The Interpretation and Measurement of R&D Intensity - A Note', Research Policy, 17, pp.301-307. It should also be noted that the OECD's definition of 'high-tech' is based on the amount of R&D spent by a sector.

71. Organisation for Economic Co-operation and Development (2005), OECD Science, Technology and Industry Scoreboard 2005, (OECD, Paris).

72. Griffith, R., and Harrison, R. (2003), Understanding the UK's Poor Technological Performance, (Institute for Fiscal Studies, London).

73. Abramovsky, L., Harrison, R., and Simpson, H. (2004), Increasing Innovative Activity in the UK? Where Now for Government Support for Innovation and Technology Transfer?, (Institute for Fiscal Studies, London).

2.2.2.2. Innovation needs to be understood in light of patterns of specialisation

The UK has developed strongly in pharmaceuticals, biosciences more generally, chemicals, oil, many service sectors, particularly financial services, law and design, and the production and operation of the complex, software-intensive capital goods that underpin much of the global economy (such as aerospace, military systems, and complex IT systems). By contrast, we have slipped in mass production sectors, such as car production, and other sectors related to IT such as consumer electronics (although even here there are pockets of strong performance, particularly among foreign-owned firms operating in the UK).

The UK is not a high-tech manufacturing economy akin to Sweden, Finland, Switzerland, Japan or the US, so to make comparisons as if it is makes little sense. The DTI's *R&D Scoreboard* illustrates the importance of sectors and how, because sectors differ substantially in their use of R&D as a source of innovation, sectoral composition has a major influence on international performance.[74] Different countries have different R&D sector specialisations: IT, software and pharmaceuticals in the US, automotive and electronics in Japan, and pharmaceuticals and aerospace in the UK.[75] Indeed pharmaceuticals and aerospace and defence together contribute 52 per cent of the UK 750's R&D (UK top 750 companies list).

Comparisons of the number of firms in the R&D Global 1,000 and the FT Global 500 list of the world's largest companies show that Japan and Germany have high R&D scores because they are R&D specialists. Both have more than twice the proportion of top R&D companies than top firms by size.[76] The US is balanced and has similar proportions in both lists, while the UK, with its strength in financial services, resources and retailing, has a 50 per cent larger proportion in the FT Global 500.

This suggests that R&D spending figures substantially under-estimate the innovative nature of the UK economy. More importantly, the UK specialises in sectors with high wealth creation efficiency, whether R&D-intensive (such as pharmaceuticals), capital equipment intensive (oil and gas) or services (finance). In general, it is more useful to examine the UK's performance at a sectoral level, that is, to compare our performance in, for example, retailing or chemicals with the same sectors in other countries, rather than to aggregate data across sectors. Further, it is important to consider the wealth that is generated by certain sectors, that is, to look at the outcome, rather than focus on selected inputs such as R&D.

2.2.2.3. There are inherent problems with the collection of R&D data

There are also biases in the definition of such indicators. For example, the agreed definition of the business R&D as a proportion of GDP excludes development activities such as petroleum exploration even though these generate innovations and new scientific discoveries.[77] This example is particularly pertinent to the UK with its large oil exploration sector. This sector spends on average £1.11 billion per year in the United Kingdom Continental Shelf (UKCS) area alone on activities that could be interpreted as the sector-specific equivalent of R&D.[78] Including this expenditure alone as R&D would increase the UK's business R&D intensity by more than 11 per cent (increasing it from 1.8 to 2 per cent).

Similarly, the measure of the 'public funding of innovation' is defined as the proportion of firms that have received any public financial support for innovation, but excludes tax incentives. The UK favours the use of tax incentives, rather than having business relying on direct support (as in some other European countries).

Finally, there are methodological issues with this data, despite the considerable efforts that have been devoted to the development of indicators such as business R&D. Countries that contribute to these figures collect R&D data in different ways. For example, there are variations in the way in which a firm's R&D is assigned to an industry, in particular for firms conducting heterogeneous research activities. The OECD's *Frascati Manual* recommends breaking R&D down by 'product field,' that is, the R&D is assigned to the industries of final use. Not all countries follow this method, however. Some countries follow a 'principal activity' approach in which a firm's entire R&D is assigned to that firm's principal industrial activity code. Many countries follow a combination of these approaches. As a result, the OECD suggests that "caution" should be exercised when using this data.[79]

74. Department of Trade and Industry (2005), The 2005 R&D Scoreboard, The Top 750 UK and 1000 Global Companies by R&D Investment, (DTI, London).

75. See also Patel, P., and Pavitt, K. (1998), 'Uneven (and Divergent) Technological Accumulation Among Advanced Countries: Evidence and a Framework of Explanation', in Dosi, G., Teece, D.J., and Chytry, J. (eds.), Technology, Organization, and Competitiveness: Perspectives on Industrial and Corporate Change, (Oxford University Press, Oxford). See also Archibugi, D., and Pianta, M. (1992), The Technological Specialisation of Advanced Countries, (Kluwer Academic Press, Dordrecht).

76. For the FT Global 500, see: http://www.ft.com/reports/ft5002006.

77. This indicator is used in numerous international surveys and is based on an agreed definition of what constitutes R&D as set out in the Frascati Manual, see Organisation for Economic Co-operation and Development (2002), Frascati Manual 2002, Proposed Standard Practice for Surveys on Research and Experimental Development, (OECD, Paris).

78. Based on average oil exploration and appraisal (E&A) data 1990-2000 in the UK, see Department of Trade and Industry (2001), Development of Oil and Gas Resources 2001, (DTI, London).

79. See Organisation for Economic Co-operation and Development (2005), OECD Science, Technology and Industry Scoreboard 2005, (OECD, Paris).

2.2.2.4. Patenting is a useful measure of innovation for only a small fraction of the UK economy

It follows that countries specialising in sectors that have a high propensity to patent, such as biotechnology or IT, will have a higher performance in overall patenting per capita, even though their patenting performance in that or other sectors may be poor. On the other hand, countries that specialise in sectors that have a lower propensity to patent, such as aerospace, will perform badly, although they may be world leaders in such areas. Logically, firms are less likely to patent in sectors where patents are poor barriers to imitation. For example, patents do not yet fully measure technological activities in software, and so copyright law is often used as the primary means of protection against imitation in this sector.

Sectoral diversity in patterns of innovation show that the number of patents granted per £10 million of R&D investment varies significantly. Investments in electronics or IT hardware R&D generate nine times as many patents as similar investments in pharmaceuticals. This makes the number of patents a very poor indicator of a country's innovation performance.[80] According to the Fourth Community Innovation Survey (CIS 4), across all sectors of the UK economy factors such as lead-time advantage over competitors and secrecy are far more important for businesses than are patents (31 and 30 per cent of businesses cite the former as important factors, while only 15 per cent cite the latter).[81]

The UK may have a comparatively low share of businesses that apply for patents, but it has the highest proportion of businesses across the EU that use some form of protection (such as trademarks, copyrights or secrecy).[82] Again, this relates to the sectoral composition of the UK economy. For example, the financial services sector is generally regarded as one of the UK's most innovative sectors, as well as one of its most important.[83] The UK has the largest international banking sector, accounting for 20 per cent of global cross-border lending, and (as a possible proxy for its investment in innovation) spent $6.6 billion on information technology systems in 2004.[84] Yet it (unsurprisingly) scored the lowest of all sectors in the UK in applications for patents in the CIS 3.[85] This is more likely to indicate a problem with the indicators used to measure innovation and the models of innovation that underpin them, than with the UK's booming financial services sector.

A fairer and more accurate method is to correct for the differing propensities to patent amongst both countries and sectors, something that we make an initial attempt at in Part II, Section 3.

2.2.2.5. Measurements of advanced scientific research and of knowledge transfer from research institutions to industry do not accurately represent modern knowledge creation or the process of commercializing that knowledge

The implicit assumption in traditional surveys of innovation is that R&D (or patenting, or scientific publication) is synonymous with innovation, which is itself synonymous with economic growth and social progress. However, innovation is not simply the generation of knowledge; it is the diffusion, integration and exploitation of knowledge that leads to economic and social value.

For example, aggregate comparisons of scientific publications across countries can be misleading. This is because journal publication as an output of research varies in importance between scientific fields, and different countries have different areas of emphasis (the UK tends to focus on the medical, life and environmental sciences, but is weaker in the physical sciences and engineering). Further, the relationship between research, development and diffusion will differ across these fields.

The UK invests less in university research than the US. Yet university-based research is not a primary source of knowledge that can be applied directly for the purposes of innovation in the majority of the UK economy.[86] Moreover, the fact that the UK does not invest in R&D at anywhere near the same level as the US and many Nordic countries also does not exclude the UK economy from benefiting from research conducted in these and other countries, so long as we have the systems and skills required to absorb it effectively. Indeed, the diffusion of technology and its incremental adaptation to new environments is frequently more important to economic growth than the initial invention.[87] However, training and skills remain a key issue in determining the ability of countries to exploit externally produced innovations.

80. Department of Trade and Industry (2005), The 2005 R&D Scoreboard, The Top 750 UK and 1000 Global Companies by R&D Investment, (DTI, London).

81. Department of Trade and Industry (2006), Innovation in the UK: Indicators and Insights, DTI Occasional Paper No. 6, (DTI, London).

82. Jaumotte, F., and Pain, N. (2005), Innovation in the Business Sector, OECD Economics Department Working Paper No.459 (OECD, Paris).

83. The UK financial services sector accounted for 5.3 per cent of GVA in 2003, employed more than one million people, and generated £20 billion in exports (7.2 per cent of total UK goods and services exports combined). These figures increase considerably if other services closely associated with financial services are included, such as management consultancy, legal and accountancy services. See HM Treasury (2005), The UK Financial Services Sector: Rising to the Challenges and Opportunities of Globalisation, (HM Stationery Office, London).

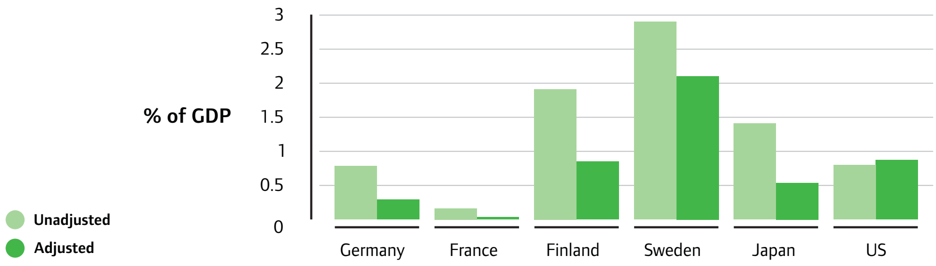
84. Flowers, S. (2006), 'Systems of Systems - Exploring the Innovation Array', working paper, (Centrim/University of Brighton, Brighton).

85. According to this survey, only one per cent of enterprises who were involved in innovation activity in the "Financial intermediation" sector had applied for at least one patent. Table UK. 14A, European Commission (2004), Innovation in Europe, Results for the EU, Iceland and Norway, (European Commission, Brussels). This data relates to 1998-2000.

86. For example, only two per cent of UK businesses identify universities or other higher education institutions as important sources of information for innovation, see Department of Trade and Industry (2006), First Findings from the UK Innovation Survey, 2005, (DTI, London). Of those businesses that are involved in cooperative ventures for innovation, only a third have universities as partners, while three-quarters have suppliers as partners, see Department of Trade and Industry (2006), Innovation in the UK: Indicators and Insights, DTI Occasional Paper No. 6, (DTI, London).

87. Mowery, D., and Rosenberg, N. (1989), Technology and the Pursuit of Economic Growth, (Cambridge University Press, Cambridge).

Figure 6: Business R&D intensity gap adjusted for sectoral composition



Source: OECD.[98]

International consultancy firms have been particularly important in helping to diffuse technology and new management techniques to the UK from other nations. The same is true of foreign direct investment (FDI) by multinational corporations. In recent years the UK has been the world's most successful economy at attracting FDI. In 2005, $219 billion came to the UK which, even without the approximately $100 billion that came from the merger of Shell with Royal Dutch Petroleum, still surpassed our nearest rival the US (with $106 billion).[88] In some sectors, foreign firms have demonstrably superior managerial capabilities and the very open nature of the UK economy has enabled them to succeed in sectors even where the UK has a relatively poor innovative performance.[89] The very open nature of the UK economy has allowed it to benefit from international innovation; international firms setting up here have been very successful. UK R&D is more internationalised than its competitors, and foreign-owned firms are more active in supporting R&D in the UK than they are in other countries.[90] Twelve of the 17 foreign-owned companies in the UK that invest more than £50 million in R&D have a much larger R&D intensity than their parent companies, suggesting that they prefer to conduct their R&D in the UK.[91]

More generally, the UK tends to perform well when businesses operate within an environment that encourages or forces the accumulation of technological capabilities and supplies appropriate workforce skills and technology. The UK pharmaceutical industry has a regulatory environment that encourages technological accumulation,[92] and the UK science system has been responsive to the demands of the industry for skilled biomedical researchers and graduates.[93] Indigenous automobile manufacturers on the other hand were unable to accumulate the required technological capabilities and exhibited poor training and skill levels compared to Germany and Japan, contributing to the decline of the sector.[94]

Further, investments in capital goods and non-R&D investments are more important than formal R&D for commercial innovation, at least as judged by businesses themselves. According to data from the Community Innovation Survey, intramural (within the business) R&D amounts to only one-quarter of overall investment in innovation by UK businesses.[95] Investments in physical capital are growing faster than investments in knowledge capital in the UK as well as in Italy, Japan, Australia, Belgium, Germany, the Netherlands, and Austria (while in France, the US and the Nordic countries it is the other way around).[96] (This also then raises a question mark over the notion that we are collectively heading towards a universal knowledge economy).

By substantially over-estimating the importance of R&D to innovation and the contribution of high tech manufacturing sectors in particular, there is a danger that the development of policies in this area is driven by 'high-tech envy.'[97] (As noted above, high-tech manufacturing comprises only 2.5 per cent of the UK economy, and only 2.8 per cent of a leading high-tech country such as the US). In falling subject to this misplaced obsession, the UK could neglect the 'hidden' forms of innovation that make the UK a dynamic and successful economy and society.

88. Financial Times (2006), 'Britain Tops World in Foreign Investment', 24th January.

89. For example, anecdotal evidence suggests that Japanese car manufacturing in the UK achieves much higher levels of productivity than UK based firms, while US firms operating in the UK achieve substantially higher productivity outputs from their investments in ICT than UK firms. Nissan's Sunderland factory, for example, produced 330,000 cars in 2002. It is also important to be clear about sub-sectors in these industries: while car production may be slowing down in the UK (although it is still very high by EU standards) engine production is doing extremely well.

90. Arthur D. Little (2005), Internationalisation of R&D in the UK, A Review of the Evidence, (Department of Trade and Industry/Office of Science and Technology, London).

91. Department of Trade and Industry (2005), The 2005 R&D Scoreboard, The Top 750 UK and 1000 Global Companies by R&D Investment, (DTI, London).

92. Thomas, L. G. (1994), 'Implicit Industrial Policy: The Triumph of Britain and the Failure of France in Global Pharmaceuticals', Industrial and Corporate Change, 3, pp.451-489.

93. Lattimore, R., and Ravesz, J. (1996), Australian Science: Performance from Published Papers, Bureau of Industry Economics, Report 96/3, (Australian Government Printing Office, Canberra).

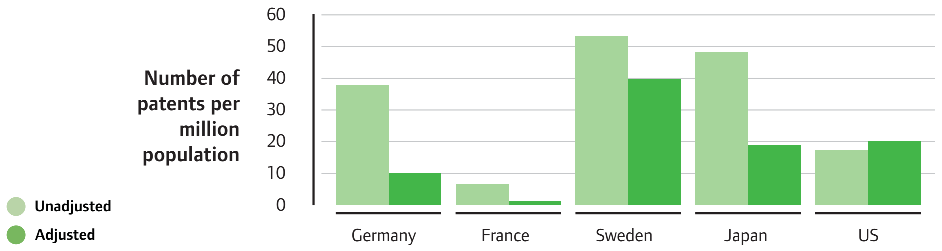
94. Jagger N, Nesta L, Gerova V, Patel P. (2005), Sectors Matter: An International Study of Sector Skills and Productivity, SSDA Research Series RR14, (Skills Sector Development Agency, London).

95. Department of Trade and Industry (2006), Innovation in the UK: Indicators and Insights, DTI Occasional Paper No. 6, (DTI, London).

96. p.10, Smith, K. (2002), What is the Knowledge Economy? Knowledge Intensity and Distributed Knowledge Bases, Intech Discussion Paper 2002-6.

97. It has been suggested high-tech manufacturing added less than one per cent to US GNP between 1980 and 1995, see p.13, Smith, K. (2002), What is the Knowledge Economy? Knowledge Intensity and Distributed Knowledge Bases, Intech Discussion Paper 2002-6.

Figure 7: Patenting activity per capita gap adjusted for sectoral composition



Source: OECD.[100]

2.3. The UK performs better on new, adjusted measures of innovation

It is possible to begin to construct fairer comparisons of innovation performance between countries. One way to do this is to focus on individual sectors, particularly sectors in which traditional indicators are known to be important (as in the example of the pharmaceutical sector, above). Another way to produce fairer comparisons is to adjust for the different sectoral composition of national economies.

For example, adjusting business R&D intensity according to sectoral composition produces a quite different picture of the UK's performance (Figure 6). The graph here shows how the gap between the UK's R&D intensity and that of other leading countries closes when sectoral composition is taken into account (that is, the baseline of the graph represents the UK, hence the reason it does not appear itself on the graph).

The one exception here is the US, which has a large services sector but also invests heavily in formal R&D. However, it is also worth noting that UK services businesses report more sales arising from new or significantly improved services, and are more efficient in innovation than their US counterparts.[99]

Similarly, the gap in patenting activity also closes when sectoral composition is taken into account, sometimes quite dramatically (Figure 7). (Again, the UK is represented by the baseline).

Attempting to recalculate indicators based on existing figures will, however, only get us so far in understanding the true state of innovation in the UK. There is limited point in trying to adjust indicators to better reflect sectors of the economy that they were not meant to reflect in the first place. It is therefore essential for the UK to develop a new process to gain an understanding of those sectors that are under-represented or entirely excluded from traditional indicators.

98. Unadjusted data from Organisation for Economic Co-operation and Development (2005), Main Science and Technology Indicators (MSTI): 2005/2 Edition, (OECD, Paris). Adjusted gaps due to sectoral composition from Organisation for Economic Co-operation and Development (2005), Economic Survey of the United Kingdom 2005: Raising Innovation Performance, (OECD, Paris).

99. Cambridge-MIT Institute (2006), Innovation Efficiency – A Transatlantic Comparison, (Cambridge-MIT Institute, Cambridge).

100. Unadjusted data from Organisation for Economic Co-operation and Development (2005), Main Science and Technology Indicators (MSTI): 2005/2 Edition, (OECD, Paris). Based on triadic patent families, that is, sets of patents taken at the European Patent Office (EPO), the Japanese Patent Office (JPO) and the US Patent & Trademark Office (USPTO) that share one or more priorities, and using R&D intensity as a proxy for patenting activity intensity. Adjusted gaps due to sectoral composition from Organisation for Economic Co-operation and Development (2005), Economic Survey of the United Kingdom 2005: Raising Innovation Performance, (OECD, Paris).

Part III: 'Hidden innovation' is ignored in traditional indicators but is crucial to the UK economy

An alternative approach is required to capture innovation as it exists in sectors that are currently neglected by traditional indicators. To this end, we undertook five case studies of sectors that are not represented by traditional indicators and in which we had limited expectation of discovering innovative activity. What emerged was a broader understanding of innovation that challenges many of the traditional assumptions that underlie UK innovation policy. The five areas are not intended to represent the full extent of hidden innovation in the UK or the most important; many other areas could have been chosen in their place. Rather, they serve to demonstrate the limitations of the current approach.

3.1. Traditional innovation that doesn't show up in traditional indicators: A 'hidden research system' in the National Health Service that has developed 300 new genetic tests

In general, technological change in medicine is neglected in academic understandings of innovation – and therefore in the traditional indicators used to measure innovation. The 50,000 medical scientists working in the NHS, from more than 50 different disciplines (four per cent of the NHS workforce) are relatively unpublicised and have been referred to as a hidden research system (in comparison, GlaxoSmithKline employs 15,000 people in its research teams worldwide).[101]

Since the mid-1980s, more than 300 novel tests have been developed through this system in the field of genetics alone.[102] The genetic services offered in the UK are among the most comprehensive in Europe.[103] These include biochemical genetic testing (for example, post-natal testing for early detection and treatment of the degenerative brain condition PKU), cytogenetic testing (for example, prenatal screens and tests for Down's syndrome), and molecular genetic testing (for example, pharmacogenetic testing to predict adverse reactions prior to the prescription of certain drugs).

There are around 10,000 single gene disorders. Most are rare, but together they affect up to five per cent of the population and cause considerable ill health and premature mortality. The treatment and care of patients with these disorders also costs health and social services about £2 billion each year.[104] Six out of 10 people are likely to develop a disease that is at least partially genetically determined by the age of 60.[105]

Innovations in genetic testing allow more precise diagnosis of genetic disorders, which allows earlier and more effective treatment. With improved diagnosis, patients and physicians can make more informed decisions about future treatments. While there are a number of major genetic diseases for which there is currently no cure, early diagnosis can potentially ease patients' concerns about their future and allow couples to make decisions about their reproductive choices. With some kinds of genetic dispositions to cancer, for example, it is possible to identify more-at-risk groups, who can then be given the opportunity to change their lifestyles or to take prophylactic measures. For example, newborn babies can be screened for phenylketonuria and given appropriate treatment to avoid mental retardation later in life.

In the NHS in England, the bulk of genetic testing is performed in 20 Regional Genetics Centres, each serving a population of between two and six million people. The growth in the number of tests conducted in shown in Figure 8. These centres offer clinical diagnoses, laboratory testing and counselling services for individuals and their families. The services operate on a 'hub and spoke' arrangement, with clinical specialists from the centre undertaking clinics at a range of peripheral hospitals. This approach allows greater accessibility for patients and contact with other hospital staff. This work is multi-disciplinary, and, in addition to the laboratory scientists, comprises doctors, specialist nurses and genetic counsellors, data handling and genetic record facilities in one functional unit. This ensures common values, rapid transfer of new information and expertise, and facilitates personal consultation in resolving very rare and difficult cases.[106]

101. Hicks, D. M., and Katz, J. S. (1996), 'Hospitals: A Hidden Research System', Science and Public Policy, 23 (5), pp.297-305. The Government aims to increase this by 30,000 by 2008, see Fisher, R. (2005), 'Stand Up and Be Counted', New Scientist, 15th October.

102. Clinical Molecular Genetics Society audit of laboratories, see: www.cmgs.org.

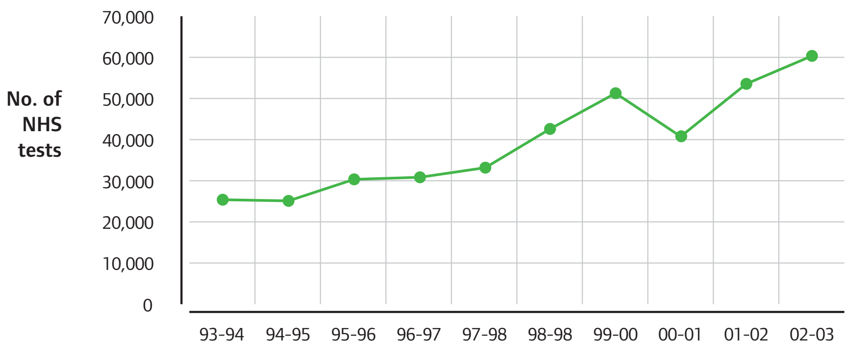
103. Harris, R., and Reid, M. (1997), 'Medical Genetic Services in 31 Countries: An Overview', European Journal of Human Genetics, 5 (2), pp.3-21.

104. Department of Health (2003), Our Inheritance, Our Future - Realising the Power of Genetics in the NHS, (DoH, London).

105. Ibid.

106. Expert Working Group (2000), Laboratory Services for Genetics, (Department of Health, London).

Figure 8: DNA molecular tests in English Regional Genetics Centres (1993-2003)



Source: Clinical Molecular Genetics Society.[107]

There is similarly developed provision in Scotland, Wales and Northern Ireland. Four Regional Genetic Centres in Scotland (in Aberdeen, Dundee, Edinburgh and Glasgow) provide clinical and laboratory genetic services both within their own areas and through their outreach clinic network to all parts of Scotland and the Islands. The Molecular Genetics Laboratories within the four centres work as a formal Consortium, which is co-ordinated, commissioned and funded at national level for NHS Scotland. The Consortium arrangements mean that there is equity of access to all available molecular genetic tests for any Scottish patients. Wales also has an international reputation for the quality and delivery of its Medical Genetics Service, which has led the development of cancer genetics and neuro-genetics services. It has played an important role in developing standards of clinical governance in the UK and has pioneered equity in access and delivery. Clinical genetics services are provided on a regional basis for the population of Northern Ireland, with outreach clinics offered throughout the region.

Although there is a significant social value to these innovations, this is not reflected in traditional innovation metrics. Innovation here is developed informally, and relies on the interactions between physicians, research scientists, clinical scientists, charities and other funding organisations, rather than 'ivory tower' production by standalone R&D laboratories in firms and dedicated research establishments. Further, this system appears able to innovate without the need for the venture capital, patent enforcement or spin-off firms – all conditions that current policy implies are necessary for successful innovation. Indeed, the extent of this co-operative and non-services financially-incentivised innovation challenges the appropriateness of the focus of most innovation policy on competitive environments. Rather, this area suggests that the 'need to do something' is a more powerful incentive for clinical staff and researchers than any commercial motivation.

This case study is consistent with previous research that has suggested radical innovation in medicine frequently originates from within the hospital network rather than industry.[108] Only after a market has been established do commercial enterprises enter the picture, often to productise and mass-produce diagnostic tests, although laboratories in the NHS have shown they can develop these capabilities.

Innovative activities in this area have often been achieved only through the exploitation of slack in the system, for example, through the use of resources that are left over from other projects. Maintaining a margin for such activity would seem absolutely essential if novel services are to continue to develop. In this sense, innovative activities happen around the edges of policy, rather than being driven or directed by it.

In response to these expectations, in 2001, the Secretary of State for Health announced an initial investment of £30 million. These funds were used to recruit sufficient numbers of staff specialising in genetics, create two National Genetics Reference Laboratories to assess new advances and methods of service delivery, six Genetic Knowledge Parks (GKPs) to build a knowledge base on all aspects of human genetics (co-funded with the DTI), and establish a UK Genetic Testing Network (UKGTN) to co-ordinate the evaluation, commissioning, funding and prioritisation of

107. As referenced in Parliamentary Office of Science and Technology (2004), NHS Genetic Testing, (POST, London).

108. Gelijns, A., and Rosenberg, N. (1999), 'Diagnostic Devices: An Analysis of Comparative Advantages', in Mowery, D., Nelson, R. E. (eds.), Sources of Industrial Leadership, (Cambridge University Press, Cambridge).

services for genetic disorders. In 2003, the Department of Health published a Genetics White Paper *(Our Inheritance, Our Future)*, outlining an additional £50 million for further investment.[109]

The UKGTN has begun to formalise the assessment process for rare inherited disorders. However, this more formal approach may have unintended consequences – it may reduce the slack identified earlier as being crucial to the current system. It remains to be seen whether two centres undertaking this task formally will be as effective as a larger informal development network using highly specialised local skills and resources.[110] A further review of progress in England is expected to be published in 2007.

3.2. Built to fit: Product, process, service and organisational innovation through client collaboration in engineering consultancy

Engineering comprises a diverse set of disciplines that underpins the entire physical infrastructure of a modern economy. Yet it is neglected compared to science in understandings of innovation and its prominence in innovation policy. While much of the innovation in this area derives from the expertise and creativity of individual engineers, it is often dependent on client or wider stakeholder engagement in the context of specific projects, including insurers, building contractors, regulators and planners.

Construction is one of the UK's largest industries employing more than three million people (on-site, in material supply, and in professional services).[111] The UK industry is worth over £100 billion each year and contributes almost 10 per cent to GDP (approximately four times the contribution of high-tech sectors). The consultancy sub-sector represents approximately 10 per cent of the total construction industry. Three of the largest firms are Atkins, Mott MacDonald Group, and Arup Group. Total fees earned by all consultants amounted to £6.12 billion in 2005.[112] The leading trade association, the Association for Consultancy and Engineering, represents more than 800 firms, which employ around 45,000 technical staff (the total employment by consultancies is estimated at 108,000, including 64,000 engineers[113]). These firms expect continued growth in major markets such as North America and Australasia, which reflects the strong international reputation of UK firms and their ability to export their service offering. Total overseas earnings for UK engineering consultancies amounted to nearly £2 billion in 2004.[114]

Collectively, engineering consultancies provide services for the total life cycle of client assets, from conceptual design, through planning and permitting, to decommissioning clients' assets. They operate in many different sectors, from health and education to transport, but the roles they perform in these sectors are broadly similar. As identified in industry surveys, in general UK engineering firms are moving away from offering pure engineering services. Only 60 per cent of the services offered by the largest firms now fall into the pure engineering category; an average of 15 per cent of their business is now derived from transport planning and 10 per cent from environmental consulting.[115] As part of this consultancy work, firms have developed a wide range of bespoke tools and techniques, such as modelling software, electronic onsite data collection and risk assessment, and prefabricated components.[116]

The development of multi-disciplinary consultancies operating across multiple sectors has increased the capacity of these consultancies to cope with projects that demand innovative solutions. Through establishing innovative knowledge management systems such as online forums for firms' various communities of practice, large firms in particular have been able to leverage their global knowledge base to deliver technical expertise rapidly to a particular locality.

Innovation is not typically part of the original brief when a consultancy is engaged, rather it evolves out of a process of mediation with a client - particularly with well-informed, experienced and imaginative clients. In this sense, these firms are used to acting as open innovators, collaborating with many partners and working between many different contexts.[117] Engineering designers involved in complex, non-routine design processes rely in particular on face-to-face conversations with other designers for solving problems and developing new innovative ideas.[118] Hence 'soft skills' such as relationship building, adaptation and flexibility are crucial to developing innovative approaches and solutions.

109. The implications of the White Paper for Scotland have been examined in a separate review, see Scottish Executive (2006), Review of Genetics in Relation to Healthcare in Scotland, (Scottish Executive, Edinburgh). The Welsh Assembly Government has provided an additional recurring investment of £1.5 million to develop the future of Medical Genetics Services in Wales. The Department of Health, Social Services, and Public Safety in Northern Ireland also conducted a review alongside the White Paper, see Department of Health, Social Services, and Public Safety (2003), Review of Clinical Genetic Services in Northern Ireland, (DHSSPS, Belfast).

110. The Expert Working Group report in 2000 recommended that no major changes should be made to the existing structure of regional genetic laboratories and their relationship with clinical genetic services and with academic departments. This was because the development of genetic testing laboratories within or in close proximity to clinical genetics services has ensured a close working relationship between laboratory staff and clinicians to ensure that genetic testing offered is appropriate for the individual patient and that adequate and appropriate pre-test and post-test counselling is undertaken, see Expert Working Group (2000), Laboratory Services for Genetics, (Department of Health, London).

111. Association for Consultancy and Engineering (2005), Consultancy and Engineering State of Business Summer 2005, (Association for Consultancy and Engineering, London).

112. According to the New Civil Engineer annual survey for 2006, the NCE Consultants File, see www.nceplus.co.uk.

113. New Civil Engineer NCE Consultants File annual survey for 2005, see www.nceplus.co.uk.

114. Ibid.

115. Association for Consultancy and Engineering (2005), Consultancy and Engineering State of Business Summer 2005, (Association for Consultancy and Engineering, London).

However, larger firms are now beginning to offer 'innovation' to clients as a 'product.' One study has noted how Arup uses high profile 'magnet' projects to help maintain and enhance its reputation for solving difficult problems.[119] This also helps to recruit and retain high quality staff wanting to work on demanding projects.[120] The Mott MacDonald Group, for example, was responsible for the Central Artery Jacked Tunnels project in Boston, part of the single largest civil engineering project in American history (known locally as the 'Big Dig'). The project involved jacking three full-size interstate highway tunnels (the largest well over 100 metres long) each with sections weighing up to 30,000 tonnes, under an operational commuter railway in downtown Boston. To stabilise the soft ground, Mott MacDonald and its North American company Hatch Mott MacDonald decided to freeze it, creating 200,000 cubic metres of artificial tundra – the world's largest man-made iceberg. This contributed to more than $300 million in construction savings over traditional approaches and had substantial environmental advantages. This acclaimed project won a distinguished list of accolades including the 2004 Nova Award at the Construction Innovation Forum Awards, the Special Award for Outstanding Individual Achievement at the 2003 Quality in Construction Awards, the International Achievement prize in the 2003 Building Awards, the 2002 British Construction Industry International Award, and the American Society of Civil Engineers' most prestigious award for innovation, the Charles Pankow Award.

Other factors, such as regulation, also stimulate innovation in this sector. Environmental policy on vehicle emissions, as well as geopolitical events, has had a strong effect on the demand for and availability of research funding for work on fuel-electric hybrid motors to support the automotive sector. Similarly, global trends towards the privatisation of utilities are driving the demand for Public Finance Initiative (PFI) related work. Overall, government and the public sector are a significant factor in innovation in this area – as the major clients and users, as the regulators, and as the main provider of education.

Through innovation, engineering consultancies generate public benefits including an enhanced quality of experience for users, improved safety and reduced costs for clients. Measuring the overall economic benefits generated by these firms is difficult, given the range of sectors in which they operate and the numerous forms that innovation can take. Engineering consultancies are not well represented by measures such as the DTI's *Value Added Scoreboard* because they do not capture most of the value that they create (most is passed onto the client).[121] Hence, these firms can have comparatively low profit margins in comparison to firms in other highly innovative sectors, such as pharmaceuticals. This is why external funds for investment in engineering innovation are relatively unforthcoming in the UK, and the sector tends to be ignored by venture capitalists, despite its size and importance.

All but the smallest consultancies have links to universities, for example through contract research and sponsorship of PhD projects, which compensates for their own lack of formal R&D staff or facilities. Some consultancies invest between one and five per cent of their revenues in R&D, although this varies greatly between firms (in some instances consultancies compete effectively for government and European Commission research funding as part of client-led consortia). More generally, the innovative capacity of engineers is highly dependent on their learning and training in science, engineering and technology disciplines, especially at university level.

Despite the high levels of innovative activity present in engineering consultancy, the diversity of innovation and the mixture of tangible and intangible elements means that the standard indicators of innovative activity such as patenting and R&D spend are less appropriate. This is because innovations often do not warrant a patent and because much innovation derives not from formal R&D spend but from work undertaken within client projects.

116. According to a 1993 study conducted in the UK, the US and Sweden, consulting engineering and design firms were investing heavily in new information technology, which was rapidly becoming an indispensable component of international competitiveness in the industry, see UNCTAD (1993), 'Information Technology and International Competitiveness: The Case of the Construction Services Industry', (UNCTAD, New York/Geneva). New technologies have led to the integration of project work and new sources of competitiveness in major firms, see Baark, E. (1999), 'Engineering Consultancy: An Assessment of IT-Enabled International Delivery of Services', Technology Analysis and Strategic Management, 11 (1), pp.629-647.

117. As noted in 'Using Innovation Technology: Proctor & Gamble and Arup', chapter three in Dodgson, M., Gann, D., and Salter, A. (2005), Think, Play, Do: Technology, Innovation and Organization, (Oxford University Press, Oxford).

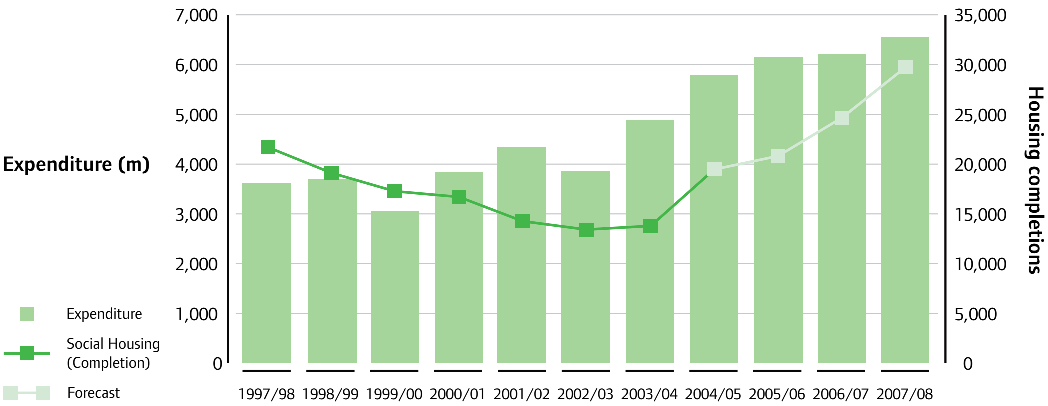
118. Slater, A., and Gann, D. (2001), Sources of Ideas for Innovation in Engineering Design, (SPRU, Brighton).

119. Chapter three, 'Using Innovation Technology: Proctor & Gamble and Arup', in Dodgson, M., Gann, D., and Salter, A. (2005), Think, Play, Do: Technology, Innovation and Organization, (Oxford University Press, Oxford).

120. Salter, A., and Gann, D. (2003), 'Sources of Ideas for Innovation in Engineering Design', Research Policy 32 (8), pp.1309-1324.

121. The DTI's Value Added Scoreboard provides benchmarking tools for companies of all sizes to compare their wealth creating characteristics against their best European competitors. Value added is measured as sales less the cost of bought-in materials, components and services.

Figure 9: Social housing total expenditure and new house builds (completions) in England (1997-2008)



Source: ODPM and HM Treasury.[130]

3.3. Transforming an under-performing sector through innovative interventions: Regulation and incentives to improve social housing

Most innovation is not in cutting-edge science and technology or the development of new services and products; the application of existing knowledge and technology to existing sectors is commonly far more significant. One example is social housing.[122] This sector is in the process of being transformed from one of the UK's poorest performers into a dynamic innovative sector that is not only supplying high quality housing, but also exploits product and process innovation to address a range of environmental, social, crime health, transport and urban regeneration issues.[123]

Over the last 30 years, the provision of social housing had not kept pace with need. During the 1980s under-investment in housing meant fewer social homes were built and the quality of the existing public housing stock fell. By 1997 there was a £19 billion backlog of repairs in local authority housing and two million social houses failed to meet decency standards.[124] In 2003, 1.4 million social homes (out of 4.1 million) and 1.1 million vulnerable homeowners and private tenants still lived in homes that did not meet decency standards.[125] Yet the number of newly-built social houses available for rent fell from 42,700 in 1994-95 to around 21,000 in 2002-03.[126] This fall in the number of social houses had another consequence: local authorities and housing associations, in targeting help towards those in greatest need, inadvertently increased the domination of social housing by those who are not in work, resulting in greater concentrations of poverty and deprivation in some housing estates.

As the 2004 *Barker Review* of housing supply noted, inadequate or insufficient housing is linked to social problems (crime, drug abuse and other social problems lead to those who can move out to do so, leaving the most vulnerable living in increasingly undesirable areas), poor education, poor health and low labour mobility (which inhibits the UK's economic potential).[127] The 2000 Green Paper, *Quality and Choice – A Decent Home for All* set a target that all social housing (and private sector housing for vulnerable groups) should meet its "decent homes" standard by 2010.[128]

By the end of 2004, this agenda had reduced the number of non-decent homes by one million (and an additional 130,000 private sector homes had been made decent), while £18 billion had been invested in existing council and housing association homes (with a further £7 billion investment for 2004-06).[129] This meant that by 2006 capital spending on council homes was an average of 55 per cent higher than it was in 1997 (adjusting for inflation). This led to a projected 50 per cent increase in new social house building by 2007-08 compared to 2004-05 - an additional 10,000 homes a year (Figure 9).

However, this investment has also been accompanied by efforts to encourage greater innovation in house building.[131] In part, this is to ensure that the increased building targets can be achieved.[132]

122. For the purposes of concision, this case study focuses on England.

123. Stockerl, K. (2003), 'Innovation Intermediaries: The Emergence of Customer Active Innovation Systems in the British Social Housing Sector', unpublished DPhil Thesis, SPRU, University of Sussex. For a review of the policy background to these changes see Malpass, P., and Mullins, D., (2002), 'Local Authority Housing Stock Transfer in the UK: From Local Initiative to National Policy', Housing Studies, 17 (4), pp.673-686.

124. HM Treasury/Office of the Deputy Prime Minister (2005), Housing Policy: An Overview, (HMT/ODPM, London).

125. Ibid.

126. HM Treasury (2004), Review of Housing Supply, Delivering Stability: Securing our Future Housing Needs, Final Report (The Barker Report), (HM Stationery Office, London).

127. Meen, G., (2005), 'On the Economics of the Barker Review of Housing Supply', Housing Studies, 20 (6), pp.949-971.

128. Office of the Deputy Prime Minister (2000), Quality and Choice – A Decent Home for All, (HM Stationery Office, London). A home is decent if it: meets the current statutory minimum standard; is in reasonable repair; has reasonably modern facilities and services; and provides a reasonable degree of thermal comfort. For example, a dwelling fails to provide reasonably modern facilities and services when it lacks three or more of the following: a kitchen which is 20 years old or less; a kitchen which has adequate space and layout; a bathroom which is 30 years old or less; an appropriately located bathroom and WC; adequate noise insulation; adequate size and layout of common entrance areas for blocks of flats. See Department for Communities and Local Government (2006), A Decent Home: Definition and Guidance for Implementation, June 2006 Update, (DCLG, London).

129. The Government's five year plan was published in January 2005, see Office of the Deputy Prime Minister (2005), Sustainable Communities: Homes for All, (HM Stationery Office, Norwich). Homes for All was accompanied by a sister document, Sustainable Communities: People, Places and Prosperity, which set out how the Government is helping the most deprived neighbourhoods, by tackling poverty, poor health, crime and worklessness in an integrated way, see Office of the Deputy Prime Minister (2005), Sustainable Communities: People, Places and Prosperity, (HM Stationery Office, Norwich).

Through a combination of regulation, incentives and consistent pressure, the Government is encouraging the use of Modern Methods of Construction (MMC). Whereas the majority of homes in the UK are constructed using traditional 'brick and block' methods, from 2004 a quarter of publicly-funded new social housing has been required to use MMC (by the Housing Corporation, the social housing regulator for England and Wales). This is equivalent to 5,000 homes per year (three per cent of new housing in the UK).

One form of MMC is off-site manufacture (OSM). This involves the manufacture of house parts offsite in a specially-designed factory, with components including panels (ready-made walls, floors and roofs) and modules (ready-made rooms, which can be fitted together to make a whole house or flat). The potential benefits of MMC are that houses can be built more quickly (and with fewer defects), with greater energy efficiency (by requiring less transport of materials), and with less disruption onsite during construction. However, in many cases traditional methods still remain cheaper than MMC, given the cost for house builders of converting to MMC, including building new manufacturing plants and developing new skills,[133] and especially where the reaction of consumers and mortgage lenders is unknown. Further, the nature of the planning system may have operated against the introduction of OSM by increasing delays and uncertainty. These drawbacks make the Government's deep and consistent support for MMC crucial to the transformation of the sector.

The Millennium Communities, overseen by the regeneration agency English Partnerships, are using MMC. The Millennium Communities are new developments, mixing homes, shops, workspaces and community facilities. They incorporate good public transport links, innovation in building technology, energy efficiency and ecological and environmental strategies. They aim to create sustainable jobs as well as education and training opportunities and are developed in close consultation with the communities they relate to. By 2010 there will be more than 6,000 exemplar homes across all seven Millennium Communities. One example is the Greenwich Millennium Village (GMV), the first of the Millennium Communities, is located at the southern end of English Partnerships' 121 ha (300 acre) Greenwich Peninsula site. The GMV is being built using a combination of traditional on-site methods and factory produced components such as bathroom 'pods' and cladding panels. So far, the GMV has largely met its environmental targets: waste has been reduced by 56 per cent and energy use over the lifetime of the development will be reduced by 65 per cent.

More generally, the Housing Corporation has raised the environmental performance standard required from all the homes that it funds, to a 'good' standard in 2005 under the EcoHomes environmental assessment, and to 'very good' in 2006. Energy efficiency improvements will also have been made to over 1.3 million social homes between 2001 and 2010, as part of the Decent Homes effort.

Demonstration projects have been supported by the Office of the Deputy Prime Minister (ODPM) and now by the Department for Communities and Local Government (DCLG) and the DTI. Such projects help to overcome informational market failures, by identifying and demonstrating the benefits of such techniques and establishing best practice. *A Design for Manufacture* competition was launched in 2005 with English Partnerships to demonstrate that it is possible to build a home that reaches good standards of accessible design and environmental performance for £60,000. The competition invited bids for the right to construct one or more new developments, providing a total of up to 1,000 homes by 2007 (one-third of them for first time buyers) on a selection of English Partnerships' sites.

Over the next five years the Government aims to present 100 more new developments with *Building for Life Awards* for their high quality. This is in addition to non-Government initiatives, such as the demonstration projects run by the Housing Forum (a trade association). Since 1999, the Forum has run 140 new-build, refurbishment and maintenance projects across the UK.[134] The social sector accounts for 95 per cent of these projects. These have been selected as demonstrating innovative approaches to construction, both in terms of the technology used (such as OSM) and the processes used to deliver the projects (such as partnering and supply chain management).

130. HM Treasury/Office of the Deputy Prime Minister (2005), Housing Policy: An Overview, (HMT/ODPM, London).

131. For the specifics of innovation in construction see Gann, D. M. (1994), 'Innovation in the Construction Sector', in Dodgson, M., and Rothwell, R., (eds.), The Handbook of Innovation, (Edward Elgar, Aldershot).

132. Office of the Deputy Prime Minister (2003), Government Response to ODPM Select Committee Report on Planning for Sustainable Communities in the South East, (HM Stationery Office, London).

133. The Construction Industry Training Board (CITB ConstructionSkills) funded by industry and Government, is developing MMC training courses for the estimated 2,000 workers erecting MMC housing with no formal qualifications. The Egan Review in 2004 found that while technical skills in this country are strong, we need to develop generic skills such as project management, leadership, team working and communications, see Office of the Deputy Prime Minister (2004), The Egan Review: Skills for Sustainable Communities, (ODPM, London). The Government has responded to the Egan Review by establishing a new National Skills Centre to develop skills and expertise, in partnership with CABE, EP, English Heritage, professional institutions, skills bodies, and local and regional government.

134. Housing Forum, (2002), The Housing Forum Demonstration Project Reports: The Challenges Ahead, (Housing Forum, London).

Innovation has taken the form of changes in products, processes and the supply chain, particularly through the careful and imaginative application of regulation. This stands in stark contrast to the crude market-based models inherent in many of the simpler models of innovation. Changes in governance have transformed the industrial structure of the sector to a far more effective and innovative system.[135] Long-term, consistent pressure and leadership from Government and an institutionalised process of continuous improvement have led to radical changes and a switch from low to high innovation.

A shift has occurred from functional specialisation to a networked, open innovation system where project-based organisations, comprised of temporary collaborations of various specialised firms, engage in innovative activity to hit rising targets and environmental standards.[136] While there still remains a major problem with the provision of affordable, high quality housing within the UK, this area is a somewhat unexpected example of successful innovation.[137] Such innovations have little to do with formal R&D, scientific or university-based research, high-technology or radical innovation, yet they have been transformational and have made a positive impact on large sections of UK society. They demonstrate the innovative nature (or the potential) of 'low technology' sectors. Lastly, this area has a huge range of indicators, metrics and key performance indicators that could be drawn on to track its innovative performance.

3.4. Co-evolution of innovation: Product and service innovation by government and the private sector in tax planning

Aggressive tax planning is a particular form of tax avoidance by which schemes or arrangements are put in place for the primary purpose of avoiding tax. It differs from traditional tax advice (where firms go to tax advisors for advice that is individually crafted to their particular situation) in that financial products and services are mass-produced and then mass-marketed to customers and clients who have not actively sought financial advice on reducing their exposure. To do this, accountancy firms have supplemented their traditional accounting and auditing services by developing organisational structures and strategies to sell these 'products' to corporations and wealthy individuals.[138]

Although official data is hard to come by, it has been estimated that the UK revenue authorities may be losing more than £100 billion of tax revenues each year through legal tax avoidance.[139] The US is estimated to have lost nearly $311 billion in 2001, up from $32 billion in 1973.[140] Global holdings deposited in off-shore accounts were estimated to have reached $6 trillion dollars by 1998.[141] As a result, the global tax avoidance industry is attracting increasing attention from policymakers.[142] Accountancy is a significant industry in the UK: combined fees income for the entire accountancy sector reached £7.62 billion in 2006, and the 'Big Four' firms accounted for the majority of this (£5.5 billion, an increase of £700 million on the previous year).[143] Of course, only a small proportion of these fees derive from tax planning services. While this field has been the subject of some academic study, it has not yet been examined from the perspective of innovation.

An example of a tax planning product from the US is a Bond Linked Issue Premium Structure (BLIPS). This scheme functions as a 'loss generator' whereby it generates a large paper loss that is then offset against other income to shelter it from tax.[144] As such, it takes the form of a complex transaction involving a shell company, bank loans, offshore accounts, fake losses, write-offs from the US Treasury and a special entity called a Strategic Investment Fund. One accountancy partnership sold 186 of these products between October 1999 and September 2000, making $53 million in fees. The US Treasury, on the other hand, contends that it lost $1.4 billion in unpaid taxes.

Innovations such as this actually comprise multiple innovations. First, the initial product innovation - that is, the development of the structure of the BLIPS. Second, the business model innovation that occurred in the 1990s, in the shift from the provision of bespoke advice to individual clients to a system in which networks of firms develop a series of sophisticated products that are mass marketed to multiple clients. Third, the innovation by governments in the form of the increasingly complex regulations that have attempted to control aggressive tax planning.

135. See Miozzo, M., and Dewick, P. (2003), 'Networks and Innovation in European Construction: Benefits from Inter-Organisational Co-operation in a Fragmented Industry, International Journal of Technology Management, 27 (1), pp.68-92.

136. Wigglesworth, R., and Kendall, J. (2000), 'The Impact of the Third Sector in the UK: The Case of Social Housing', Civil Society Working Paper 9, London School of Economics. For a historical perspective on these changes compare Hills, J. (1989), 'The Voluntary Sector in Housing: The Role of British Housing Associations', in James, E. (ed.), The Non-Profit Sector in International Perspective, (Oxford University Press, Oxford).

137. For some of the specific problems that still remain within the sector despite recent changes, see Stephens, M., Burns, N., and MacKay, L. (2003), 'The Limits of Housing Reform: British Social Rented Housing in a European Context', Urban Studies, 40 (4), pp.767-789.

138. Sikka, P., and Hampton, M. P. (2005), 'The Role of Accountancy Firms in Tax Avoidance: Some Evidence and Issues', Accounting Forum, 29 (3), pp.325-343.

139. Lyssiotou, P., Pashardes, P., and Stengos, T. (2004), 'Estimates of the Black Economy Based on Consumer Demand Approaches', Economic Journal, July, pp.622-640.

140. US Senate Committee on Finance (2004), Bridging the Tax Gap, (US Government Printing Office, Washington DC).

141. p.191, Jordana, J., and Levi-Faur, D. (2004), 'The Politics of Regulation in the Age of Governance', in Jordana, J., and Levi-Faur, D. (eds.), The Politics of Regulation, (Edward Elgar, Cheltenham).

142. General Accounting Office (2004), Comparison of the Reported Tax Liabilities of Foreign and US Controlled Corporations: 1996-2000 (GAO, Washington DC); Organisation for Economic Co-operation and Development (1998), Harmful Tax Competition: An Emerging Global Issue, (OECD, Paris); Organisation for Economic Co-operation and Development (2004), The OECD's Project on Harmful Tax Practices, The 2004 Progress Report, (OECD, Paris); Home Office (1998), Review of Financial Regulation in the Crown Dependencies, (HM Stationery Office, London); US Senate Permanent Subcommittee on Investigations (2003), The Tax Shelter Industry: The Role of Accountants, Lawyers and Financial Professionals, (US Government Printing Office, Washington DC); US Senate Permanent Subcommittee on Investigations (2005), The Role of Professional Firms in the US Tax Shelter Industry, (US Government Printing Office, Washington DC).

As with so many other sectors, new idea generation is only one of many sources of innovation here. Existing products are continually updated and modified through a process of incremental innovation as new financial regulations are developed, an improved understanding of customer requirements is gained, and new areas of possible exploitation are identified.

This development process points to the importance of networks of distributed skills and expertise, and also the importance of trust in these networks. The networks of financial service professionals who regularly work together rely heavily on trust and work to flexibly reallocate the benefits and costs of transactions. The pattern in the 1990s was that accountancy firms established research units within their tax departments, in which tax and audit staff developed products based on their expertise and their knowledge of firms' financial arrangements. Innovation in aggressive tax planning now occurs in complex international networks of financial services organisations such as accountants, bankers, lawyers and financial advisors, together with their clients. It is therefore shaped both by internal drivers within client firms (such as the ethical integrity of senior management), and by external drivers (such as the legal infrastructure that guides the provision of financial services).

Complex regulatory responses by governments have encouraged the extension of the networked innovation approach, as the tax planning community now needs increasingly sophisticated skills. This complexity has increased further in recent years with the greater use of derivatives to structure financial deals in order to minimise tax exposures.[145]

In response to innovation by firms, national regulators are constantly innovating in order to close loopholes. This reflects the increasing importance of regulation in the modern economy, because with the more efficient production of goods comes more efficient production of 'social evils' that might require regulation. In short, state regulation tends to increase with the growth of privatisation.[146] As aggressive tax planning has become more international, regulators have sought to co-ordinate their efforts through international bodies such as the OECD. The recent third meeting of the OECD Forum on Tax Administration in South Korea, which included the heads of revenue bodies from the 30 OECD member countries, adopted the 'Seoul Declaration,' calling for increasing cooperation between tax authorities to detect, deter and respond to international tax non-compliance. The declaration also demands that member countries implement a range of administrative reform measures to cope with challenges in tax administration.

It is also worth noting the development in the Australian regulatory system of a close relationship between The Centre for Tax System Integrity at the Australian National University and the Australian Taxation Office. This has led to a more responsive regulation strategy that focuses on 'promoters' (the most aggressive tax planners), helps taxpayers to comply where appropriate, and education programmes that inform investors of the risks associated with aggressive tax planning. This approach has had some success.[147] As has been noted, in the US corporate income taxes as a percentage of GDP have fallen almost continuously, while in Australia they have grown faster than GDP since 1986.[148]

Innovation in aggressive tax planning does, however, have mixed economic and social consequences. Aside from the bureaucratic burden on governments that constantly attempt to stem loss of revenue by devising increasingly complex regulatory systems, aggressive tax planning has shifted the social distribution of taxation regressively towards the poor,. Taxation is now focused on less mobile forms of capital and citizens who cannot afford tax advice.

Aggressive tax planning hurts developing countries by making it easier for elites to move money off-shore. This reduces the tax base, creates channels for money laundering, and generates the potential for financial instability. However, governments create extra complexity in the system by setting up new rules to patch leaks, and this complexity can be exploited by the next generation of tax planning products.[149] This can create a vicious (albeit innovative) circle of avoidance and regulation.[150]

Some areas of innovation are under-reported for a reason.[151] Aggressive tax planning is a large and lucrative market, and exposing it to the public gaze has not been in the interest of participants. But it does highlight the influence of government regulations, since the legal infrastructure defines both the possibilities and the prohibitions on particular transactions. This interdependence results in the co-evolution of products with developments in regulation. Innovation in one amplifies innovation in the other.

143. Accountancy Age (2006), 'Top 50 Accountancy Firms 2006', 29th June.

144. See US Senate Permanent Subcommittee on Investigations (2003), The Tax Shelter Industry: The Role of Accountants, Lawyers and Financial Professionals, (US Government Printing Office, Washington DC).

145. Derivatives are complex financial contracts that can be used to generate precise financial results at known levels of risk.

146. Braithwaite, J. (2006), Markets in Vice, Markets in Virtue, (Oxford University Press, Oxford), also p.10, Jordana, J., and Levi-Faur, D. (2004), 'The Politics of Regulation in the Age of Governance', in Jordana, J., and Levi-Faur, D. (eds.), The Politics of Regulation, (Edward Elgar, Cheltenham).

147. Braithwaite, J. (2006), Markets in Vice, Markets in Virtue, (Oxford University Press, Oxford).

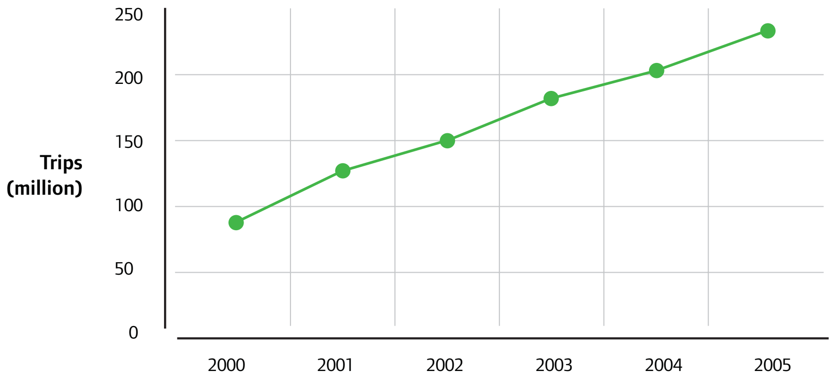
148. p.28-30, Jordana, J., and Levi-Faur, D. (2004), 'The Politics of Regulation in the Age of Governance', in Jordana, J., and Levi-Faur, D. (eds.), The Politics of Regulation, (Edward Elgar, Cheltenham).

149. The provision of tax shelters is meant to be constrained by regulations requiring disclosure. In the UK, these requirements have been substantially increased since the Finance Act 2004 and new regulations set out in the 2004 Budget. Disclosure of tax planning is now required so that the Inland Revenue gets information earlier about potential contrived and artificial schemes whose main purpose is to avoid tax. Similar rules have existed in the US, but there has been much non-compliance. Further measures were introduced in the 2006 Budget.

150. McCaffery, E. J. (1990), 'The Holy Grail of Tax Simplification', Wisconsin Law Review, 1267.

151. Hasseldine, J., and Li, Z. (1999), 'More Tax Evasion Research Required in New Millennium', Crime, Law and Social Change, 31 (2), pp.91-104.

Figure 10: Trips taken using the National Cycle Network (2000-2005)



Source: Sustrans.[154]

3.5. National impact through local innovation: Collaborative social innovation in the development of the National Cycle Network

The public and non-profit sectors represent a considerable part of the UK's economy. The public sector contributed over £145.4 billion (14.2 per cent) of the UK's total GVA in 2003 (compared to the market sector's £877.1 billion, or 85.7 per cent), comprising central government (£64.7 billion), local government (£60.3 billion) and public corporations (£20.4 billion).[152]

Innovation in these sectors may therefore be significantly beneficial to society (and potentially the economy) but wholly non-commercial and be unlikely to show up on traditional indicators of innovation. One example is the National Cycle Network. The Network was initiated in 1995 and has so far led to the creation of 10,000 miles of cycle routes throughout the UK. Prior to its creation, the UK had little provision for cycling compared to many other European countries. The charity responsible, Sustrans, is a membership organisation but it also raises project funding, principally from trusts and local and central government. Its income in 2004-5 was £23.5 million, a significant increase on previous years funded in part by a contract from the Department for Transport (previously, the Department for Transport, Local Government and the Regions, DTLR), to implement safe routes to schools.

The Network has been created from more than 1,000 separate projects. Collectively, the routes pass within one mile of 50 per cent of the UK population and within two miles of 75 per cent. During 2005, 193 million journeys were made on traffic-free sections of the Network, a figure that has increased every year since its launch (see Figure 10).[153]

As Sustrans notes, including this data in national travel statistics would show a much more positive picture of the levels of walking and cycling in the UK, and make the case for investment in these sustainable modes more compelling. Given that 58 per cent of all car journeys are less than five miles – the distance that traffic-free routes are encouraging people to cycle – the continued growth and use of the Network could have considerable environmental, social and personal benefits. It also represents a new form of health intervention, by providing a means for better health rather than campaigning to try to influence personal behaviours.[155] In 2003, 35 per cent of users could have used a car for their trip but instead used the Network, while 72 per cent of users said they were more active due to the Network.[156]

As a major social innovation initiated by a charity and taken forward largely in cooperation with the public and civil sectors, the Network challenges the predominantly private sector focus of innovation research. Private-sector involvement was largely confined to fulfilling contract work that had been conceived, planned and resourced by players in the public and charity sectors.

152. Office for National Statistics (2005), United Kingdom Input-Output Analyses, (HMSO, London).

153. Sustrans (2005), The National Cycle Network, Route User Monitoring Report To End of 2005, (Sustrans, Newcastle).

154. Ibid.

155. Lawlor, D. A., Ness, A. R., Cope, A. M., Davis, A., Insall, P., and Riddoch, C. (2003), 'The Challenges of Evaluating Environmental Interventions to Increase Population Levels of Physical Activity: The Case of the UK National Cycle Network', Journal of Epidemiol Community Health, 57, pp.96–101.

156. Department for Transport (2005), Encouraging Walking and Cycling: Success Stories, (DfT, London).

This innovation is also highly localised. Sustrans works with a wide range of other organisations, especially local transport authorities but also landowners, schools and local communities, to deliver the component parts of the project. It now has more than 1,000 partner organisations, many of which have contributed their own resources to help create the Network. A collective vision, enthusiasm and persistence have been important factors in its success.

The Network has certainly been managed as an innovation, but not in the traditional sense. The diffuse nature of the interests involved mean that this is much more a case of managing a network and a set of relationships than taking control of a discrete project and seeing it through to completion. Organisational relationships have been the source of the best (and most difficult) aspects of this innovation.

This initiative also has little to do with R&D or the science-based view of innovation. There are elements of engineering involved, but none at the cutting-edge of knowledge. As an innovation, the Network has largely been a matter of taking a few good ideas, establishing multiple strategic partnerships and implementing them with a clear vision and drive and determination.

3.6. Hidden innovation means that we need to broaden our understanding of innovation

These five case studies demonstrate the commercial and social value of a range of different types of innovation, none of which (for various reasons) show up on traditional indicators or are encouraged through existing innovation policy. Some (such as the genetic tests created by the NHS) are technological and scientific products (the traditional focus of innovation research and policy), but most represent non-traditional innovations from new processes to novel business models and relationships. They illustrate the diversity of actors involved in the generation, the implementation and the diffusion of innovations. Government in particular can be important in shaping innovation, as a client for many firms and organisations but also as a regulator. Identifying and managing risk and any unforeseen side-effects of innovation is also an important government function.

Collectively, these case studies indicate a number of important facets regarding the reality of innovation in the UK:

First, they collectively reinforce the **importance of networks and inter-disciplinary interaction** in the development of innovations, particularly when the process is considered across all of its phases of invention, development and dissemination. However, these networks need not be formal and frequently thrive on their informality, as in the case of genetic testing. Even in the highly commercial areas of tax planning and engineering, informal networks seem to play a pivotal role. It appears that different types of networks and relationships may be better at conducting different forms of innovation (for example, in some cases, informal networks may be more conducive to radical forms of innovation, because they may be more flexible than formal or structured networks).

Second, they highlight that important innovations can occur in **non-commercial environments**. In certain cases, such as the National Cycle Network, they remain entirely non-commercial. In others, such as genetic testing, non-commercial development can lead to commercial production.

Third, the cases of social housing and tax planning demonstrate the crucial **role played by the public sector** in bounding and informing innovation by commercial organisations.

Fourth, they demonstrate the need for a **broadly distributed capacity for innovation** within society. In the following section, we examine the implications that hidden innovation has for the UK's approach to education.

Finally, they reveal the relative **paucity of knowledge** about a host of important fields of innovation. It is no surprise, therefore, to find that they are ignored by innovation policy as well.

While it appears that the areas highlighted by these case studies are innovating quite well, it should be noted that the government plays a leading role in all but one of them, although that role is significantly different from the traditional forms of intervention that are associated with innovation (for example, tax subsidies for formal research and development). The case of social housing demonstrates the change that can occur with focused effort. If the government is able to make successful interventions in stimulating innovation in science and technology, perhaps similar success could be achieved in accelerating existing levels of innovative activity in, for instance, financial services or the creative industries.

There also remain important sectors of the UK economy and society that consistently under perform. Perhaps, for example, more creative thinking could be applied to the management and rehabilitation of the prison population. Over the last ten years, the total prison population has increased from 51,000 in June 1995 to more than 76,000 in June 2005, and currently the Home Office's most conservative projection for the prison population in 2013 is 90,250 individuals.[157] This stands in stark contrast to the current useable operational capacity of 79,968. The UK has the highest detention rate in the European Union and 55 per cent of British prisoners currently re-offend. Equally, issues such as transport infrastructure[158] and mental health[159] are examples where there appears to be a pressing need for greater innovation.

3.7. Intermediate skills and a refocused education system are critical to the development of hidden innovation and the absorption of innovations developed elsewhere

Only one of our case studies of hidden innovation relies on advanced scientific knowledge. However, reflecting an over-concern with the generation of new knowledge through fundamental scientific research, the typical focus for the debate regarding education and innovation concerns the supply of people with highly advanced science, engineering and technology (SET) skills. While there are some causes for concern in certain subject areas, overall the supply of SET skills in the UK is fairly strong,[160] with more than 10 per cent of 24 year-olds holding a SET degree (more than in the US and Germany); only South Korea and France perform better in this respect.[161]

However, many SET graduates do not work in direct SET areas. Only two per cent of SET graduates are employed in R&D services.[162] Forty-five per cent of SET graduates work in non-SET occupations, including (typically better rewarded) jobs in banking, finance and insurance.[163] This does not mean that they are not contributing to the UK's innovative capacity. Indeed, although the importance of pure university-based research in innovation has been over-estimated, the role of universities in enabling innovation by providing trained people who are skilled at solving complex problems has traditionally been under-valued.

This situation does, however, present a different sort of problem. Having large numbers of SET graduates helps to raise the UK's capacity to absorb new foreign knowledge (and lowers the cost of doing so). That is, as long as there are enough SET graduates working domestically in related fields to apply the resultant knowledge, foreign R&D can be as valuable to the UK as domestic R&D.[164] However, the proportion of graduates in such positions in the UK is lower than in the US, Japan, Finland or Sweden.[165] The OECD has suggested that the most significant inhibitor of UK innovation is an insufficient capacity to absorb foreign knowledge.[166] As a result, public investment in research should be seen primarily as inducing demand *for* innovation as well as increasing its supply. By focusing on generating 'talent not technology' (in the title of one research study on the role of universities in innovation), the UK is more likely to benefit from the open nature of its economy and its resulting ability to exploit foreign innovation, direct investment and talent.

As has been suggested by the Leitch Review, the UK's future prosperity will also depend upon its wider skills base; the UK workforce must have the skills to take advantage of technological developments, and to cope flexibly with the changes brought by globalisation.[167] Workers with more skills are demonstrably more productive and also more flexible and adaptable. By measures of intermediate skills, however, the UK compares poorly with its competitors. Only 28 per cent of the UK workforce has intermediate skills compared with 51 per cent in France and 65 per cent in Germany.[168] Eighty-five per cent of German adults and 77 per cent of French adults of working age are qualified at Level 2 or higher compared with 64 per cent of UK adults.[169] A recent study indicates that increasing the literacy score of a country by one per cent leads to a 2.5 per cent rise in labour productivity and a 1.5 per cent increase in GDP per head.[170] Similarly, it has been estimated that improvements in the skills of UK workers have contributed around one-fifth of the annual growth in the UK economy over the past 25 years.[171]

157. Home Office (2006), Statistical Bulletin, Prison Population Projections 2006-2013, England & Wales, (Home Office, London).

158. The quantifiable cost of transport delays to the City of London is conservatively estimated to be £230 million a year. This is equivalent to £750 a year for each person working in the City or to about £1 million per business day for the City as a whole, see Corporation of London (2003), The Economic Effects of Transport Delays on the City of London, (Corporation of London, London).

159. 16 per cent of adults of working age have a mental illness, while eight per cent are seriously ill. By 2020, mental health conditions are expected to be the most common type of impairment, see Mental Health Foundation (2003), Statistics on Mental Health Factsheet, (Mental Health Foundation, London).

160. Department of Trade and Industry (2006), Science, Engineering and Technology Skills in the UK, DTI Economics Paper No. 16, (DTI, London).

161. Engineering and Technology Board (2005), Engineering UK 2005, (ETB, London).

162. Department of Trade and Industry (2006), Science, Engineering and Technology Skills in the UK, DTI Economics Paper No. 16, (DTI, London).

163. Ibid.

164. Jaumotte, F. and Pain, N. (2005), From Ideas to Development: The Determinants of R&D and Patenting, OECD Economics Department Working Paper No. 457, (OECD, Paris).

165. Cotis, J. (2006), Economic Growth and Productivity, (OECD, Paris).

166. Ibid

167. The Government commissioned the Leitch Review to identify the UK's optimal skills mix in 2020 to maximise economic growth, productivity and social justice, and to consider the policy implications of achieving the level of change required. See HM Treasury (2005), Leitch Review of Skills, Skills in the UK: The Long-Term Challenge, Interim Report, Chapters 1-6, (HMSO, London).

168. As noted in Department for Education and Skills (2005), Realising the Potential, A Review of the Future Role of Further Education Colleges, (DfES, Annesley).

169. Ibid. 'Level 2' qualifications include five or more GCSEs, O-Levels or equivalent at grades A*-C, NVQ Level 2, and BTEC first or general diplomas.

170. Coulombe, S., Tremblay, J., and Marchand, S. (2004), International Adult Literacy Survey Literacy Scores, Human Capital and Growth Across Fourteen OECD Countries, (Statistics Canada, Ottawa).

A skills gap is likely to be a significant inhibitor of innovation in the UK. For example, it has been suggested that around one-fifth of the UK's productivity gap with France and Germany is a result of the relatively poorer skills of workers in the UK.[172] In addition, UK businesses do not invest in the innovative potential of their employees. Only six per cent of expenditure on innovation by UK businesses goes on training, compared to the 37 per cent that is invested in new machinery, equipment and software (although this varies considerably by sector).[173] As the Leitch Review suggests, any moves towards a more highly skilled economy can only be achieved if there is an improvement in the supply of highly skilled labour.

There have already been a range of initiatives across the education systems of the UK nations that recognise the extent and scope of these challenges. For example, in England, there are initiatives in entrepreneurship education, personalised learning, citizenship, the use of ICT, after-school clubs and extended schools, and the Creative Partnerships and Building Schools for the Future programmes. In Northern Ireland, the revised curriculum has been designed to place greater emphasis on the development of skills for lifelong learning, making connections across different parts of the curriculum, increasing the discretion teachers can exercise in matching the curriculum to the needs of learners, and using assessment as a tool for improving learning. In Scotland, the 'national debate on education' produced ideas for how to ensure more innovative and flexible approaches to the curriculum and how to identify the needs of individual learners. This led onto the *Curriculum for Excellence*, which codified the capacities, attributes and capabilities that will lie at the heart of curriculum renewal. Similarly, in Wales, a range of skills are intended to be integrated appropriately across the curriculum, including ICT skills, mathematical skills, problem-solving skills and creative skills.

The question is whether these developments are likely to meet the greater challenges of innovation in the 21st century, and in particular, given the broader innovation agenda, whether they are likely to ensure that as many people as possible can contribute to and participate in innovation. In short, the UK needs to consider quickly and carefully what an education system designed around supporting and promoting innovation would look like.

171. Bell, V., Burriel-Llombart, P., and Jones, J. (2005), A Quality-Adjusted Labour Input Series for the United Kingdom (1975-2002), Bank of England Working Paper 280, (Bank of England, London).

172. O'Mahoney, M., and de Boer, W. (2002), Britain's Relative Productivity Performance: Updates to 1999, (National Institute for Economic and Social Research, London). See also Layard, R., McIntosh, S., and Vignoles, A. (2002), Britain's Record on Skills, (Centre for Economic Performance, London School of Economics, London).

173. Department of Trade and Industry (2006), Innovation in the UK: Indicators and Insights, DTI Occasional Paper No. 6, (DTI, London).

Part IV: Building the policy agenda that the UK needs to meet the national challenges of the 21st century

4.1. Innovation policy does not reflect the reality of innovation in the UK

Greater public investment in science and technology, especially in public science, has been necessary and valuable. The UK has not been alone in focussing on formal scientific and technological R&D in universities and in the manufacturing sector (especially in high-tech manufacturing), and related outputs such as patents and the publication of scientific papers. However, this relies on the traditional linear model of innovation that is increasingly out-of-step with innovation practice and which fails to include the vast majority of the economy. As a result, we are in danger of failing to maximise the UK's capacity for innovation.

The current emphasis serves to reinforce the national myth that the primary deficit is in our failure to exploit the inventions that we develop. This results in a (consequently logical) focus on publicly-funded research and knowledge transfer. By extension, the same logic leads to an under-emphasis on building the human capital and absorptive capacity necessary to exploit the outputs of the science bases of other countries.

It is now possible to draw a direct line between the traditional indicators that are supposed to capture innovation and the various policies that have been developed in response to the UK's poor performance on these indicators.[174] In effect, the indicators have themselves *become* policy, in the sense that increasing R&D expenditure is policy, as is increasing knowledge transfer from universities, and so on.

Why then has innovation policy fallen so out of sync with innovation? There are three practical reasons and three that stem from the historical and political realities of government. First, advances in understanding innovation often follow changes in the economy. There is often a lag between reality and conceptual understanding. Second, the indicators used to measure innovation are based on these new conceptual understandings, and these too take time to be developed and collected. Third, the more recent and more complex models of innovation do not lend themselves to straightforward measurement because they deal in greater complexity than earlier models. (The ease with which traditional indicators are collected can however be overplayed; it is worth noting that the latest edition of the manual that defines the standard practice for measuring R&D is 255 pages long).[175]

Additionally, policymakers have found it difficult to move beyond the science and technology foundations of innovation policy for three historical reasons. First, innovation policy grew out of science and technology policy, but has subsequently absorbed aspects of enterprise policy, and education and skills policy as well. This process of absorption has allowed science and technology to remain dominant in innovation policy. In other words, areas such as education and skills have been grafted onto a framework for innovation policy that remains focused on SET, rather than causing this framework to be radically revised.

174. The DTI produces its own set of innovation indicators, but even though these have a broader coverage than many other surveys, including areas such as skills, management and labour markets, the main policies and programmes can still be seen to follow the more familiar indicators. See Department of Trade and Industry (2006), UK Productivity and Competitiveness Indicators 2006, (DTI, London).

175. Organisation for Economic Co-operation and Development (2002), Frascati Manual 2002, Proposed Standard Practice for Surveys on Research and Experimental Development, (OECD, Paris).

Second, the audit culture that prevails in government encourages a reliance on existing metrics whether or not they are representative. As explained above, this is not necessarily a case of 'measuring the easily measurable,' because traditional indicators are bound by hundreds of pages of definitions and exclusions. But it does encourage an over-reliance on easy-to-represent measures that can be measured year-on-year. Calculating R&D intensity may require 255 pages of the *Frascati Manual*, but it does (finally) result in a single number.

Third, without innovation being identified as a major cross-cutting priority (in the manner of social inclusion), the existing remits of government departments and agencies have discouraged the cross-governmental thinking that modern understandings of innovation require. For example, the DTI currently houses the Office of Science and Innovation and is responsible for the majority of sectors of the UK economy, but HM Treasury has responsibility for overseeing the financial services industry and the Department for Culture, Media and Sport (DCMS) has the creative industries within its remit. Needless to say, education and health (and any innovation therein) remain the province of the DfES and DoH respectively.

This moment represents an opportunity to break out of a cycle in which outdated understandings lead to the collection of often inappropriate data that serves to create an overly pessimistic view of innovation in the UK. Rather than seek to improve performance according to a narrow set of indicators which do not properly represent the UK, policymakers should consider the implications of a broader innovation agenda that would maximise our ability to meet future economic and social challenges.

4.2. Six general implications for policy to effectively promote innovation in the UK

First, we need a **broad** view of where innovation comes from and where it applies, else we fail to exploit the full innovative potential of the vast majority of our economy. We need to see innovation as a broadly-spread capacity that applies across the economy, including within public services, and not just in traditional science- and technology-intensive areas. Greater attention should be given to the complex processes involved in innovation, the importance of incremental changes, and the role of diffusion.[176]

Second, we should consider the importance of the **drivers** of this new and broader definition of innovation. Policy must begin to recognise that the knowledge and skills required to innovate and to absorb innovation need to be widely distributed in society, rather than supposedly being centralised in R&D departments or elite academic institutions. This would include a focus on an education system that is able to develop foundation skills: analysis, problem-solving, creativity, imagination, resourcefulness and flexibility – in other words, our collective capacity to initiate, absorb, support, organise, manage, and exploit innovation in its many forms. While current policy may over-estimate the importance of academic research as a source of innovation, it may under-estimate the damage that low per capita investments in public research have had on the production of skilled scientists and engineers who can apply their skills in the wider economy. It is with our capacity to integrate (adopt and use) knowledge, rather than to generate it (or be the first to commercialise it), that we should be most concerned.

Third, we need a **textured** innovation policy that recognises that one size does not fit all sectors. The recipe in the pharmaceuticals sector will not work for financial services or for public services. This leads to a requirement for us to gather sounder intelligence and analysis of the sources and contribution of innovation across different economic sectors. The UK's future will be as a creative and service economy. We need a much better understanding of the dynamics driving innovation in areas such as the City of London, popular music and business services.

176. Mowery, D., and Rosenberg, N. (1998), Paths of Innovation, Technological Change in 20th-Century America, (Cambridge University Press, Cambridge).

Fourth, innovation policy needs to be **imaginative** and encompass a wide range of interventions that are relevant to stimulating and supporting innovation. The case studies presented in this report indicate how creative interventions such as demonstration projects and prizes can help make previously poorly performing sectors (such as social housing) both more innovative and a source of socially desirable outcomes. It would also be useful to focus more on the multi-directional flows within and between science and technology, architects and developers, designers and producers, government and industry, management and engineering, universities and industry, customers and suppliers.

Fifth, we should create an innovation policy that is **appropriate** to UK conditions. A striking feature of most innovation policies around the world is their similarity. Almost without exception, they focus on sectors such as IT, biotech and nanotech; on increasing public and private investment in R&D; and on strengthening links between the science base and industry. In the past, we have learned and borrowed from Japan, Silicon Valley and Scandinavia. A distinctive UK innovation system would focus on sectors that play a marginal role in the policies of countries with larger manufacturing sectors. One factor would be the role of regulation in promoting innovation. The UK has a track record for innovation through intelligent regulation (or a light regulatory touch), from stem cell research to innovative financial products in the City of London and privatisation to open up telecoms markets. The UK's capacity for innovation-promoting regulation across different fields is a key capability. Linked to this is understanding the critical role of markets and consumers in pulling and enabling innovation. Britain's position in creative industries is in part due to the role of experimental and receptive young consumers in major cities. As users become more central to innovation so understanding the capacity for markets to generate innovation becomes more critical.

Sixth, we need greater clarity regarding the **outcomes** of innovation (rather than just the outputs). The focus of the UK's innovation policy should be determined by what we as a nation want from innovation, rather than focusing on innovation as an end in itself.

4.3. Toward a national mission for innovation: The UK should seize the opportunity to create a world-leading innovation policy, and reap the resultant rewards

The UK is not alone in grappling for the understandings, metrics and policies that will effectively capture and stimulate the reality of innovation in the 21st century. However, this is not an unsolvable problem – it can be addressed with concerted effort, intellect and political will. Moreover, the UK has some considerable strengths as it faces up to the challenge. We have a strong background in innovation studies, particularly in research centres such as SPRU, CRIC, CENTRIM, the Innovation Studies Centre, and PREST, and policymakers across the UK are increasingly realising that policy and measurement have fallen out of sync with the reality of innovation. The pessimism generated by the familiar appraisals of UK innovation is being replaced by a more positive understanding of the multitude of innovative and creative forces at work in UK society. What is needed is the articulation of a national mission around innovation, one that encompasses the complexity of innovation while remaining a simplified guide to action.

In considering what shape this new approach would take, Finland and Manchester present two useful examples (for further detail, see Appendices C and D). The former is a country that has undergone a deeply-self-critical examination of its strengths and weaknesses and proceeded to define a holistic National Innovation Strategy that cuts across every area of its economy and society. The latter is an example of a UK city-region that has built a strong coalition of industry, academic, cultural and government leaders around an all-encompassing manifesto that builds on its strengths with the aim of becoming a strong but specialised contributor to the global economy.

The UK is well-placed to be a leader of an international shift in innovation policy. Aside from the intrinsic benefits of becoming a more skilled, more innovative country, the creative, open nature of our society combined with our developed system of regional and national government means that the UK is well positioned to take advantage of innovations developed elsewhere. This combination of being able to generate knowledge and capture and exploit the knowledge of others is what it means to be a hub in the future global economy. By embarking upon a considered, concerted drive toward a national mission for innovation, the UK will be well-positioned to lead the world in the application of knowledge, enterprise and creativity and to meet the national challenges of the 21st century.

Appendix A: Glossary

ALMO	Arms Length Management Organisation
BBC	British Broadcasting Corporation
BERD	Business Expenditure on Research and Development
BLIPS	Bond Linked Issue Premium Structure
CABE	Commission for Architecture and the Built Environment
CBI	Confederation of British Industry
CDVF	Community Development Venture Fund
CENTRIM	Centre for Research in Innovation Management, University of Brighton
CIC	Centres of Industrial Collaboration
CIS	Community Innovation Survey
CITB	Construction Industry Training Board
CRIC	Centre for Research on Innovation and Competition, University of Manchester
D&R	Development and Research
DCLG	Department for Communities and Local Government
DCMS	Department of Culture, Media and Sport
DETI	Department of Enterprise, Trade and Industry (Northern Ireland)
DETR	Department for Transport, Environment and the Regions
DfES	Department for Education and Skills
DfT	Department for Transport
DHSSPS	Department of Health, Social Services and Public Safety (Northern Ireland)
DoH	Department of Health
DTI	Department of Trade and Industry
DTLR	Department for Transport, Local Government and the Regions
ECF	Enterprise Capital Fund
EGF	Early Growth Fund
EIS	European Innovation Scoreboard
EP	English Partnerships
EPO	European Patent Office
EUROSTAT	Statistical Office of the European Communities
FDI	Foreign Direct Investment
GAO	US General Accounting Office (now Government Accountability Office)

GDP	Gross Domestic Product
GERD	Gross Expenditure on Research and Development
GKP	Genetic Knowledge Park
GMV	Greenwich Millennium Village
GNP	Gross National Product
GVA	Gross Value Added
HEIF	Higher Education Innovation Fund
HERD	Higher Education Investment in Research and Development
HMSO	Her Majesty's Stationery Office
HMT	Her Majesty's Treasury
HMRC	Her Majesty's Revenue & Customs
ICF	Innovative Clusters Fund
IFS	Institute for Fiscal Studies
ISI	Institute for Scientific Information
ITI	Intermediary Technology Institutes
JPO	Japanese Patent Office
KTP	Knowledge Transfer Partnership
LEC	Local Enterprise Council
LSVT	Large Scale Voluntary Transfer
MIT	Massachusetts Institute of Technology
MMC	Modern Methods of Construction
MSTI	Main Science and Technology Indicators
NESTA	National Endownment for Science, Technology and the Arts
NHS	National Health Service
NIS	National Innovation System
ODPM	Office of the Deputy Prime Minister
OECD	Organisation for Economic Co-operation and Development
OGC	Office of Government Commerce
OSI/OST	Office of Science and Innovation (formerly, Office of Science and Technology)
OSM	Off-Site Manufacture
PFI	Public Finance Initiative
POST	Parliamentary Office of Science and Technology
PPD	Product and Process Development

PREST	Policy Research in Engineering, Science and Technology, University of Manchester
PSREF	Public Sector Research Exploitation Fund
R&D	Research and Development
RCUK	Research Councils UK
RDA	Regional Development Agency
RIF	Regional Innovation Fund
RIS	Regional Innovation Strategy
RSL	Registered Social Landlord
RTD	Research and Technological Development
RVCF	Regional Venture Capital Funds
SBRI	Small Business Research Initiative
SBS	Small Business Service
SCF	Scottish Co-investment Fund
SCI	Science Citation Index
SCORE	Scottish Executive Collaborative Research Programme
SEEKIT	Scottish Executive Expertise, Knowledge and Innovation Transfer
SET	Science, Engineering and Technology
SFLG	Small Firms Loan Guarantee Scheme
SIC	Science and Industry Council
SIF	Strategic Investment Fund
SMART	Small Firms Merit Award for Research and Technology
SME	Small or Medium Enterprise
SPRU	Science and Technology Policy and Research Unit (University of Sussex)
TSB	Technology Strategy Board
TUC	Trade Union Congress
TVS	Technology Ventures Scotland
UKCS	UK Continental Shelf
UKGTN	UK Genetic Testing Network
UKHTF	UK High Technology Fund
UNCTAD	United Nations Conference on Trade and Development
USPTO	U.S. Patent and Trademark Office
WAG	Welsh Assembly Government

Appendix B: Details of innovation priorities, policies and initiatives across the UK

B.1. Innovation policy across the UK

B.1.1. UK central government policy

In 2003, the DTI published its *Innovation Report*.[177] In the foreword to the report the Prime Minister stated that:

> *"We want the UK to be a key knowledge hub in the global economy, with a reputation not only for outstanding scientific and technological discovery, but also to be a world leader in turning that knowledge into new and exciting products and services. In terms of business R&D and patenting we will aim to be the leading major country in Europe within ten years."*[178]

The terms of reference of the DTI report were wide-ranging. They included an assessment of the UK's relative performance, the identification of areas where market or institutional features inhibit innovation in UK firms, identification and prioritisation of the policy levers that might address the market and institutional failures, and comparison of these with current government policy and support. While the review did consider the rationales for particular support schemes and evidence on their effectiveness, it made very few recommendations for reforms to specific schemes or for the introduction of any new schemes (one recommendation was for the formation of a business-led Technology Strategy Board (TSB) to ensure that policy reflected business needs and was informed by business processes). Instead, it made some more general recommendations, for example, with regard to government procurement, increasing the role of the Small Business Service in advancing knowledge transfer and innovation, and for the development of the Technology Strategy.

The following year (2004), the *Lambert Review* of business–university collaboration made several recommendations to improve links between universities and businesses, which the Government accepted.[179] This was prompted by the recognition that while UK firms have many network relationships, relatively few cite universities or public research institutes as sources of information. The Review gave support to two existing schemes, LINK and Knowledge Transfer Partnerships (KTPs). However, the report suggested improvements to the marketing of the KTP scheme and also to the marketing of R&D tax credits in order to raise awareness and take-up by businesses. It made a number of recommendations concerning direct public funding for university research, and suggested possible extensions to the LINK scheme and the Higher Education Innovation Fund (HEIF) as ways of allocating funding for business-relevant research. (The 2004 Budget announced measures building on the recommendations of the Lambert Review, including changes to the Higher Education Innovation Fund to provide funding for universities for technology transfer activities).

177. Department of Trade and Industry (2003), Innovation Report, Competing in the Global Economy: The Innovation Challenge, (DTI, London).

178. p.3, ibid.

179. HM Treasury (2003), Lambert Review of Business–University Collaboration: Final Report, (HM Treasury, London).

At the time of the 2004 Spending Review, the Government announced an increase in public spending on science over the period to 2007–08 and published details of its 10-year framework for science and innovation. The *Science and Innovation Investment Framework 2004-2014*, published jointly by HM Treasury, the DTI and DfES in July 2004, set out a series of goals in public and private sector R&D activity, interactions between business and the publicly funded research base, and improvements in skills.[180] This document presented a list of the UK's ambitions in science and technology, including: 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; increased business engagement in drawing on the UK science base for ideas and talent; and a strong supply of scientists, engineers and technologists.

It also expanded the role of the TSB and charged it with reporting annually on its activities and on Government policies that relate to technology innovation and knowledge transfer. The DTI has also committed to a Public Service Agreement (PSA) target for the period 2005–08 to improve the relative international performance of the UK research base and increase the overall innovation performance of the UK economy, including through effective knowledge transfer between universities, research institutions and businesses.[181] The *Science and Innovation Investment Framework 2004-2014* also established a target to increase the UK's R&D intensity from 1.9 per cent in 2003 to 2.5 per cent by 2014.

In November of the same year, the DTI published its five-year programme *Creating Wealth from Knowledge*, which mapped out a new industrial policy with the ambition to make Britain the most attractive place in the world for scientific research.[182] It emphasised the need for the greater exploitation of science and technology and a step-change in innovation in the economy and in workplaces.

B.1.2. Devolved administration policy

This consistent emphasis on scientific and technological invention has also been reflected in the other UK nations. In Scotland, innovation programmes have grown from the analysis set out in the *Framework for Economic Development in Scotland, A Science Strategy for Scotland and the Smart, Successful Scotland Strategy.*[183] *Smart, Successful Scotland* focussed on four themes: productivity (and the 'productivity gap' with other leading competitor nations); entrepreneurship (in particular, raising the rate of new firm formation); the skills required for a flexible labour market; and 'digital connections.' The Scottish Executive has also recently published a consultation on a *Science and Innovation Strategy for Scotland*, which identified seven themes (including maintaining and developing the excellence of the science research base, and intensifying knowledge exchange between academia and business).

In Northern Ireland, the innovation strategy was developed in parallel with the DTI *Innovation Report,* with the active participation and consensus of all major stakeholders and partners, and with a view to providing a framework for the creation of a globally competitive, innovation-driven economy in Northern Ireland. This strategy, *Think, Create, Innovate*, was published in 2003, with an emphasis on the better integration of public, private and higher education R&D efforts as well as the need to increase levels of R&D expenditure throughout the region.[184] In the more recent Action Plan there are six areas for action (all of which display a familiar emphasis): resourcing R&D; supporting knowledge and technology transfer; developing a greater awareness of intellectual property management; leading a regional innovation system (including establishing a Regional Science-Industry Council); promoting cross-sectoral collaborations; and enhancing interregional collaborations (across the UK, Ireland, the EU and beyond).[185]

In Wales, the Assembly Government's *Innovation Action Plan* (2003) established five broad themes for establishing a stronger culture of innovation in Wales: communicating the importance and benefits of innovation to business; supporting high growth businesses; better equipping people to innovate; building the best innovation support provision; and making the most of the capabilities of higher education institutions, encouraging technology development, transfer and commercialisation, and closer links between academia and

180. HM Treasury/Department of Trade and Industry/Department for Education and Skills (2004), Science & Innovation Investment Framework 2004-2014, (HM Treasury/DTI/DfES, London).

181. For details of the DTI's PSA targets, see www.dti.gov.uk/psa_target.html.

182. Department of Trade and Industry (2004), Department of Trade and Industry Five Year Programme, Creating Wealth from Knowledge, (DTI, London).

183. Scottish Executive (2001), A Smart, Successful Scotland, Ambitions for the Enterprise Networks, (Scottish Executive, Edinburgh), Scottish Executive (2004), A Smart, Successful Scotland, Strategic Direction to the Enterprise Networks and An Enterprise Strategy for Scotland, (Scottish Executive, Edinburgh).

184. Department of Enterprise, Trade and Investment (2003), Think, Create, Innovate, (DETI, Belfast).

185. Department of Enterprise, Trade and Investment (2005), The Regional Innovation Strategy for Northern Ireland, Action Plan September 2004 to August 2006, (DETI, Belfast).

businesses more generally.[186] This was followed in 2005 by the Assembly Government's Strategic Framework for Economic Development consultation document, *Wales: A Vibrant Economy*, which states that innovation is the key to establishing a sustainable competitive advantage.[187] In January 2006, the Welsh Assembly Government launched a consultation entitled *A Science Policy for Wales?* The First Minister's foreword acknowledged that arguments in favour of Wales having a science policy had become more compelling, because of the need to compete in the global knowledge economy and to ensure the integration of higher education and private sector strenghts in science and technology.

B.2. Governmental structures around science, technology, engineering and knowledge transfer are extensive

B.2.1. UK central government

Because of its heritage in science and technology policy, the Department of Trade and Industry (DTI) has emerged as the focal point for the governance of the current UK system of innovation. The DTI influences UK innovation through a variety of channels. The Office of Science and Innovation (OSI) evolved out of the Office of Science and Technology (OST) and is responsible for the funding of basic research largely via the research councils. It also provides the secretariat for the Chief Scientific Advisor who coordinates science and technology across Government. In order to promote the exploitation of S&T, the DTI takes the lead on a number of mechanisms (such as Foresight, LINK and Foresight LINK Awards) and has joint responsibility with the DfES on others like HEIF. The Science and Innovation Group (formed from the Innovation Group and Science and Engineering Base) is the focus for the Department's work to improve the overall innovation performance of the UK economy, working closely with the OSI and other DTI Groups (such as the Business, Energy, Fair Markets and Services Groups).

The Technology Strategy Board (TSB), formed in October 2004, advises the Secretary of State for Trade and Industry on business research, technology and innovation priorities for the UK, the allocation of funding across these priorities and the most appropriate ways to support them, by acting as a high level forum for interaction between business, government and other stakeholders.

Whilst the DTI is the major central government actor in UK innovation policy, a number of other departments undertake innovation related activities. The DfES, with its responsibility for all issues relating to education in England, plays a fundamental role in providing the education and skills required to stimulate innovation, while the Department for Communities and Local Government 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).

Following the publication of the *Innovation Report*, the Steering Group on Innovation in the Knowledge Economy (chaired by the Secretary of State for Trade and Industry) meets on a quarterly basis with the intention of coordinating the work of all Government departments on the science, innovation and wealth creation agendas.

A new Cabinet committee on Science and Innovation was formed in March 2005 (subsuming the former Cabinet Science Policy Committee and the Ministerial Group on Science, Innovation and Wealth Creation), in order to determine and oversee the implementation of the Government's policies in relation to those areas. Further, an Innovation Stakeholder Group was set up in response to a proposal in the *Innovation Report*. The original membership of the Innovation Stakeholder Group included the TUC and the CBI. Membership was later broadened to include representatives from other intermediaries, businesses, the Research Councils and RDAs.

B.2.2. Direction of university research

The budgets for the research councils come from the office of the Director-General Research Councils in the OSI, but the overall coordination of research council policy is now conducted by Research Councils UK (RCUK). The higher education funding councils (separate bodies exist for England, Scotland, Wales and Northern Ireland), provide general funding for universities (used mainly for academic salaries and research infrastructure), while the research councils provide funding for projects, research training and centres. The other principal funding source for research is the charitable non-profit sector, along with the private sector.

186. Welsh Assembly Government (2003), Wales for Innovation, The Welsh Assembly Government's Action Plan for Innovation, (WAG, Cardiff).

187. Welsh Assembly Government (2003), Wales: A Vibrant Economy, (WAG, Cardiff).

B.2.3. Business support services

Operating at a number of levels throughout the system is a wide range of business support organisations, operated by government or on behalf of government. These include Business LINKs, the Regional Development Agencies (RDAs), Regional Technology Centres, technology brokers such as the British Technology Group, contract research and development companies and other information providers.

B.2.4. Regional innovation policy

The nine RDAs are the main vehicles for the delivery of the DTI's innovation policies in the English regions and as such hold the lion's share of budget and responsibility for the innovation agenda. The RDAs develop Regional Innovation Strategies (RIS) in consultation with a wide range of regional and local actors. Typically, an RIS addresses issues such as the identification and stimulation of industrial sectors of particular regional significance, regional networks that foster collaboration, the exchange of good practice, and the level of interaction between universities/research institutions with local/regional businesses, particularly SMEs.

The RDAs have also established Science and Industry Councils (SICs) or similar arrangements, to bring together science, technology and business representatives from the private sector and universities. The SICs provide a mechanism for RDAs to engage with the knowledge base, whether it resides in research institutes, universities or leading edge companies located in the region.

B.2.5. Devolved administrations

The Scottish Executive has a dual role of responsibility for policy formulation and for the administration of a number of schemes designed to enhance innovation in Scotland.[188] Scottish Enterprise, and Highlands and Islands Enterprise, play an important role in the implementation of policy on R&D and innovation, and to a lesser extent in the support and direction of R&D and innovation in Scotland. Their activities are wide-ranging including skills development and support of cluster initiatives and incubation. Scottish Enterprise is focused around four main areas in innovation: the provision of advice to firms; provision of grant funding for innovation and R&D; measures designed to help with commercial exploitation of the science base; and the development of venture capital activity. The Scottish Enterprise Network has 12 local enterprise companies (LECs), located across the central belt, eastern and southern Scotland. Highlands and Islands also has a local enterprise network.

In Northern Ireland, similar to England, the lead department in innovation has been the Department of Enterprise, Trade and Investment (DETI), but as noted above, the regional innovation strategy was developed by an inter-departmental working group with membership from each Northern Irish government department and Invest NI, under the chairmanship of the DETI. Invest NI was established in 2002 as the main economic development organisation in Northern Ireland; promoting innovation is one of its core objectives (especially higher R&D spending and knowledge transfer).

In Wales, the Welsh Development Agency was devoted to helping businesses in Wales succeed through the application, management and development of innovative ideas and new technologies. Underpinning this drive for technological improvement and inspired innovation is the 'Innovation Works' campaign, part of the Welsh Assembly Government's action plan for innovation. The functions of the Welsh Development Agency, a former Assembly Sponsored Public Body, are now part of the Welsh Assembly Government's Department of Enterprise, Innovation and Networks (DEIN). DEIN now manages the Wales Innovators Network (WIN), which has been receiving attention as a model of support from outside Wales.

B.3. Major policies and programmes are focused tightly on science, technology, engineering and knowledge transfer

B.3.1. UK central government initiatives

In England there are a range of initiatives, led primarily by the DTI and the RDAs, which have aimed to increase R&D activity. The Grants for Research and Development scheme replaced the SMART scheme in 2003 and provides grants to SMEs for both research and development projects. A related grant-based scheme is the Grant for Investigating an Innovative Idea, which reimburses consultancy advice. The LINK scheme dates back to 1986 and provides support for pre-commercial collaborative research between businesses and research institutions. The Collaborative Research and Development Scheme builds on the LINK scheme by providing support for research partnerships between UK industry and the research base.

188. See the study commissioned by the Scottish Executive, Roper, S., and Love, J. (2006), The Scottish Innovation System: Actors, Roles and Actions, (Aston Business School/Cardiff University, Birmingham/Cardiff).

The OSI manages the Public Sector Research Exploitation Fund (PSRE) that has been running since 2001. The fund was created as a response to the Baker Report on realising the economic potential of public sector research establishments.[189] The aim of the fund is to enable public sector research establishments to develop their capacity to exploit their science and technology potential and to provide seed funding to support the business creation and development from ideas emerging the public sector science base. £50 million has been invested to date.

Knowledge Transfer Partnerships (KTPs) provide financial support for collaborative projects between businesses and individuals from public or private research organisations, higher education institutions or further education colleges, where a graduate undertakes a research placement at a business. Staff from the business and from the research partner jointly supervise the graduate and the project. Knowledge Transfer Networks provides grants to set up networks in specific technology areas; a preceding scheme, Faraday Partnerships, was introduced in 1997 and provided grant funding for consortia of institutions and organisations (universities, trade associations and businesses), to promote research, technology transfer and the commercial exploitation of science and technology. The Higher Education Innovation Fund (HEIF) was established in 2000 as an umbrella initiative under which to consolidate schemes for the improvement of higher education funding, industry–academia collaboration, and support for the commercialisation of university research. HEIF is providing £187 million for knowledge transfer activities in 2004–06.

There are a range of grants that are available to SMEs to research and develop technologically innovative products and processes, from simple low cost development projects to those that are likely to generate much wider economic benefits and have strategic importance for a technology or sector. Perhaps the most prominent policy is the R&D tax credits scheme; these credits are a company tax relief which can either reduce a company's tax bill or, for some SMEs, provide a cash sum. Their aim is to encourage greater R&D spending in order to promote investment in innovation. Between April 2000 and April 2005, around 17,000 claims for R&D tax credits were made with around £1.3 billion of support claimed.[190] The R&D tax credit works by allowing companies to deduct up to 150 per cent of qualifying expenditure on R&D activities when calculating their profit for tax purposes. Companies which are SMEs can, in certain circumstances, surrender this tax relief to claim payable tax credits in cash from HM Revenue & Customs.

Further, there are five main schemes that have been established by the Government (managed by the Small Business Service's Investment Fund Management Directorate) to stimulate an increased flow of private capital into new and growing small businesses. These are the Regional Venture Capital Funds (RVCFs) in the English regions, the UK High Technology Fund (UKHTF), the Early Growth Funds (EGFs), a series of Enterprise Capital Funds (ECFs), and the Community Development Venture Fund (CDVF), more commonly known as the Bridges Fund. These schemes are in addition to the Small Firms Loan Guarantee Scheme (SFLG), established in 1981.

The DTI's Global Watch Service also provides support to help UK businesses improve their competitiveness by identifying and accessing innovative technologies and practices from overseas.

The *Innovation Report* had also challenged government departments to identify how they might use their purchasing power to stimulate innovation from businesses. The DTI's Five Year Programme has continued this emphasis, with the DTI working with the Office of Government Commerce (OGC) to publish a guide for public purchasers that provides practical help and advice on dealing with innovative proposals.[191] Similarly, the Small Business Research Initiative (SBRI) has, since its launch in 2001, acted as a cross-departmental initiative which aims to improve the success of small R&D-based businesses in obtaining contracts from government bodies.

189. HM Treasury (1999), Creating Knowledge Creating Wealth, Realising the Economic Potential of Public Sector Research Establishments, (HMT, London).

190. Department of Trade and Industry website, accessed 10th July 2006.

191. Office of Government Commerce/Department of Trade and Industry (2004), Capturing Innovation - Nurturing Suppliers' Ideas in the Public Sector, (OGC/DTI, London).

B.3.2. Regional initiatives

All of the RDAs have published regional economic strategies that include innovation and are putting an increasing focus on innovation as a driver of economic development. In 2001-02, the DTI established a £15 million Innovative Clusters Fund (ICF) for RDAs to promote cluster development and business incubation. A further £35 million was provided by the DTI as part of the then Regional Innovation Fund (RIF). (The RIF has now been subsumed within the 'single pot' funding arrangements for the RDAs, increasing their flexibility to mix funds to promote regional economic development). Other regional innovation support mechanisms include the Regional Venture Capital Funds (RVCFs) and the Centres of Industrial Collaboration (CICs). Further, the three northern RDAs have committed to promoting Science Cities as part of their £100 million investment in university-business collaboration over the next six years. This has already started with Manchester, York and Newcastle. The March 2005 budget confirmed that three further science cities will be developed in Bristol, Birmingham and Nottingham.

B.3.3. Initiatives in the UK nations

The Scottish Funding Council's Knowledge Transfer Grant (to assist commercialisation) has doubled in size to at least £12 million for 2005-06. A newly revamped Technology Ventures Scotland (TVS) reviews and advises on the implementation of policies and projects relating to commercialisation and technology transfer in line with the Scottish Executive's *Smart, Successful Scotland*. The members of TVS's Advisory Forum include representatives from business, academia and government. The SCORE (SME Collaborative Research programme) and SEEKIT (Scottish Executive Expertise, Knowledge & Innovation Transfer grant scheme) initiatives are intended to boost interaction between industry and the science base. SCORE supports projects involving pre-competitive activities in R&D jointly undertaken between SMEs and public sector research bodies, while SEEKIT grants are awarded to eligible public sector organisations, such as universities, for projects that improve the ability of Scotland's science base to work with business, including, for example, outreach projects. The Scottish Co-investment Fund (SCF) is an equity investment fund set up by Scottish Enterprise and part-funded by the European Regional Development Fund. Scotland's Intermediary Technology Institutes (ITIs) are focused on 'techmedia' (communication technology and digital media), energy and life sciences sectors, and provide access to cutting edge technology for new and existing high growth companies. Finally, the SMART scheme continues (as SMART: SCOTLAND); successful applicants receive funding of 75 per cent of the cost of carrying out a technical and commercial feasibility study lasting between six and 18 months, with a maximum award of £50,000.

In Northern Ireland, as part of the Regional Innovation Strategy, a Higher Education Innovation Fund for Northern Ireland has been established, along with a Pilot Proof of Concept Fund and 18 Research & Technological Development (RTD) centres of excellence (in areas such as nanotech, genomics and integrated aircraft technology, where the region has the skills and institutions to be internationally competitive). These are in addition to Invest NI's complementary pre-competitive research, near-market and technology transfer programmes that seek to ensure the participation of SMEs and micro-businesses in the region's R&D. These programmes include Compete, START, SMART, Product & Process Development (PPD), and KTP.

In Wales, support for high growth businesses has been delivered in particular through the network of Technium centres that provide high-tech incubator space and links to research and expertise in higher education institutions. Support for innovation is also provided through the Knowledge Bank for Business, which provides tailored advice and support to businesses with high growth potential. The service includes diagnostic review and benchmarking, and training on finance, innovation management, and performance improvement. The Welsh Assembly Government has backed these initiatives with an additional £10 million a year for innovation and technology to stimulate a greater knowledge and science-based economy. Other important science and technology facilities include the newly created Institute of Life Sciences in Swansea, The Centre for Advanced Software Technology in Bangor and ECM2 in Port Talbot.

Appendix C: A National Innovation Strategy: Making Finland a leading country in innovation

Finland has been repeatedly ranked as one of the leading countries in innovation, at least according to the traditional indicators. Nevertheless, it has recognised the need to develop its approach to innovation in a potentially radical manner because it is facing something of an innovation dilemma, albeit one that many other countries would welcome. Its strengths in high-tech and formal R&D (as evidenced by the development of world class businesses such as Nokia) have raised concerns regarding the future balance of Finland's capacity for innovation. Finland's (typically centralised) objectives for innovation policy have been considered within the context of the national innovation system (NIS) approach since the early 1990s. Evaluations, benchmarking activities and other means of policy intelligence are used extensively by the policymakers in order to identify national strengths, weaknesses, opportunities and threats. The Finns now recognise the need to move beyond the science and technology focus, especially with regards to the country's comparatively low levels of non-technological innovating SMEs, and in overall levels of entrepreneurship.

A major objective of Finnish science and technology policy has been to ensure a more balanced development of the innovation system and to promote co-operation within it. Over time, the goal is to develop more horizontal and collaborative relationships between more sectors, and between policymaking in areas such as the economy, industry, the labour market, the environment, regional policy, and the social and healthcare sectors. This represents an explicit recognition that the conditions for knowledge-based development are created in society at large, and within different policy sectors, not just within the science and technology sphere.

Sitra, the Finnish National Fund for Research and Development, published a report in April 2005 entitled *Making Finland a Leading Country in Innovation*.[192] The report presented the results of Sitra's Competitive Innovation Environment development programme launched in late 2004. During the programme, 24 leading decision makers representing government ministries, companies, universities and research institutes and other actors well-versed in innovation policy issues prepared specific proposals on how Finland can secure its future success via innovation. The resulting 27 proposals cover a wide range of areas such as innovation policy, the taxation system, the education system, immigration policy, company networking, and a system of regional centres. Together, they represent a truly national blueprint for innovation success.

192. Sitra (2005), Making Finland a Leading Country in Innovation, (Sitra, Helsinki).

Appendix D: Building on regional strengths: Manchester's Knowledge Capital and Science City initiative

Manchester's Science City programme is being led by the Manchester: Knowledge Capital Partnership, a grouping of academic institutions, public bodies, and businesses from across the Manchester city region that seeks to provide the leadership to realise the potential of the knowledge assets within the city region. In the core Manchester city region alone there are 800 knowledge-based businesses, employing more people than the entire UK biotech sector, in addition to the strong capacity in higher education research. The Greater Manchester Economic Development Plan and the Manchester: Knowledge Capital Partnership envisage the creation of many more knowledge-related jobs over the next decade, generating significant economic and social benefits across the city region based on skills development, knowledge transfer activity, business support programmes, centres of excellence and improved (physical and virtual) connectivity as critical elements for enhanced global competitiveness.

The Science City initiative will be driven forward through six 'Innovation Partnerships'. These groups of academic, industry and public leaders will focus on areas where Manchester has existing research and business strengths that offer the potential for economic growth. These are: Shaping the Future of Healthcare; Personal Broadcasting; Design for Sustainability; Nuclear Futures; Future Fabrics; and Clean Aviation. It is also intended that the initiative will be as focused on social benefit as it is on economic opportunity, and that extensive public engagement and communications activity will unlock benefits for all and will have widespread support.

A major strand of this activity is the development of the Manchester Science City initiative that aims to establish the Manchester city region as a place where innovation delivers tangible benefits, not just in science and technology sectors but in areas of everyday public life. The initiative is developing a holistic programme that combines opportunities with established strengths, focussing on: adopting a real-world approach to science that links academia to industry; examining possible markets and ensuring that scientific development fits those markets; and seeking public engagement at all levels through learning and education and public debate.

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