

# ECONOMICS

**BERR ECONOMICS PAPER NO. 4**

Regulation and innovation:  
evidence and policy implications

DECEMBER 2008

**BERR** | Department for Business  
Enterprise & Regulatory Reform

Department for  
**Innovation,  
Universities &  
Skills**

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The views expressed within BERR Economics Papers are those of the authors and should not be treated as Government policy. We welcome feedback on the issues raised by the BERR Economics Papers, and comments should be sent to [berr.economics@berr.gsi.gov.uk](mailto:berr.economics@berr.gsi.gov.uk)

# Foreword

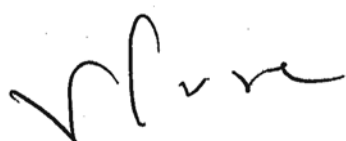
At the time of writing, the UK is in the midst of a credit crunch and economic downturn. Achieving higher levels of innovation, particularly by business, has therefore become even more important as it can help facilitate economic recovery by raising UK productivity and competitiveness. At the same time, innovation also have a pivotal role to play in successfully tackling strategic social and environmental challenges such as climate change by helping deliver the government's ambition to move to a low carbon economy.

The *Innovation Nation* White Paper published in March 2008 identified the potential importance of regulation as a tool for promoting innovation and called on the Department for Innovation, Universities and Skills (DIUS), the Department for Business, Enterprise and Regulatory Reform (BERR) and the Better Regulation Executive (BRE) to explore how regulation may promote or hinder innovation.

This paper presents the emerging findings from an extensive review of the evidence on regulation and innovation. It shows that the relationship between regulation and innovation is complex and dynamic. Regulation – either directly or indirectly – can affect the nature and direction of innovation as well as the ways in which businesses innovate. Over time, as new technologies, products, and business models are developed, new markets and market failures may emerge necessitating changes to the current regulatory framework.

A key finding of the paper is that the impact of regulation on innovation is influenced by the way in which new proposals are designed, implemented and enforced. For example, government is more likely to promote, or at best avoid hampering beneficial innovation if it clearly informs businesses of future changes in regulation well in advance. That would allow sufficient time to comply with new rules and requirements while being clear in specifying the desired outcomes which cannot always be achieved using existing technologies and business practices.

The evidence presented in this paper has been used to develop a number of practical suggestions for ensuring that the potential impact of any new proposals on innovation is taken into account at all stages of the policy making process. In particular, it has helped inform a voluntary checklist of regulatory principles for promoting innovation which regulators could consider in their work and could help deliver better long-term outcomes. This checklist is set out in the short paper, *Helping Regulators to Promote Innovation*, which has been published this month by DIUS alongside its first Annual Innovation Report.



**Vicky Pryce**

Director General, Economics, BERR & Joint Head, UK Government Economic Service

# Executive Summary

The White Paper, *Innovation Nation*, published by DIUS in March 2008 identified the potential importance of regulation as a tool for promoting innovation and called on DIUS, BERR and the BRE to explore how regulation may promote or hinder innovation.

Over the past few months, DIUS has led a project with BERR and the BRE to better understand the relationship between regulation and innovation, particularly by businesses and the ways in which regulators can promote innovation. As part of this work, a review of the current evidence on regulation and innovation has been carried out and initial discussions have been held with the Confederation of British Industry (CBI), the manufacturer's organisation EEF as well as most of the independent regulators.

This paper presents the evidence which has emerged from an extensive review of the literature. It has been used to develop a voluntary checklist of principles for promoting innovation which regulators could consider in their work and could help deliver better long-term outcomes. The checklist is presented in the short paper, *Helping Regulators to Promote Innovation*, which has been published this month by DIUS alongside its first Annual Innovation Report.

## The relationship between regulation and innovation

The main conclusion which emerges from an extensive review of the evidence is that the relationship between regulation and innovation is extremely complex and dynamic.

Changes in the regulatory framework do not immediately and directly bring about changes in innovation. In practice, changes in regulation interact with other government market-based and regulatory policies to bring about changes in innovation either directly or indirectly as a result of changes in competition, skills, investment and entrepreneurial activity by altering the incentives and risks of innovation as well as the costs and benefits.

The complex nature of the relationship between regulation and innovation stems in part from the fact that the links are multi-dimensional. Regulation can affect innovation on both the supply-side and demand side of the innovation system. For example, it can influence decisions on the inputs used (e.g. R&D investment, external knowledge), the nature of outputs (e.g. the characteristics of new differentiated products and services) and the direction of innovation (e.g. demand for particular technologies).

The relationship is also dynamic in that the development of new technologies, products and business processes can lead to the emergence of new markets and market failure which, in turn, may necessitate changes to the current regulatory framework.

## The impact of regulation on innovation

Changes in the regulatory framework can have both a positive and negative impact on innovation behaviour and outcomes. The direction of the impact depends on a number of factors relating to the way in which new proposals are designed, implemented and enforced.

From the evidence which has been gathered, it can be concluded that policy makers, analysts and regulators are more likely to help, or at best avoid hampering beneficial innovation if they:

- Provide businesses with some flexibility as to how they deliver desired policy outcomes
- Clearly inform businesses of future changes in the regulatory framework well in advance so that they have sufficient time to comply with new rules and requirements
- Specify desired outcomes which cannot be easily achieved using existing technologies and business practices
- Stipulate clear requirements which are easily understood by businesses, reducing the possibility of misinterpretation
- Impose minimum compliance costs on businesses
- Complement other government market-based and regulatory-based policies which promote innovation

## Practical implications

The evidence which has been gathered as part of this project has been used to develop a number of non-binding practical suggestions for ensuring that proper consideration is given to the potential effects of new proposals on innovation at all stages of the policy making process. These include:

- The possibility of using an policy making filter test to identify at the very start of the innovation process the potential impact of new proposals on innovation
- **Subject to the filter test**, ensuring that the effects of new proposals on innovation are adequately considered in the analysis underpinning impact assessments and post implementation reviews
- The use by regulators of a voluntary checklist of principles for promoting innovation which they could consider in their work and could deliver better long-term outcomes

# 1. Introduction

At the time of writing the UK is currently experiencing difficult economic conditions. Commodity prices are higher than they once were, increasing the costs of supplying goods and services; access to finance has become more difficult and expensive as a result of the credit crunch; and UK businesses are facing stronger competition from countries with relatively lower labour costs such as India and China who are steadily moving into higher-value added economic activities. In addition, many countries in the global economy – including the UK – are now in an economic downturn and there is great uncertainty as to how severe it will be and how long it is likely to last.

Against this backdrop, innovation has become even more crucial to raising productivity, economic growth and prosperity in the UK. Defined as the successful exploitation of new ideas, innovation can involve the development of new technologies, products and processes, as well as new business models, organisation structures and management practices.

In recent years, innovation has become one of the key policy areas targeted by government as part of its efforts to raise productivity and reduce the gap with other industrialised countries, in particular the United States. The sixth paper published as part of the Productivity Series by HM Treasury and DTI in 2007 – *Productivity in the UK 6: progress and new evidence*<sup>1</sup> – identifies the channels through which innovation can raise productivity. For example, firms directly involved in innovation can generate productivity gains by developing new higher value added goods and services or improving the efficiency of their business processes. There may also be spillover effects whereby firms not directly involved in innovation improve their own productivity by adopting new ideas and technologies developed by others<sup>2</sup>.

The UK also views innovation as playing a crucial role in tackling strategic social and environmental challenges such as climate change through the development and adoption of low carbon and energy efficient technologies and more sustainable business growth models.

1 The Productivity Series can be found on the HM Treasury website at: [http://www.hm-treasury.gov.uk/ent\\_prod\\_index.htm](http://www.hm-treasury.gov.uk/ent_prod_index.htm)

2 Several studies illustrate the importance of innovation in driving forward productivity. O'Mahony and de Boer (2002), updating their own analysis, find that around 80% of the productivity gap between the UK and US in 1999 can be attributed to total factor productivity (TFP), which includes amongst other factors innovation and technological spillovers. Cameron (2003) found that a one percent increase in R&D spending by UK manufacturing firms is estimated to have increased TFP by between 0.2 and 0.3 per cent in the 1980s. Earlier work by Griliches (1980) found a similar result in which a one percent increase in R&D spending is estimated to have raised total factor productivity growth by 0.07%

## Government's innovation strategy

The UK has long recognised the importance of innovation and has taken a number of steps to raise the level of innovation in the economy by offering greater support for businesses involved in innovation. Measures include:

- The introduction of R&D tax credits in 2000 aimed at raising the level of business R&D expenditure
- The establishment of various business support products aimed at promoting greater R&D collaboration among firms and between business and academia (e.g. Collaborative R&D, Grant for R&D, Knowledge Transfer Networks and Knowledge Transfer Partnerships)
- Establishment of the Technology Strategy Board (TSB) in 2004 responsible for advising government on business research, technology and innovation priorities for the UK, and the allocation of funding<sup>3</sup>.

More recently, the increasing importance of innovation in helping deliver strategic economic, social and environmental challenges has been reflected in the publication of four key strategy documents:

- Lord Sainsbury's Review of UK Science and Innovation Policy, *Race to the Top*, published in October 2007, which concluded that in a global economy UK firms should move further into higher value-added goods, services and industries
- The Innovation White Paper, *Innovation Nation*, published in March 2008, which outlined the Government's vision for making the UK the best place in the world to run an innovative business or public service and set out a number of new proposals for delivering this goal
- The Enterprise Strategy, *Enterprise: unlocking the UK's talent*, published at the same time to emphasise the link between innovation and enterprise, which set out the importance of creating the right business environment and regulatory framework for new innovative firms to start up and grow
- The Manufacturing Strategy, *Manufacturing: New Challenges, New Opportunities*, published in September 2008, outlined the steps government is taking to further promote innovation, one of which is the launch next year of its integrated Low Carbon Industrial Strategy aimed at helping UK manufacturers exploit the opportunities created by a move to a low carbon economy.

3 The TSB formed part of the UK Government's Science and Innovation ten-year framework published in July 2004, which set out a long-term vision for UK science and innovation together with ambitions for public and private expenditure in R&D to reach 2.5 per cent of GDP by 2014. In 2007, the TSB was re-launched with a wider remit and increased financial backing.

## Purpose of paper

The Innovation White Paper, *Innovation Nation*, identified the potential importance of regulation as a tool which government can use to promote innovation in businesses and make the public services more innovative. However, it recognised that the effects of regulation on innovation are often complex in that regulation can both help and hinder the development of socially desirable new technologies, products and processes. It concluded that further work was needed and proposed two actions:

1. DIUS and the Better Regulation Executive in BERR will work with the Business Council for Britain and others to identify how regulation may promote or hinder innovation
2. DIUS and the Better Regulation Executive in BERR will use existing regulators' fora to share experience on how their activities could promote innovation.

Over the past few months, DIUS has led a project with BERR and the BRE to better understand the relationship between regulation and innovation, particularly by businesses, and the ways in which regulators can promote innovation. As part of this work, a review of the current literature on the links between regulation and innovation was carried out and initial discussions were held with the Confederation of British Industry (CBI), the manufacturer's organisation EEF as well as most of the independent regulators.

This paper presents the evidence which has emerged from an extensive review of the literature. It has been used to develop a voluntary checklist of regulatory principles for promoting innovation which regulators could consider in their work and could help deliver better long-term outcomes. The checklist is presented in the short paper, *Helping Regulators to Promote Innovation*, which has been published this month by DIUS alongside its first Annual Innovation Report.

## Structure of paper

This paper is structured as follows: Chapter 2 provides a brief introduction to innovation and regulation and discusses in greater detail the different ways in which regulation can affect innovation; it also presents a conceptual model developed to illustrate the different causal and feedback effects which characterise the regulation-innovation relationship. Chapter 3 then discusses some of the factors which may influence the impact of regulation on innovation and the particular circumstances under which it may promote or hamper beneficial innovation by businesses. Section 4 then considers some practical ideas for policy makers, analysts and regulators which could help ensure that the potential effects of new proposals on innovation are fully considered in the policy development process.

# 2. The Links between Regulation and Innovation

## Business innovation

Firms innovate for different reasons. They may do so to gain a competitive advantage in existing markets and/or gain access to new emerging ones. They may innovate in order to comply with new regulatory requirements. Equally, they may innovate in order to mitigate the impact of regulations on their business and reduce compliance costs.

Innovation by businesses is much broader than simply research and development (R&D). It can be technological and non-technological in nature and occur at any point in the firm's value supply chain from product design and development through production to sales and marketing.

Innovation can also take many forms. Product innovation refers to the design, development and commercialisation of new and improved tangible goods and services. Process innovation refers to the introduction of new and improved means of producing and delivering goods and services.

Products or processes that are entirely new, embodying new ideas or characteristics can be described as radical innovations. Those which are adaptations of existing ideas or applied in new environments are described as incremental innovations.

### **BOX 1: EXAMPLES OF INNOVATION AND THE ROLE OF ICT**

There has been significant innovation in the telecommunications industry built around the emergence of new technologies including internet/broadband. The consumer electronics industry has brought to the market new products including mobile phones, blackberries and MP3 players. The world is also moving into a digital age with the possibility of accessing a greater number of TV channels than was previously possible using analogue, many of which are now available in high definition.

Improvements in information and communication technologies (ICT) have also led to the emergence of new business models, organisational structures and services. For example, the internet has enabled retail banks to offer internet accounts which can be accessed on-line by customers from the comfort of their own living room. In the same way, the internet has also made it easier for people to book air and rail tickets on line.

Source: NESTA (2008)

Product and process innovation are usually measured by indicators including R&D expenditure, capital good and software investment, registered patents and number of science, technology, engineering and mathematics (or STEM) graduates.

However, businesses innovate in other ways which may not be so well captured by these metrics<sup>4</sup>. These include developing new organisational structures and business models, adopting new management practices and combining existing technologies and processes in new ways. These examples of innovation are referred to as '*hidden innovation*' and are seen to have become as prevalent and important as more traditional forms of technological innovation<sup>5</sup>. Innovation activity in services and the public sectors has often tended to be under-represented because much of it is hidden innovation.

More formally, the OECD-Eurostat Oslo Manual distinguishes between four different types of innovation: product, process, marketing and organisation. These are defined in Box 2 below.

#### **BOX 2: FOUR DIFFERENT TYPES OF REGULATION**

***Product innovation*** – the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics

***Process innovation*** – the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software

***Marketing innovation*** – the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing

***Organisational innovation*** – the implementation of a new organisation method in the firm's business practices, workplace organisation or external relations

Source: OECD (2005)

4 Current metrics do not also accurately capture creativity – the generation of new ideas – which is a crucial element of the innovation process. A useful discussion of creativity and the role it plays in innovation can be found in DTI Economics Paper No 15, *Creativity, Design and Business Performance* <http://www.berr.gov.uk/files/file13654.pdf> published in 2005

5 See NESTA (2008) *Total Innovation: why harnessing the hidden innovation in high-technology sectors is crucial to retaining the UK's innovation edge* Research Report, May 2008 for a more detailed discussion of hidden innovation.

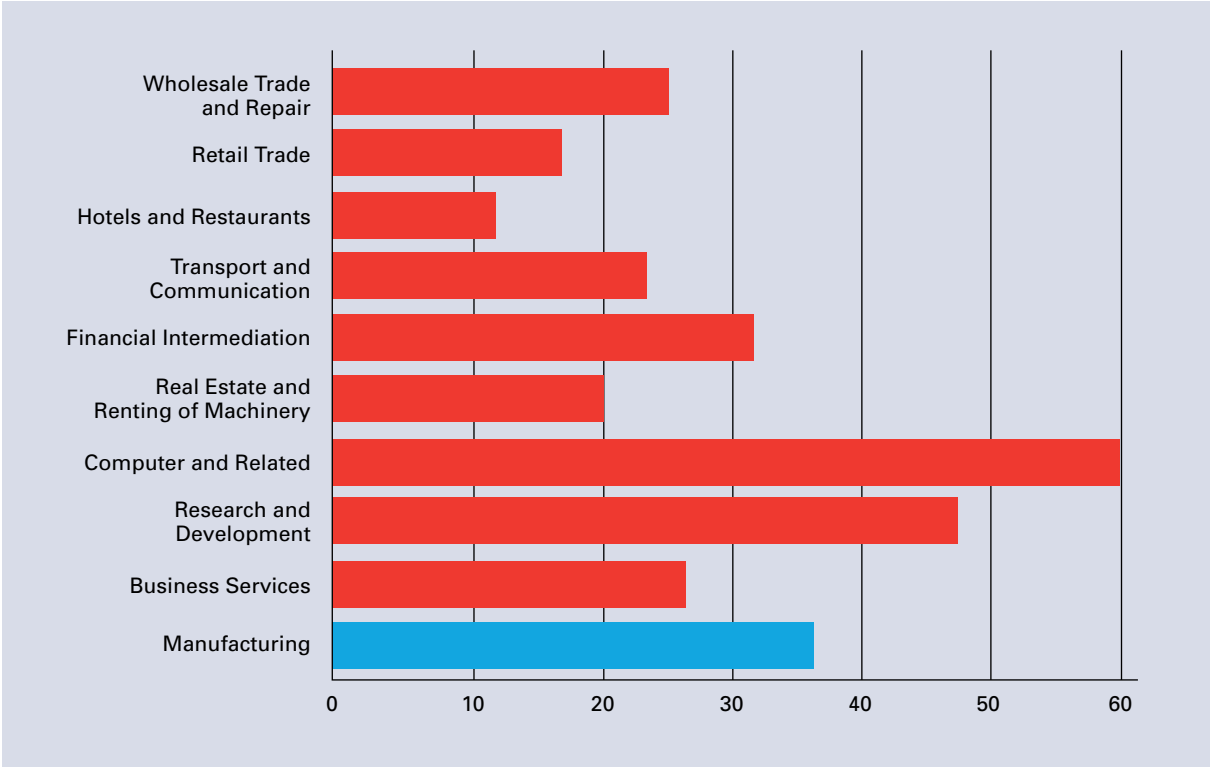
### INNOVATION PROCESS

The innovation process is complex. According to NESTA, it does not necessarily follow a linear 'laboratory to market place' model, commencing with scientific discovery and research, passing through product development, testing and manufacture to commercialisation internal to the firm.

As they note, innovation is a highly dynamic and evolutionary process with constant interaction and feedback between the different stages, with ideas and knowledge often being developed and exchanged in collaboration with suppliers, end-users and research institutes both private and public.

Innovation also varies significantly across sectors and firms within a given sector. Figures 1 to 3 below show significant variations in the percentage of firms involved in product, process and wider innovation<sup>6</sup>.

**Figure 1: Product innovation within selected sectors (percentage of firms involved in product innovation)**

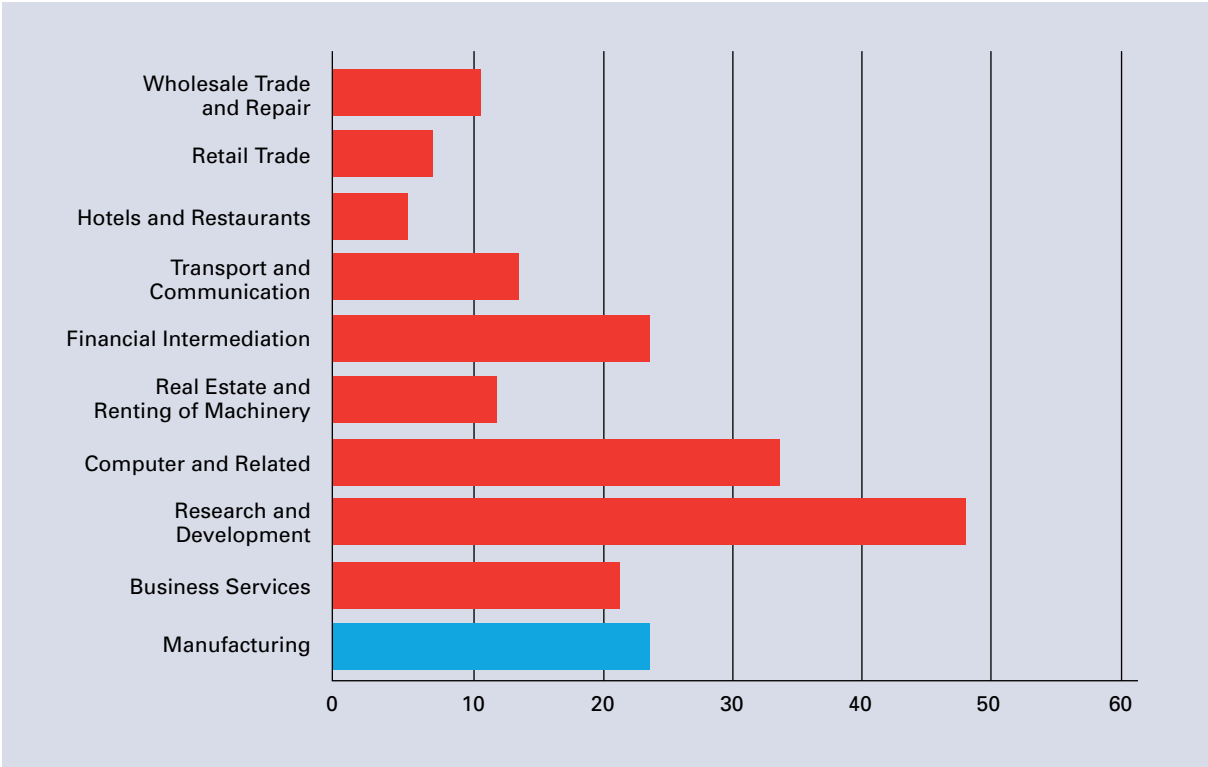


Source: Reproduced from NESTA (2008) "Taking Services Seriously."

6 In the Community Innovation Survey, wider innovation relates to major changes in management practices, business models, organisational structures and marketing strategies.

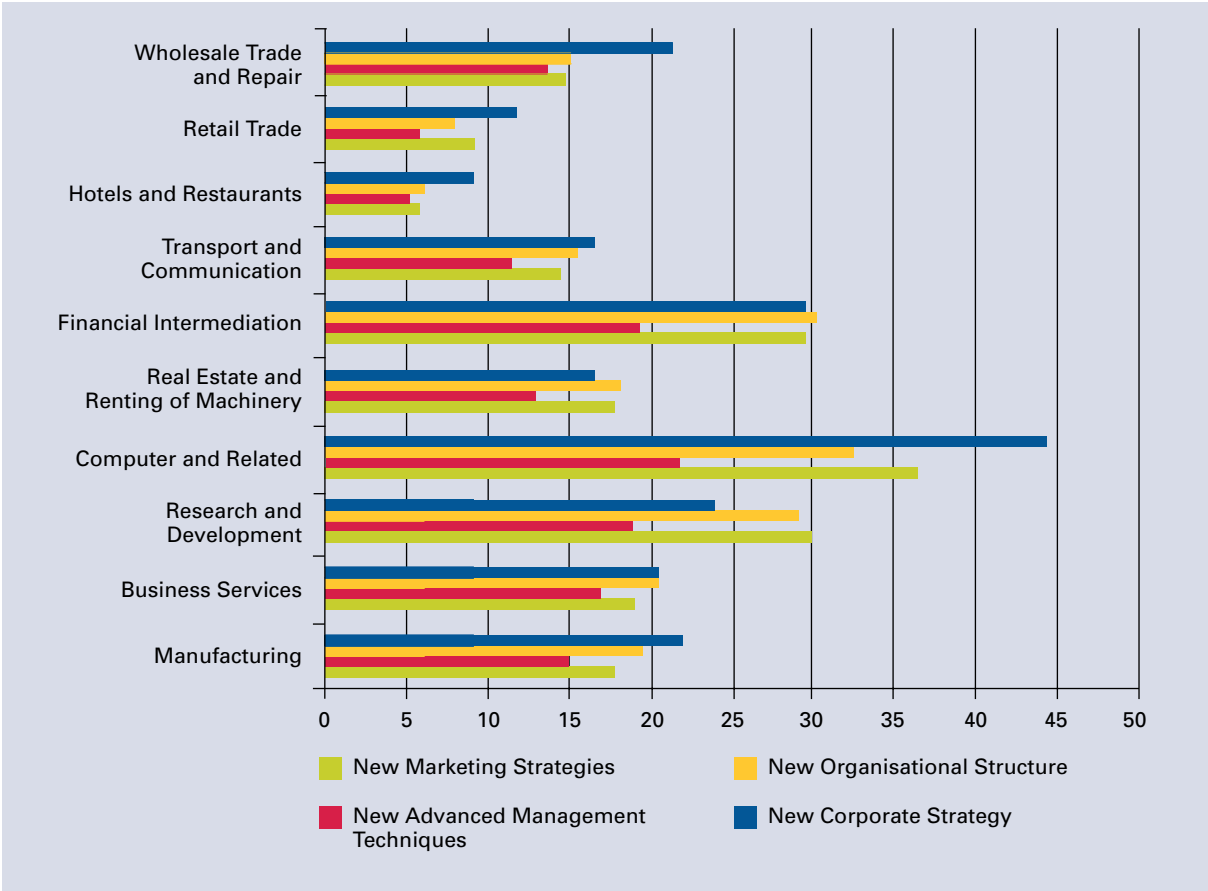
Financial services, research and development, and the computer related services sectors report a higher percentage of firms involved in product, process or wider innovation than more labour intensive sectors such as the retail trade and hotel and restaurant sectors. The figure for manufacturing masks significant differences across sub-sectors. High-technology sectors such as the advanced electronics and automotive industries, which are noted for being R&D and capital intensive, are likely to have higher percentages of firms involved in innovation than low to medium technology sectors (e.g. manufacture of clothing, wood and paper).

**Figure 2: Process innovation within selected sectors (percentage of firms involved in process innovation)**



Source: Reproduced from NESTA (2008) "Taking Services Seriously."

**Figure 3: Wider innovation within selected sectors (percentage of firms involved in wider innovation)**

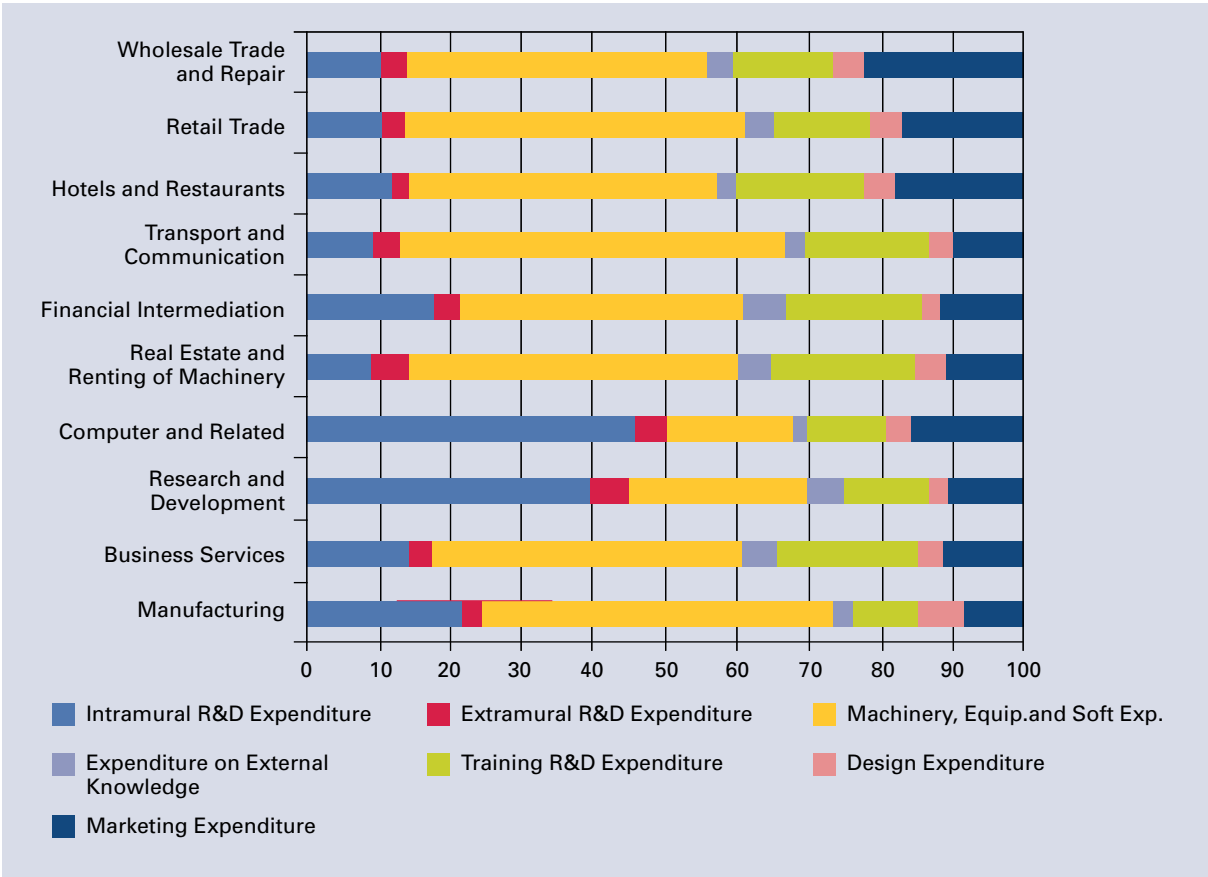


Source: Reproduced from NESTA (2008) "Taking Services Seriously."<sup>47</sup>

Innovation expenditure by firms also varies across sectors of the UK economy. For instance, in the manufacturing sector, R&D accounts for a much larger percentage of total expenditure than in the services sector. Again, there are likely to be significant differences across the manufacturing sector with R&D accounting for a higher percentage of total innovation expenditure in high-technology industries such as aerospace and pharmaceuticals.

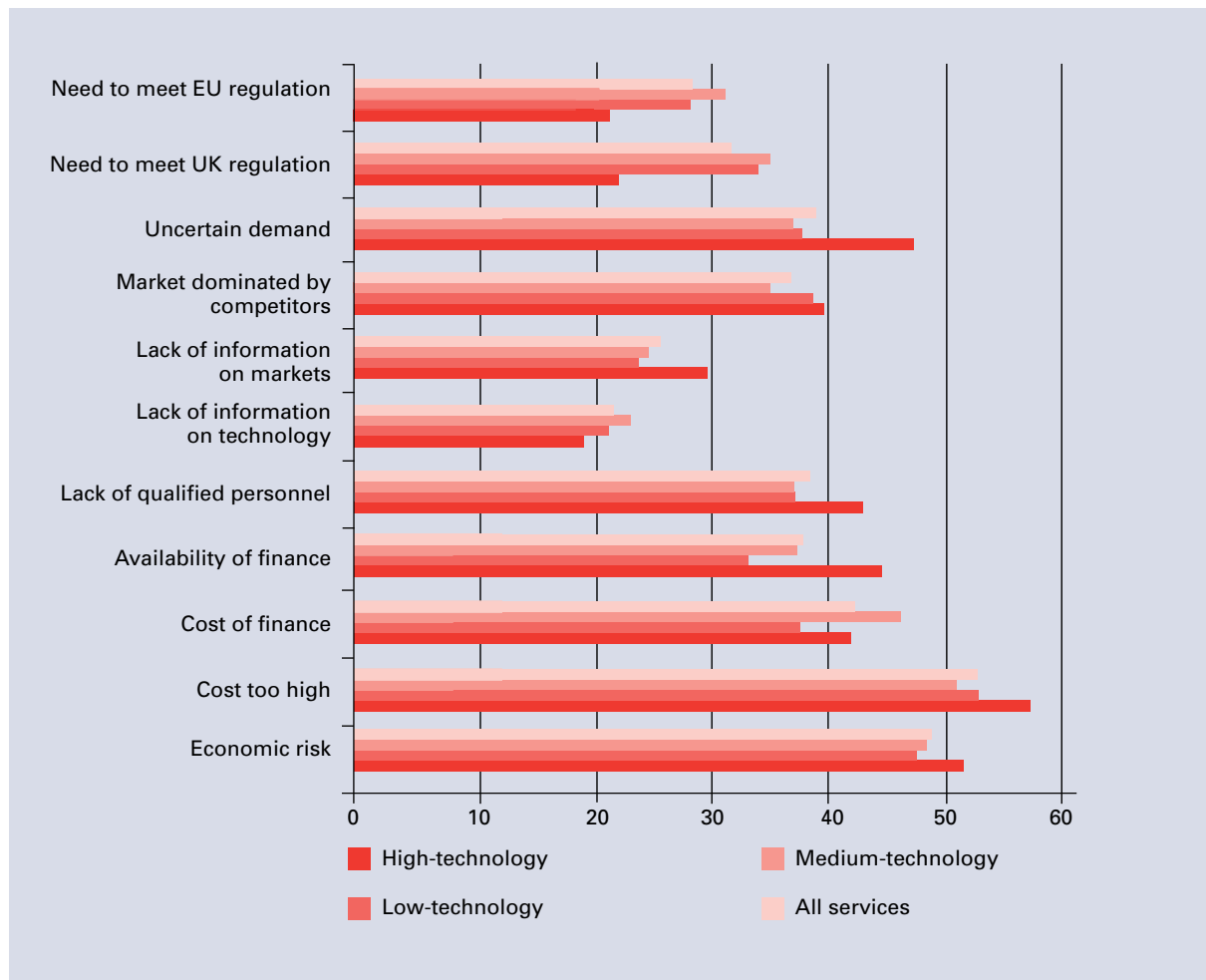
By comparison, in the services sector marketing expenditure (e.g. spending on advertising and the promotion of new products and services) accounts for a larger proportion of total innovation expenditure. Here also there are variations across sub-sectors with the highest shares found in the hotel and restaurants and wholesale and retail distribution sub-sectors.

**Figure 4: Share of innovation expenditure by sector (2002-2004)**



Source: Reproduced from NESTA (2008) "Taking Services Seriously."

**Figure 5: Barriers to innovation (percentage of firms assessing barriers as important or very important)**



Source: Reproduced from NESTA (2008) "Taking Services Seriously."

Figure 5 above reports some barriers to innovation as being more important in some sectors than others. For example, compliance with regulation is viewed as a major barrier to innovation by a relatively larger number of firms providing services and businesses in low and medium technology sectors while a comparatively greater percentage of firms in high-technology sectors consider the cost of innovation, risk and demand uncertainty as important barriers to innovative activity.

## Regulation

Regulation<sup>7</sup> is a set of formal and informal rules that govern the behaviour of private individuals, businesses and public organisations. It is used by governments to influence choices, decisions and preferences in a way which helps deliver economic, social and environmental objectives that are in the public interest.

7 The UK's government consultation document on regulatory budgets published in August 2008, defines regulation as: "a rule with which failure to comply would result in a business coming into conflict with the law or being ineligible for continued funding, grants and other applied for schemes. This can be summarised as all measures with legal force imposed by central government and other schemes operated by central government".

Regulation may be used to correct market failures in an economy by encouraging or preventing particular forms of economic behaviour by businesses and consumers. There are four generic instances in which market failure can occur:

- *Market power* – firms have the ability to raise the price (or reduce the quality) of a good or service without losing significant custom because of a lack of actual or potential competition. For example, the presence of significant economies of scale may act as barriers to entry for new firms in high technology sectors such as aerospace and pharmaceuticals
- *Public goods* – a good or service which is non-rival and non-excludable in consumption will be under-supplied by private firms. This is because as soon as it is made available, people cannot be prevented from using it, making it impossible for firms to recoup their costs by collecting payments from users. For example, firms may be unwilling to develop new ideas because knowledge can now be disseminated very quickly and widely making it extremely difficult for them to charge other firms who use them
- *Externalities* – individuals and firms do not take into account the impact that their actions may have on third parties. This results in goods and services which deliver wider benefits for society being under-supplied by private firms while those which impose wider costs on society are over-supplied. For example, firms may improve their own productivity by adopting new ideas, technologies and processes developed by another. However, this is not taken into account by private firms resulting in a lower level of innovation activity being carried out relative to what society as a whole may prefer
- *Asymmetric or incomplete information* – the poor availability of good quality information about the characteristics of a particular good or service (e.g. quality, benefits, cost, risks) prevents firms and individuals from making fully informed decisions and can lead to significant search costs. For example, banks may be reluctant to offer loans to an entrepreneur because of significant uncertainties about the likely success of their new innovation and may in some cases, require further information about its commercial viability to help inform their decision.

Regulation may also be used by governments as an instrument for protecting disadvantaged groups in society, achieving equity objectives such as income re-distribution or helping to re-generate economically deprived areas<sup>8</sup>.

The UK government uses horizontal (or economy-wide) regulation to correct market failures regardless of where in the economy they occur, focusing on specific economic relationships and/or behaviour. Some examples are set out in Table 1 below.

8 These issues are discussed in more detail in the Green Book published by HM Treasury.

**Table 1: Examples of relevant horizontal regulation in the UK**

Area of regulation	UK legislation
Competition <sup>9</sup>	Competition Act 1998 Enterprise Act 2002
Consumer protection	Sale of Goods Act 1979 General Product Safety Regulations 2005
Intellectual Property	Copyright, Designs and Patents Act 1988
Environment	Climate Change and Sustainable Energy Act 2006 Air Quality Regulations 2000, 2007
Health and safety	Health and Safety at Work Act 1974
Planning	Building Act 1984
Employment	National Minimum Wage Act 1998 Working Time Regulations 1999
Procurement	Public Contracts Regulations 2006
Company law	Companies Act 2006

Some horizontal regulations may affect some sectors of the economy more than others. In the area of health and safety, the Work at Height regulations may have a greater impact in the chemicals and construction industries than the financial and business services sector. This is because the nature of the work in these sectors is very different. For example, in the construction sector, a large proportion of the jobs involve working outside (e.g. operating cranes, walking along gantries and scaffolding and using ladders) whereas in the financial services sector the overwhelming majority of jobs are indoors and desk-based.

In some sectors however, the scale and impact of a particular market failure may be more significant to elsewhere in the economy and require more tailored solutions. Sector-specific regulation shares the same policy objectives as horizontal regulation but may differ slightly in the way it is designed and implemented.

For example, jobs in the chemicals sector involve a greater degree of risk and therefore require greater health and safety legislation (e.g. Control of Major Accident Hazards Regulation; Dangerous Substances Regulations). Some sectors such as construction, mining and electronics which produce hazardous waste material are subject to specific regulations aimed at ensuring that they are disposed of carefully.

The utilities industries such as electricity, gas, water and telecommunications are a further example of where sector-specific regulation has been needed. In the past, incumbent operators restricted the access of other utility providers to their network infrastructure (e.g. gas or water pipes or electricity wires and telephone cables) in order to reduce the amount of competition they faced.

<sup>9</sup> According to the OFT, competition regulation – and to a lesser extent consumer protection regulation – differ from other types of regulation in that they focus on the conduct of firms in the market place rather than the achievement of desired outputs or outcomes.

This had the effect of reducing the choice of providers and services available to consumers and raising the price which they had to pay for them. It also had the effect of reducing the incentive for the incumbent operator(s) to invest further in new more innovative network infrastructures and services.

Over the last two decades, however, the UK has taken a number of steps to promote stronger competition in these sectors. These have included the establishment of a number of economic regulators with the powers necessary to introduce competition wherever possible and ensure that consumers receive good quality services at reasonable prices.

In the financial services industry, sector-specific regulation is required to tackle other market failures. First, information asymmetries between consumers and financial services providers regarding the characteristics of financial products offered and the reputation of financial service providers. Second, externalities in the form of systemic risk whereby the conduct of one financial provider may have knock-on effects on others in the financial system<sup>10 11</sup>.

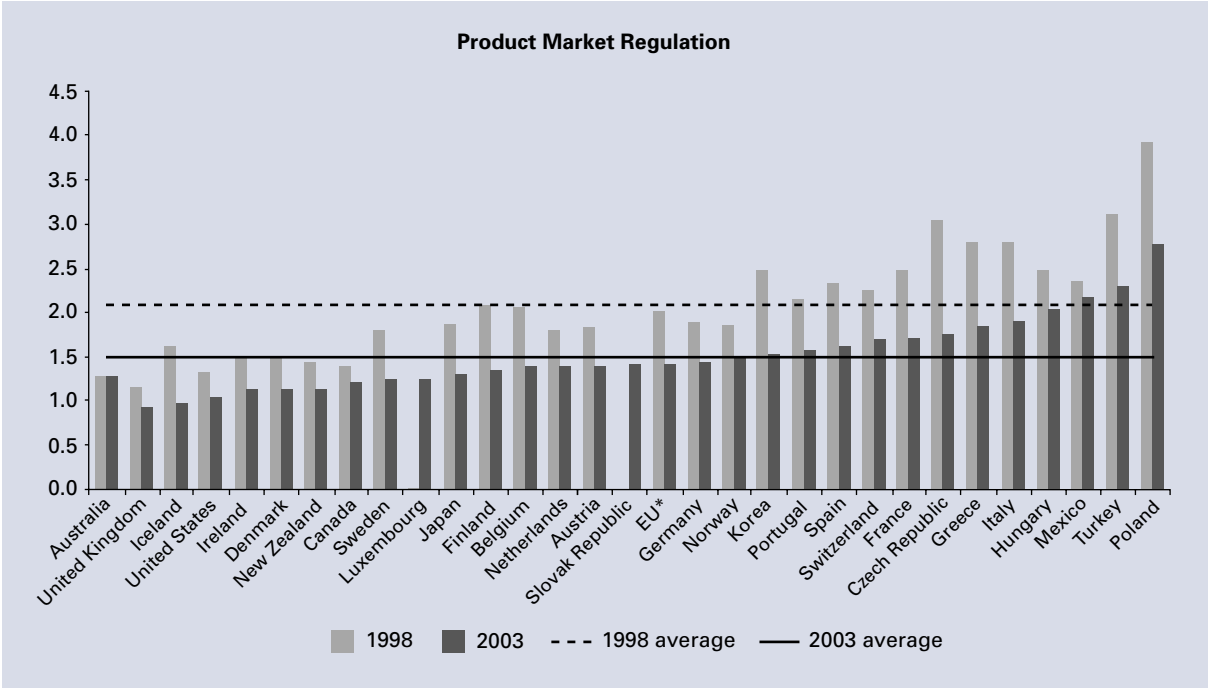
The UK's commitment to ensuring that markets are open and competitive and underpinned by the minimum amount of regulation is reflected in data compiled by the OECD on the restrictiveness of regulation in different Member States. Although, the data is now a few years old and does not take into account the steps taken more recently by the UK and other Member States to reform their regulatory frameworks, it does still provide a useful snapshot of how different countries compare in terms of the restrictiveness of regulation at the economy and sector level.

On a scale of 0 to 6 (where 0 suggests a relatively unrestrictive regulatory regime and 6 a more restrictive one) the UK was one of the least restrictive economies in 2003, as shown in Figure 6 below. In that year, the degree of regulation in the UK was judged to be comparable with the US and lower than in France and Germany.

10 See Oxera (2006) *A framework for assessing the benefits of financial regulation* for further information on the different forms of market failure which can occur in the financial services industry.

11 Systemic risk may also exist in the electricity or gas distribution network since disruption to one part of the network may have serious knock-on effects in other parts.

**Figure 6: Economy-wide regulation in selected countries**



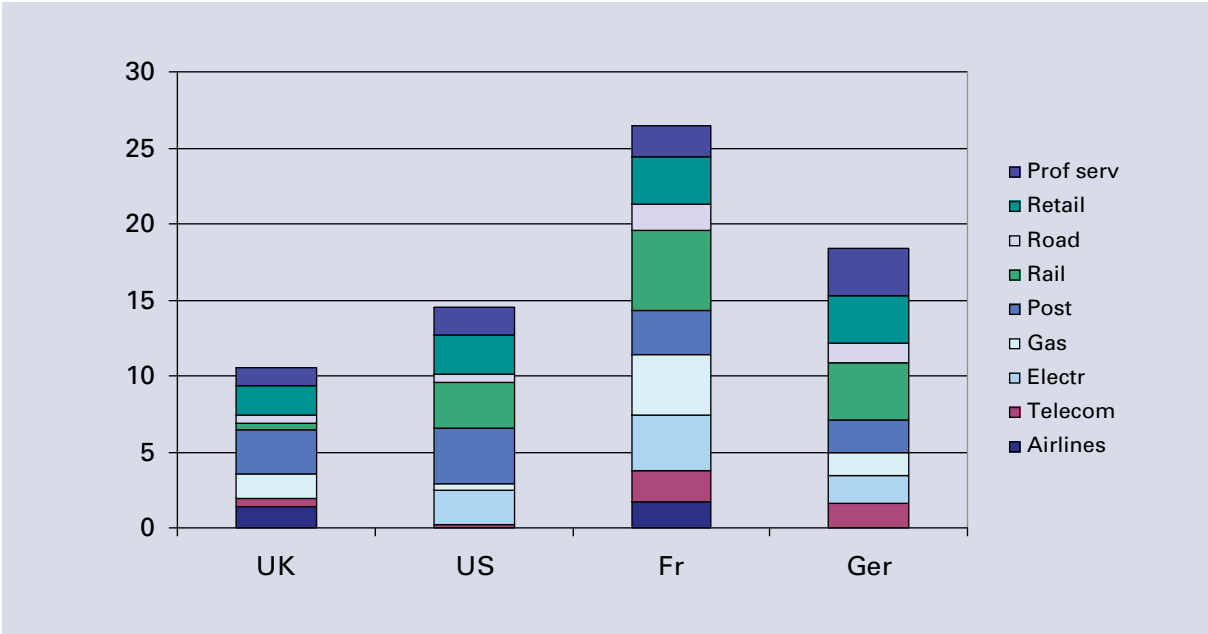
Source: OECD, Product Market Regulation Indicators Database.

Figure 7 below compares the restrictiveness of regulation in the UK, US, France and Germany for nine sectors which are subject to sector-specific regulation: professional services (e.g. accountancy and legal services), retail and the network industries (road, rail and air passenger transport, gas and electricity, post and telecommunications).

Again using the scale 0 to 6, aggregating the scores of the nine sectors reveals that sector specific regulation in the UK in 2003 was less restrictive than in the US, France and Germany<sup>12</sup>. This may in part reflect international differences in the relative severity of market failures – in particular a lack of effective competition – and the extent to which governments have been required to intervene through sector-specific regulation to tackle them.

12 Since 2003, there has been further regulatory reform in the UK postal services sector. In 2006, Postcomm removed the ‘reserved area’ in which no-one except Royal Mail could provide services, thereby fully opening the sector up to competition. Consequently, the restrictiveness of UK postal services regulation today is lower than the level depicted in Figure 7.

**Figure 7: Sector-specific regulation in selected countries in 2003**



Source: OECD, Product Market Regulation Indicators Database

**BOX 3: THE ROLE OF STANDARDS**

Standards are documents, defining best practice established by consensus and approved by a recognised body (such as the British Standards Institute)<sup>a</sup>. Standards are designed to set clear and unambiguous provisions and performance objectives in order to help trade and communication, improve use of resources, assist with bringing products from development to market, stimulate innovation through the quick and efficient dissemination of essential information, or improve the quality of life through health, safety and environmental requirements. Although standards are voluntary, and separate from legal and regulatory systems, their use may often be recommended by government to promote or discourage particular forms of economic behaviour in order to deliver policy objectives.

They are developed where there is a defined market need through consultation with stakeholders. Standards may be formal (i.e. full-consensus) or informal (i.e. 'limited' consensus), may apply to products, services and processes and may be supported by government backing if deemed appropriate. They may also be applied horizontally or vertically. Horizontal standards act across industries – for example health and safety or environmental standards – whilst vertical standards apply in specific supply chain – for example a technical standard.

a: More information on standards can be found in the BSI publication 'Introducing Standards' available at: [http://www.bsigroup.com/upload/Standards%20&%20Publications/Committee%20members/BSI\\_introducing\\_standards.pdf](http://www.bsigroup.com/upload/Standards%20&%20Publications/Committee%20members/BSI_introducing_standards.pdf)

### BOX 3 CONTINUED

Standards serve a number of functions including:

- *Performance/outcome* – standards can define desired performance criteria or desired ‘outcomes’, enabling products or services to achieve the desired effects without restricting ‘innovators’ freedom to design their products and services
- *Measurement* – standards can convey technical information in a transparent and consistent manner enabling innovators to benchmark the performance of their products/services and processes and compare it against their competitors
- *Compatibility/interface* – standards can help innovators work to ensure that new products, services and technologies are compatible with existing ones thereby promoting open and competitive markets
- *Quality* – standards can communicate to consumers that new products, services and technologies meet socially desired minimum levels of quality and safety (e.g. health and safety and environmental standards)
- *Variance reduction* – standards can promote conformity between products, services and technologies brought to market thereby enabling producers to exploit economies of scale and enabling users to have confidence in their choice of product

As a result, they can be used by government to tackle two market failures which can affect innovation: information failures and co-ordination failures

- *Informational failures* – knowledge on new ideas is often held privately by firms who may be unwilling to share information with other firms or who may lack the language to share findings with others. Standards can help diffuse technical information which other innovators can use to develop new products, services and technologies which are compatible with existing ones
- *Co-ordination failures* – firms may find it difficult to co-ordinate their effort in order to achieve a common objective leading to the duplication of research efforts and the development of new products and technologies which are not compatible with ones already on the market. Standards can help reduce transaction and search costs minimising the duplication of research and ensure compatibility of new goods, services and technologies to the benefit of consumers.

## The relationship between regulation and innovation

To date, the economic literature is still quite fragmented, comprising a large number of studies examining the impact of particular pieces of regulation on specific types of innovation in certain sectors and industries. These case studies – a selection of which can be found at Appendix A – vary considerably in depth and quality and focus mainly on the impact of competition law, environmental regulation and intellectual property policy on innovation with very few analysing the impact of other areas of regulation.

There is also relatively little good quality high-level analysis of the links between regulation and innovation. Much of the work which has been done is based on the assumption that there is a linear relationship between regulation and innovation where regulation is the *stimulus* and changes in innovation behaviour and outcomes is the *response*. However, according to Kemp (1998) the *stimulus-response* model of regulation and innovation – as it is referred to in the literature – is highly flawed because it does not recognise what he states is, “*the reciprocal and multi-faceted nature of the relationship and the myriad of factors that are influencing innovation decisions and outputs.*”

Over the past few months we have carried out an extensive – but not exhaustive – review of the literature with a view to identifying the main characteristics of the relationship between regulation and innovation. Based on the evidence which we have gathered as part of this exercise, it can be said that the relationship between regulation and innovation is complex, multi-dimensional, ambiguous and dynamic. As will become evident in the following discussion, many of these characteristics are inter-related.

### THE RELATIONSHIP IS COMPLEX AND MULTI-DIMENSIONAL

The relationship between regulation and innovation is complex because changes in the regulatory framework do not immediately and directly bring about changes in innovation. In practice, changes in regulation interact with other government market-based and regulatory policies to bring about changes in innovation either directly or indirectly as a result of changes in competition, skills, investment and entrepreneurial activity by altering the incentives and risks of innovation as well as the costs and benefits. For example:

- The removal of regulation which lowers the barriers to entry for new firms and strengthens competition among incumbents may increase the incentives for firms to develop new products and improve their business processes and models in order to remain competitive<sup>13</sup>

13 Work by the OECD provides evidence of how product market regulations which restrict competition may hamper the ability of firms to develop and introduce new products, services, technologies and business processes made possible by ICT. See for example Conway et al. (2006) *Regulation, Competition and Productivity Convergence* Working Paper No509 and Scarpetta et al. (2002) *The role of policy and institutions for productivity and firm dynamics: evidence from micro and industry data*. Working paper No. 39.

- Strengthening intellectual property rights (IPR) may increase the rewards to be made from the successful development and commercialisation of new differentiated, products and services. This may be done by broadening and lengthening patent protection or promoting more informal methods of IPR such as speed to market
- Regulations which alter the relative costs of innovation efforts may impact on decisions made by firms about the choice of innovation inputs (e.g. investment in machinery equipment and software or advertising and marketing). For example, the relaxation of labour market restrictions which make it easier for firms to hire and fire workers has led to greater take-up by businesses of information and communication technologies (e.g. computers and broadband) which, in turn, has resulted in the development of new business models based around ICT<sup>14</sup>
- The likelihood that innovation is successful may be improved by regulations which make it easier for firms to access the finance they need. As noted in DTI Economics Paper No. 7, *Competing in the Global Economy – the Innovation Challenge*, in the UK, financial regulations have biased investment against private equity leading to a situation in which major institutional investors in the UK tended to invest less in venture capital than their US counterparts<sup>15</sup>.

The complex nature of the relationship between regulation and innovation stems also in part from the fact that the links are multi-dimensional in that regulation can affect innovation on both the supply-side and demand-side of the innovation system.

On the supply side, regulation can influence decisions on inputs into the innovation system (e.g. R&D investment, external knowledge and training) as well as outputs (e.g. new differentiated products and services). For example, as the UK telecommunications sector has been opened up to increased competition, there has been a shift in investment away from infrastructure to services resulting in new products such as innovative calls plans and bundling of fixed and mobile phone services<sup>16</sup>.

On the demand-side, innovation can also drive the development of particular technologies. For example, the UK government's goal of reducing greenhouse gas emissions by 80% by 2050 is expected to stimulate the development and widespread adoption of new low-carbon technologies while its ambitions to achieve zero carbon housing by 2016 is likely to promote improved energy efficiency in design and construction of new homes.

14 The OECD report *ICT and Economic Growth: Evidence from OECD countries, industries and firms*, published in 2003, cites several econometric studies supporting the hypothesis that regulations which hampers restructuring of the firms workforce can hamper investment in ICT. These include: Gust and Marquez (2003); Bartelsman *et al.* (2002); Bartelsman and Hinlopen (2002) and Devlin (2003).

15 The paper gives the example of the 1986 Finance Act which excluded the majority of UK pension funds from investing directly in private equity funds.

16 Ofcom (2004) Strategic Review of Telecommunications – Phase 1 Consultation.

## THE RELATIONSHIP IS AMBIGUOUS

The links between regulation and innovation are also ambiguous which adds to the complexity. They are ambiguous because regulation can have both a positive and negative impact on innovation outcomes and policy objectives. The direction of the impact regulation has on innovation depends on a number of factors relating to its formulation and application and these are explored in the next chapter. Here, the ambiguous relationship is illustrated with reference to a number of areas of regulation.

Pro-competitive regulation which prohibits anti-competitive behaviour (e.g. collusive agreements or abuse of market power) can encourage innovation by reducing the barriers to entry for new more innovative firms and strengthening the incentives for incumbent firms to develop new products and improve the efficiency of their business processes in order to remain competitive. Pro-competitive regulation also enables firms to choose more freely the strategy and business model which best facilitates innovation activity.

At the same time, pro-competitive regulation may restrict innovation. For example, it may prevent firms collaborating closely at the R&D stages by preventing certain organisational structures or exclusive agreements forming – which could facilitate the transfer of knowledge and technologies – due to concerns that it would reduce competition and harm consumers.

The ambiguous nature of the relationship between regulation and innovation is supported by a number of studies. For example, work by Aghion *et al.* (2002) have found evidence of an inverted U-shaped relationship between competition and innovation whereby innovation rises as the level of competition increases, but then falls as competition becomes very intense. Levin *et al.* (1995) reach similar conclusions, finding evidence that R&D intensity and the rate at which new innovations are introduced is lower at very high levels of competition.

Intellectual Property Rights (IPR) is another area of regulation which can have a positive or negative influence on innovation. Changes to formal IPR such as broadening and lengthening patent protection may encourage innovation by enabling firms to recoup the high costs involved in developing, testing and bringing to market new technologies and products. At the same time however, stronger IPR may hamper the potential for innovation that draws on existing knowledge and ideas.

It is also important to note that regulations which successfully deliver economic, social and environmental policy objectives may adversely affect the pace and nature of innovation. For example, regulations designed to promote greater consumer protection – for instance by delivering higher health and safety standards – may lead to firms focusing on the development of a reduced number of new technologies and products which, in turn, brings about a reduction in consumer choice.

## THE RELATIONSHIP IS DYNAMIC

Finally, the relationship between regulation and innovation is dynamic in that the development of new technologies, products and business processes can lead to changes in regulation and, potentially, the objectives of the original government intervention. For example, technological and non-technological innovation may lead to the emergence of new markets and market failures which require changes to the regulatory framework in order to address them. In some cases, innovation may lead to the changes in the design, implementation and enforcement of current regulations to ensure that the benefits continue to outweigh the costs. This may be necessary in situations where businesses have adapted their processes in order to circumvent particular rules and requirements.

According to Brousseau (2000)<sup>17</sup>, technological innovation (e.g. digitalisation of transmission) changed the structure of the telecommunications sector from one characterised by a natural monopoly to one in which operators had “normal” production cost structures. This led policy makers to introduce a more pro-competitive regulatory framework paving the way for new operators to enter the industry which, in turn, spurred further innovation in the form of new products (e.g. bundling of fixed, mobile and broadband services). With technological convergence in the media and communications sectors gathering pace, operators will continue to develop new more innovative products and services which may require further changes in the regulatory framework in the future.

In the financial services industry, technological developments and increased competition following de-regulation have led to a rise in the number of service providers offering a wider range of new and more sophisticated financial products. This has generated market failure problems in the form of information asymmetries in that consumers do not have complete and perfect information about the quality of financial products offered or the reputation of financial service providers. The UK government responded by implementing the Financial Services and Markets Act 2000 which established firstly the Financial Services Authority (FSA) responsible for regulating the industry and secondly the legal framework for a single ombudsman and compensation schemes aimed at providing further protection for consumers.

## A conceptual model of the links between regulation and innovation

In Figure 8, the complex, multi-dimensional and dynamic nature of the relationship between regulation and innovation is captured in a conceptual model. Inspired by the current literature, it is underpinned by two important frameworks commonly used in government to help guide and inform policy making. The first is the framework based around the five drivers of productivity growth. This is important because regulation is one of the instruments governments can use

17 Brousseau, E. (2000) “The link between regulation and innovation: some preliminary remarks” in *The Impact of EU-Regulation on Innovation of European Industry* (eds. Leone, F and Hemmelskamp, J).

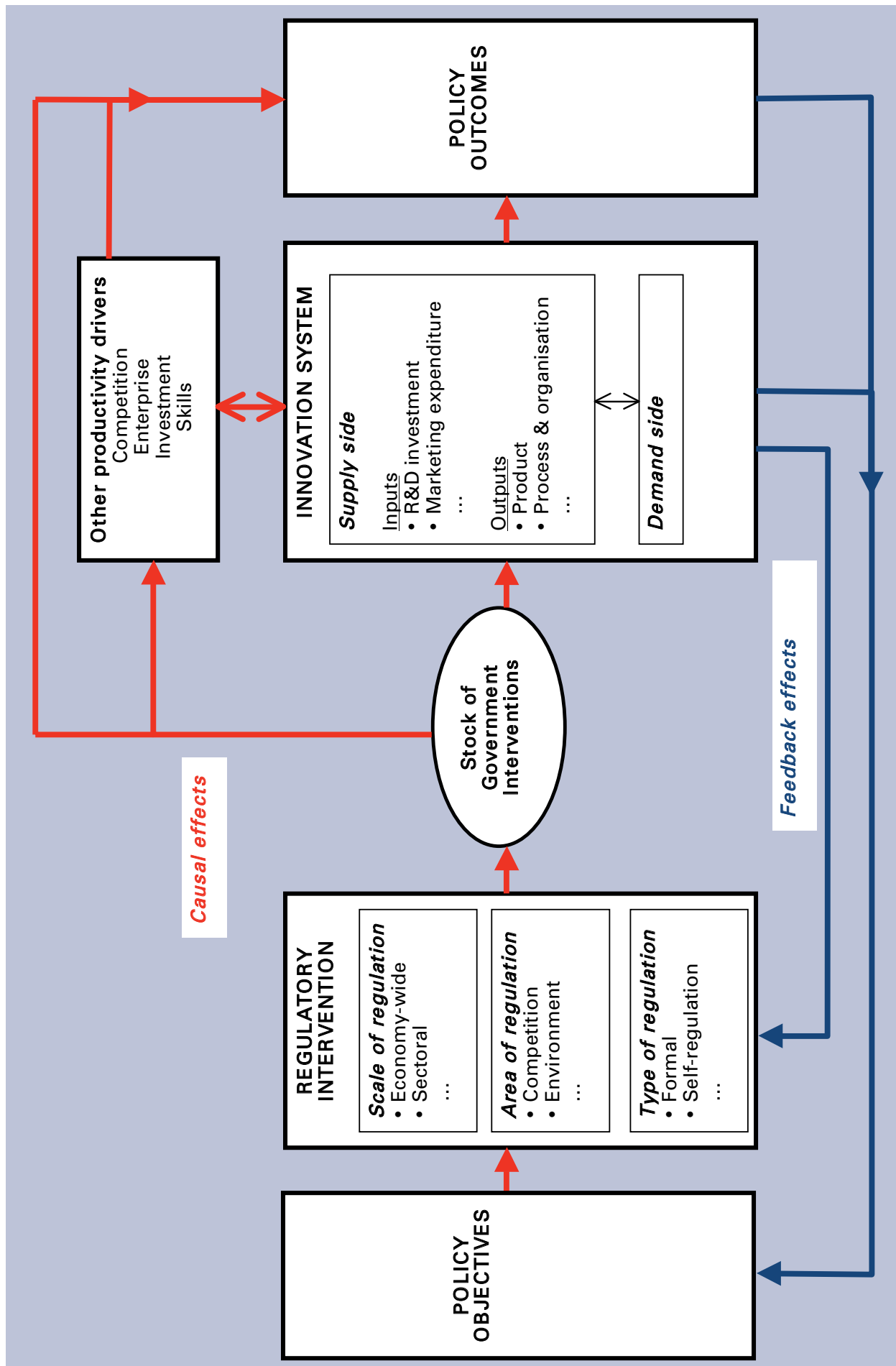
to deliver economic objectives such as higher productivity growth and social goals such as energy efficiency. Since innovation plays an important role in helping government achieve these objectives, a clear understanding of the ways in which regulation affects the five drivers of productivity – including innovation – is vital.

The second framework is the Rationale-Objective-Appraisal-Monitoring-Evaluation-Feedback (or ROAMEF) model of policy appraisal and evaluation. Linking our model to this framework is important because the dynamic nature of the relationship between regulation and innovation means that frequent evaluation of policy is required. This is because changes in the pace and direction of innovation can alter the costs and benefits of government intervention and in some cases lead to a different regulatory solution being required. This is line with the principles of good policy making set out in the Modernising Government White Paper, a subject which will be discussed in Chapter 4.

Starting from the left-hand side, we begin by defining the policy objective. As was noted earlier, this may be an economic objective such as raising productivity growth or a social or environmental objective such as reduced greenhouse gas emissions. Once the policy objective has been agreed, it is assumed that government decides to use the regulatory framework, rather than taxes or public spending, to achieve it.

Intervention through the regulatory framework may take three forms: the introduction of a new regulation; revisions to current regulation; or the removal of a existing regulation (i.e. *de-regulation*.) These interventions may apply across the whole economy or to specific sectors and relate to different areas of policy (e.g. consumer protection, competition, intellectual property). They may also involve amendments to formal rules and requirements or entail the use of alternatives such as self-regulation (e.g. voluntary codes of conduct). All these different changes in the regulatory framework, in turn, alter the total stock of government policies (regulatory, tax and spending policies) and also the scale and nature of the ***interactions*** between them.

**Figure 8: Schematic of the regulation-innovation relationship**



Government interventions through the regulatory system interact with other government market-based and regulatory-based policies to affect changes in the innovation system by altering the incentives and risks of innovation as well as the costs and benefits. Regulation may impact directly on innovation as well as indirectly by influencing other productivity drivers: e.g. strengthening competition, raising skill levels, encouraging more investment or promoting greater entrepreneurial activity.

Regulatory interventions may affect both the supply-side and demand-side of the innovation system. On the supply-side, regulatory interventions may affect business behaviour and decisions resulting in changes in innovation inputs (e.g. R&D investment, marketing expenditure) and outputs (e.g. products, processes and organisational structures). On the demand-side, regulatory interventions may alter user preferences for particular technologies and products and services leading to changes in the pace and direction of innovation.

Changes in the innovation system may, in turn, affect policy outcomes. Alone, or through the other four productivity drivers (i.e. competition, skills, investment and enterprise), innovation may have an effect on economic objectives such as productivity or social and environmental objectives such as improved health and safety or better environmental quality.

Finally, the development of new technologies, products and business practices may give rise to new markets and markets failures which require modifications, where appropriate, to the current regulatory framework and, in some cases, the introduction of new rules where none were previously necessary. By incorporating 'feedback effects' as a feature, the conceptual model captures the dynamic aspect of the relationship between regulation and innovation.

# 3. Does regulation promote or hinder innovation?

It was noted in the previous chapter that the current literature comprises mainly anecdotal case study evidence of the impact of specific pieces of regulation on innovation in particular sectors with comparatively little good quality high-level analysis of the links between regulation and innovation.

That said, a handful of studies have been found which provide particularly useful insights into the factors which influence the impact of regulation on innovation and may help policy makers ensure that new regulatory proposals promote, or at best avoid hampering beneficial innovation.

These factors relate to the way in which regulation is designed, implemented and enforced. They include: the degree to which regulations prescribe particular behaviours as well as outcomes; the extent to which businesses can comply with regulations using existing technologies and practices; the amount of advance notice businesses are given of forthcoming changes in regulation and the amount of time they have to comply with new rules and requirements; how much uncertainty there is surrounding the regulatory framework in the future and the legal interpretation of any new regulations which are introduced; the costs of complying with new rules and requirements; and the way in which changes in the regulatory framework interact with other government market-based and regulatory policies.

## The impact of prescriptive versus outcome-based regulation

All regulation, to have any impact, must clearly specify the desired outcome. For example, a regulation aimed at improving environmental quality may stipulate maximum limits on greenhouse gas emissions while laws aimed at promoting greater consumer protection may specify minimum standards of quality for products and services. Health and safety regulation meanwhile may stipulate that the risk of injury is below a certain level.

However, regulation may vary in the extent to which they specify exactly how businesses must behave in order to achieve these outcomes. In this respect, two approaches to regulation can be distinguished: prescriptive-based regulation and performance or outcome-based regulation<sup>18</sup>.

Prescriptive-based regulation sets out in detail the precise means by which the desired regulatory outcomes are to be achieved. This may include clear rules

<sup>18</sup> In financial services a distinction is made between rules-based and principles-based regulation. Under a rules-based approach, regulators set out very precisely how businesses must meet their regulatory requirements. Under a principles-based approach, regulators specify high-level regulatory requirements and leave it to businesses to choose the best means of achieving them.

on the inputs and technologies which are to be used, and the types of business processes, practices and models which are and are not permitted.

Performance or outcome-based regulations grant greater flexibility to businesses in how they achieve the desired outcome, stipulating only at a relatively high-level what they can and cannot do. In this way, performance or outcome-based regulation can encourage innovation since they have greater freedom to try out new ideas, technologies, business process, models and practices<sup>19</sup>.

However, for outcome-based regulation to be successful, the activities of businesses must be appropriately incentivised and, where necessary, enforced. Otherwise a trade-off may emerge between the benefits of new innovation and the benefits of compliance. This, May (2003) noted, occurred in New Zealand where poor monitoring of building practices resulted in the 'leaky building' crisis<sup>20</sup>.

It is also possible that performance-based regulation may discourage innovation. This could be because businesses do not wish to take the risk of developing new technologies which, although they may be technically successful, do not guarantee compliance resulting potentially in financial penalties<sup>21</sup>. This may be the reason why small and medium sized enterprises prefer prescriptive guidelines as they offer greater certainty<sup>22</sup>. As such, there may be some ambiguity as to the overall impact of performance-based regulation on innovation because of a trade-off between greater flexibility – which can promote innovation – and increased uncertainty – which may discourage it.

The literature on building regulation provides a rich source of information on the effects of a performance-based approach to regulation on innovation. In several countries, there has been a shift towards performance-based regulation because prescriptive regulations can act as barriers to product and process innovation. Citing Everall (1997), Gann (1993) and Bowley (1960) Gann *et al.* (1998) note that building regulations in the UK have been criticised in the past for inhibiting innovation by locking in practices based on traditional or existing technologies and limiting innovative behaviour.

According to Ang *et al.* (2005), performance-based building regulation has contributed to the promotion of innovation in design and building technology because it attracts high performance designers and construction specialists who have the freedom to apply new architectural ideas. Vermeulen *et al.* (2006) note that the Dutch central government has successfully introduced energy

19 For example, the Climate Change Bill currently before the House of Commons specifies, as a regulatory outcome, the reduction of greenhouse gas emissions by 80% by 2050. To achieve this, some businesses may find it more cost effective to develop and/or adopt low-carbon technologies while for others the greater use of renewable sources of energy may be a more appropriate solution.

20 See May (2007).

21 A problem with using performance-based regulation is that it is not easy to accurately define and measure ultimate outcomes. This can make it difficult to ascertain whether a firm has complied with a particular regulation raising the possibility of some firms being wrongly judged to have not complied when they in fact have. This possibility may further discourage firms from developing even more innovative ways of achieving desired outcomes.

22 See CSES (2007).

performance standards (EPS) into building regulations while giving designers freedom of choice on how to achieve them.

Foliente (2000) argues that prescriptive codes and standards can hinder the use of better and cheaper building materials and products. By way of example, he notes that prescriptive regulations impeded the widespread adoption of new building design features developed in the 1960's to reduce the damage caused by earthquakes.

## The impact of setting stringent outcomes

Stringency relates to how difficult and costly it is for firms to comply with new regulatory requirements using existing ideas, technologies, processes and business models. According to Ashford *et al.* (1985), stringency is the most important factor influencing technological innovation.

A regulation is judged to be stringent if firms need to significantly change their behaviour or develop new technology in order to comply with the regulation. Regulations which result in the latter are referred to in the environmental policy literature as *technology-forcing* regulations:

*"a relatively high degree of stringency appears to be a necessary condition for inducing more innovative compliance responses. When stringency arises from technology-forcing characteristics of the regulation, the response tends to be more innovative"* (Ashford *et al.* 1985, p429)

The regulation of vehicle fuel emissions is an excellent illustrative example of the impact of stringency on innovation (see Box 4 overleaf). It shows that when regulatory outcomes are very ambitious, as was the case in the US in the 1970s, and do not remain constant over time, requiring improved business performance over time as in the case of the EU, regulation can act as a powerful spur to innovation<sup>23</sup>.

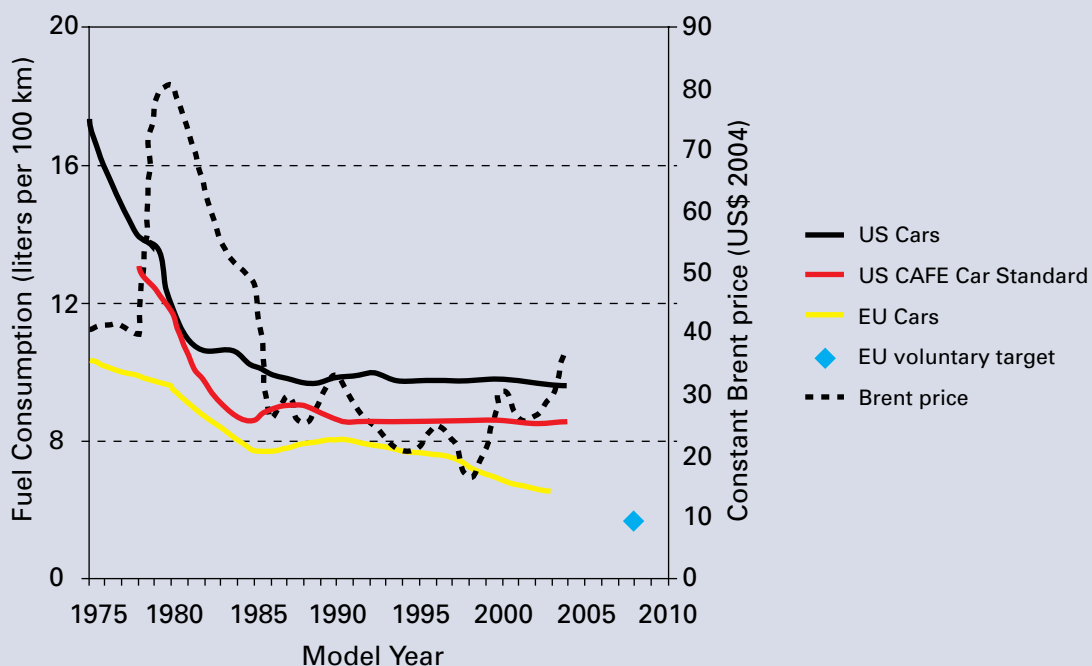
Gerard and Lave (2003) analysed the impact of the 1970 Clean Air Act which stipulated 90% reductions in tailpipe emissions over a four to five year period, to be enforced by a newly established Environmental Protection Agency (EPA). They noted that the standards were deliberately technology forcing. They concluded that even though car manufacturers were not able to meet the performance standards by the stipulated deadline, it did lead to two pre-eminent technologies – the catalytic converter in 1975 and the three way catalyst in 1981. These control technologies helped reduce aggregate emissions of hydrocarbons, carbon monoxide and nitrogen oxides between 1975 and 1985 even though the distances travelled by vehicles increased over the same period by 34%.

23 This supports the Porter Hypothesis which argues that strict environmental regulation can encourage innovation which in turn can help improve a country's competitiveness.

#### BOX 4: VEHICLE EMISSION STANDARDS IN THE US AND EU

In response to the oil crisis in 1978, the US introduced *Corporate Average Fuel Economy (CAFE)* standards for passenger vehicles and light duty trucks. The law called for a doubling of passenger vehicles efficiency to 27.5 miles per gallon (mpg) within 10 years. As the chart below shows, passenger vehicle efficiency increased from 13.5 to 27.5 mpg while that of light trucks rose from 11.6 to 19.5 mpg between 1975 and 1985.

In 1986, the standard fell to 26mpg following successful lobbying from the US automobile industry and stayed at that level until 1990 when it was restored to 27.5 mpg where it has remained unchanged ever since. As can be seen from the chart, the lack of increased stringency since 1986 in CAFE standards has been reflected in a comparatively slower rate of improvement in vehicle fuel efficiency. This compares with the EU where, even though standards are only voluntary, there has been a continual improvement in vehicle fuel efficiency since 1975, driven in part by the need to meet relatively more ambitious targets than in the US.



Source: Clerides and Zachariadis (2006)

Analysis by Taylor *et al.* (2005), which was supported by the view of industry experts, found that the 1979 New Source Performance Standards (NSPS) imposed relatively higher stringency on emission levels relative to 1970 CAA and 1971 NSPS and this led to a shift in innovation activity away from pre-combustion technologies towards post-combustion and supplementary technologies.

Ashford *et al.* (1985) analysed the impact of ten different specific pieces of health, safety and environmental legislation introduced during the 1970s on innovation (see Table 2 overleaf). They found that those regulations which could be categorised as very stringent tended to result in more radical product

innovation (e.g. the development of new products or the substitution of existing products) and process innovation (e.g. adoption of new technologies).

**Table 2: Summary of innovation responses to US environmental, health and safety regulations in the 1970s**

Substance	Type	Stringency	Industry response	
			Degree	Type
PCBs	Product	Very stringent	Radical Incremental	Product Process
CFCs	Product	Very stringent	Radical Incremental	Process Product
Mercury	Product	Very stringent	Diffusion	Product
Lead	Product	Very stringent	Diffusion	Product
Lead	Product	Very stringent	Incremental	Product
Mercury	Process	Stringent	Incremental Diffusion	Process Process
Lead	Process	Very stringent	Radical Diffusion	Both Process
Vinyl Chloride	Process	Very stringent	Incremental Diffusion	Process Process
Cotton Dust	Process	Very stringent	Diffusion	Process
Asbestos	Process	Mildly stringent	Diffusion	Process

Source: Taken from Ashford et al. (1985)

Beerepoot and Beerepoot (2007) note that in the Dutch residential building sector, new and stricter regulation and standards on energy performance have contributed to incremental innovation (e.g. the universal adoption of more energy efficient boilers. With regards energy efficiency in the UK, Gann *et al.* (1995) argue that since 1965, the prescriptive approach has forced firms to become more innovative, particularly at the component level in order to comply with more stringent standards.

Finally, Ashford *et al.* (1985) note that if regulation is not sufficiently stringent then there may be simply a diffusion of current technologies with very little new innovation taking place. For example, with the 1972 asbestos standards introduced by the Occupational Safety and Health Administration (OSHA), they concluded:

*“the failure to adopt a 0.1 fiber/cc standard, the lowest level detectable, for worker asbestos exposure inhibited development of substitute products by the asbestos industry. The industry was able to comply with the 2 fiber/cc standard simply by installing existing pollution control equipment. By failing to adopt the more stringent standard, OSHA effectively inhibited new product development and product substitution”* (Ashford *et al.* 1985, p464)

## The impact of timing

The time given for businesses to comply with a new regulation or standard can play an important role in determining the overall impact on innovation. If businesses are given too little time to comply then this may result in an inferior technological, economic and social outcome. First, businesses need time to understand proposed changes in the regulatory framework and the implications for their businesses. Then, they need time to identify and implement the appropriate changes to their business to ensure compliance, which may involve the development of new technologies or the adoption of very different business practices and models.

However, it is important to note that there is a trade-off between the benefits of innovation and the benefits of compliance. While granting firms long time frames to comply may encourage firms to develop superior more innovative technological and non-technological solutions they inevitably delay the benefits of regulation since businesses are not all complying immediately.

Nil and Tiessen (2005)<sup>24</sup> noted that the short time-schedule of the Clean Air Act (CAA) led to industry searching for a quick solution. This resulted in industry favouring catalytic converters, slowing down the development of more radical and fuel efficient technological solutions such as lean-fuel engines. As Kemp *et al.* (2008)<sup>25</sup> concluded, the particular timing and stringency of the Clean Air Act had the effect of locking out superior solutions.

Yarime (2007)<sup>26</sup> reports a similar outcome with respect to the Japanese Chlor-Alkali sector of the chemicals industry. He found that the short time scale given to industry to meet new regulations aimed at reducing mercury emissions from their plants forced them to adopt an inferior technological solution – called diaphragm technology – which produced lower quality soda and was more energy intensive. Later, industry switched into a superior technology – the ion exchange membrane process – when it became apparent that this technology was considerably more energy efficient. He noted that had industry been granted more time to evaluate the technological progress of alternative clean processes it would have been possible for industry to switch directly to the superior technology avoiding the waste in capital investment.

A time scale of appropriate length is therefore required to grant firms sufficient time to develop and implement the best technological solution which will allow them to meet the new regulation. As Ashford *et al.* (1985)<sup>27</sup> conclude,

24 Nil, J. and Tiessen, J. (2005), Policy, time and technological competition: lean-burn engine versus catalytic converter in Japan and Europe, In Sartorius, C. and Zundel, S. (eds.) (2005), "Time Strategies, Innovation and Environmental Policy", Edward Elgar, Cheltenham, UK.

25 Kemp, R. and Pontoglio, S. (2008) *The innovation effects of environmental policy instruments – a typical case of the blind men and the elephant*. A paper for DIME WP 2.5 Workshop on Empirical Analyses of Environmental Innovations, Fraunhofer Institute for Systems and Innovation Research (ISI), Karlsruhe, January 17-18, 2008.

26 Yarime, M. (2007) "Environmental policy in the presence of technological uncertainty, diversity and rigidity: the case of the Japanese Chlor-Alkali Industry" in *Industrial Innovation and Environmental Regulation: Developing Workable Solutions*, eds (Parto, S. and Herbert-Copley, B.)

27 Ashford, N.A., Ayers, C. and Stone, R.F. (1985) "Using regulation to change the market for innovation" in *Harvard Environmental Law Review* Vol 9, No2, p419-466.

*“a phased-in compliance schedule may prompt incremental improvements in technology rather than a major change, but this allows compliance technologies to be put in place sooner” (Ashford et al. 1983, p120)*

Finally, work by Standards Australia (2007) suggests that the timing of standards can also have an impact on the diffusion of new ideas. They conclude that:

*If a particular product or technical standard is imposed too early in the process of developing a new product, then the effect on innovation may be negative. On the other hand, a standard that comes along too late may result in unnecessary costs or duplication or ‘lock-in’ technologies that were not the most efficient and potentially detrimental to innovation. (Standards Australia, 2007)*

## The impact of regulatory compliance costs

The burden that regulation places on businesses may also influence the effect that it has on innovation inputs and outputs. For example, businesses may have limited budgets and if these are used to ensure compliance with a new regulation then there may be insufficient funds to finance further innovation (e.g. through investment in capital equipment, research and development and skills and training). Put another way, the opportunity cost of allocating limited resources to complying with regulation can imply ‘lost’ innovation.

The amount of innovation which may be lost as a result of regulation may depend in part on whether compliance costs are one-off or recurring and also how quickly firms can rebuild their finances following compliance to fund further innovation activity. It may also depend in part on the size of firms. Lost innovation may be greater for smaller firms than larger companies because the cost of complying with regulation is disproportionately greater<sup>28</sup>.

Prieger (2002) illustrates the impact that the burden of regulation can have on innovation. Investigating the impact of the Federal Communications Commission (FCC) decision between 1992 and 1995 not to require operators to submit detailed plans about new services, he estimated that during this period of ‘lighter regulation’ operators introduced a higher number of new more innovative services. This, he concluded, was because the preparation of plans often placed a significant administrative burden on operators in terms of technical and legal staff time and was a time-consuming process with delays of 200 days on average before approval was granted.

28 Work by London Economics/ RPA (2007) on the cumulative cost of complying with health, safety and environmental regulation in the UK industrial coatings, aerosols and speciality chemicals sector and Decker et al. (2008) on scale economies in compliance costs in the UK surface engineering sector find that the costs of complying with regulation are proportionately higher for smaller firms.

## The impact of regulatory uncertainty

The degree of regulatory or policy uncertainty plays an important role in determining the impact of regulation on business innovation. According to Ashford *et al.* (1985),

*"... regulatory uncertainty is frequently beneficial. Although excessive regulatory uncertainty may cause industry inaction on the part of the industry too much certainty will stimulate only minimum compliance technology. Similarly too frequent change of regulatory requirements may frustrate technological development."* (Ashford *et al.*, 1985, p426)

There are many examples where anticipation of future regulation has encouraged innovation. Ashford *et al.* (1985) report that prior to formal regulation of polychlorinated biphenyls (PCBs), original manufacturers and other chemical companies began to explore alternatives. Similarly, much of the asbestos industry had moved to comply with the Occupational Safety and Health Administration (OSHA) asbestos regulations before it was finally implemented. As they conclude,

*"[a] pre-regulation period allows industry time to develop compliance technologies, process changes, or product substitutes, while allowing leeway for it to adjust to ensure continued production or future commercial innovation"* (Ashford *et al.*, 1985, p426)

Taylor *et al.* (2005) provide further evidence of the way expectations of future regulation can impact on innovation. They find that patenting activity in SO<sub>2</sub> controlling technologies picked up prior to the 1967 Air Quality Act – which considered the introduction of national standards on SO<sub>2</sub> emissions – and continued even after they were finally established under the 1970 Clean Air Act.

The World Business Council for Sustainable Development (2002) also uncovered anecdotal evidence supporting the notion that a credible threat of future regulation may encourage innovation. They found that some cement companies are anticipating the introduction of climate change regulation exploring – and in some cases instituting – ways to reduce carbon dioxide emissions.

However, uncertainty about the actual shape or form of impending regulation is likely to hamper innovation. The process of developing new products and improved processes is a very risky and costly process and regulatory delay and uncertainty can add to this. As Ashford *et al.* (1985) conclude,

*"Faced with uncertainties which create risks that the technology developed will not ultimately be needed or will be unnecessarily costly, potentially innovative industries will simply adopt low-risk existing technology. Thus, only diffusion will occur."* (Ashford *et al.* 1985, p465)

Marcus (1981) notes that legal uncertainty regarding new regulations can have a similarly negative effect on innovation. Citing US evidence from the energy sector<sup>29</sup>, he notes that uncertainties of legal interpretation of clean air regulations had severely delayed new process innovations such as the conversion of industrial boilers from oil to coal and the use of composite fuels made of pulverised coal.

## The impact of interactions with other government policies

A final factor influencing the impact of regulation on innovation is the way in which it interacts with other government interventions. Government can promote innovation in two ways. They may provide firms with subsidies or tax incentives (e.g. R&D tax credits) to encourage business innovation activity and knowledge transfer. Alternatively, they may influence the innovation system using other government policies (e.g. competition policy, IPR, skills and education, procurement).

Regulatory intervention may encourage innovation if it strengthens other government policies aimed at reducing the barriers to innovation. On the other hand, regulatory intervention may work against other government policies reducing the incentives to innovate or introducing distortions in the allocation of resources in the innovation system.

For instance, Kivimaa (2008) note that environmental innovation in the pulp and paper sector such as biogasification technologies have arisen because of the alignment of environmental and technological policies with industry given sufficient time to develop new commercially viable technologies.

29 Here the Senate Committee on Interior & Consular Affairs, 1975 and Leonardi, H.D (1978) *Draft on composite fuels* Unpublished memo, The Dravo Corporation (Pittsburgh)

# 4. Practical implications for government

The previous two chapters have presented the emerging findings from an extensive review of the evidence on regulation and innovation. They have provided useful insights into the nature of the relationship between regulation and innovation, and more importantly, have shed light on the factors which may influence the impact of regulation on innovation, helping to identify the particular circumstances under which regulation may help or hinder innovation.

In this final chapter, we use this evidence to draw up some practical ideas which could help ensure that policy makers, analysts and regulators fully consider the potential impact of new proposals on innovation at all stages of the policy development process, especially in impact assessments (IAs) and post implementation reviews (PIRs).

**It is important to stress at the very beginning that these ideas do not constitute policy recommendations which, if formally adopted, could be binding on policy makers, analysts and regulators. The sole purpose for presenting them in this paper is to initiate discussion on how policy makers, analysts and regulators could better ensure that new proposals promote, or at best avoid hampering beneficial innovation and in ways which would not create additional work for all concerned.**

## Implications for policy makers and analysts

The Modernising Government White Paper, published in 1999, sets out the principles of good policy making. Amongst other requirements, the White Paper indicates that policies should be:

- forward looking
- flexible and innovative
- evidence-based

Innovation, as was mentioned at the very beginning, can help governments achieve economic goals such as improved productivity growth and competitiveness and social and environmental objectives in the public interest such as higher levels of health and safety and improved air and water quality.

Recognising the impact of proposals on innovation is therefore in line with the principles of good policy making. Innovation is a time consuming process and hence policy needs to consider the longer term, particularly as the benefits of innovation may materialise slowly over time. Innovation also requires a flexible and innovative approach to policy making since firms are able to find more innovative ways of achieving desired policy outcomes if they are given the freedom to do so. Finally, in addition to delivering benefits to businesses

and consumers, innovation can play an important role in helping policy makers deliver wider government objectives, which need to be taken into account when policy makers and analysts are carrying out impact assessments and evaluations of the costs and benefits of new and existing policy measures.

***Implication 1: Policy makers and analysts could consider using an ‘innovation filter test’ to identify at the very start of the policy development process the potential impact of proposals on innovation.***

At the start of the policy development process, policy makers and analysts could work together to consider whether new proposals are likely to have an impact on innovation behaviour and outcomes. This may be done using a simple ‘Innovation Filter Test’<sup>30</sup>, such as the one illustrated in Box 5 below.

#### **BOX 5: INNOVATION FILTER TEST**

**Do proposals significantly impact on sectors or types of firms characterised by high levels of innovation and rapid technological progress?**

This is likely to be the case if proposals affect:

- Companies reported to undertake substantial impact on innovation
- Companies in sectors characterised by rapid technological change, as generators or early adopters of technology
- Companies that are active in the generation of intellectual property (e.g. patents, designs, trademarks, copyrights)
- Companies in emerging sectors

**Do proposals affect innovation behaviour and/or outcomes**

This is likely to be the case if proposals:

- Change the incentives from innovation (e.g. make it easier to sell new differentiated products and services)
- Alter the rewards from innovation (e.g. lengthening of patent protection)
- Affect the relative costs of innovation efforts (e.g. capital investment becomes more attractive)
- Alter the risks of innovation (e.g. access to finance easier)
- Create demand for particular technologies, goods and services (e.g. low carbon technologies)

30 The Office of Fair Trading uses a similar filter test to identify potential competition concerns. This is available at: [http://www.offt.gov.uk/shared\\_offt/reports/comp\\_policy/oft876.pdf](http://www.offt.gov.uk/shared_offt/reports/comp_policy/oft876.pdf)

A positive answer to one or more of these questions would require policy makers and analysts to carry out a more detailed assessment of the potential impact of new proposals on innovation and the policy objective. A negative answer to these questions would mean that a detailed assessment is not needed. Whilst this may genuinely be the case in most instances, it may actually reflect that insufficient attention has been paid to regulatory options with more direct bearing on innovation.

Early identification of potential innovation concerns in the policy development process is crucial to allow policy makers and analysts time to explore these issues in greater depth and make any appropriate amendments to the proposals before they have been fully developed and formalised. In this way, there is a greater likelihood that proposals will help rather than hinder beneficial innovation.

*It is important to stress that the innovation filter test should be seen as an integral part of the impact assessment itself rather than a separate exercise. We are not looking to add in any way to the burden of work associated with drawing up new policy proposals, which would not be in accordance with the principles of good policy making and better regulation.*

***Implication 2: Subject to the filter test, policy makers and analysts could consider as part of their appraisal of new (de-regulatory) proposals the potential impact on innovation.***

Latest guidance published by the Office of Fair Trading in 2007 includes innovation in its revised competition filter test. Question 3, which asks whether proposals will limit the ability of suppliers to compete, advises policy makers and analysts to consider as part of their assessment whether proposals limit the scope of firms to introduce new products or supply existing products in new ways. Paragraph 6.9 states that:

*“The development of new products is a key way in which suppliers compete to attract customers. Regulations that limit the scope for innovation, for example, through restrictions on the characteristics of products that can be supplied, can restrict the intensity of competition between existing suppliers and with new suppliers. Restrictions on the production process used or means of supply can also limit the ability to innovate and limit competition” (OFT, 2007)*

However, given the importance of innovation, both as a driver of productivity, and the role it can play in helping to deliver other government objectives such as consumer protection, it is essential that the potential effects of new proposals on innovation are analysed as fully as possible. As part of this assessment, policy makers and analysts could consider answering the following questions:

- **Do proposals have the potential to promote or hamper innovation?**

Proposals may promote innovation, for example, if they encourage businesses to collaborate more closely and exchange information, knowledge and ideas with other firms and academia. Proposals may hamper innovation, for example, if it makes it more difficult for firms to finance investment in R&D or hire people with the necessary STEM skills.

- **Do proposals interact and overlap with the stock of regulations and other instruments?**

New proposals may complement existing government policies strengthening the incentive to innovate or they may interact in a way which lead to unintended consequences or actions that prevent innovation or create distortions in the innovation process with resources being diverted away from one area of innovation to another.

- **Is innovation likely to influence the effectiveness of proposals?**

On the one hand, innovation may help deliver government objectives. On the other hand, innovation may undermine government objectives, for example, if firms have found ways of circumventing regulatory requirements. In some cases, the pace of innovation may be such that a different regulatory solution may need to be found. Frequent evaluation may therefore be needed to ensure that government intervention is still justified.

- **What is the regulatory approach being adopted?**

Proposals which are outcome-based rather than prescriptive based give firms greater flexibility to innovate. Proposals which make greater use of self-regulation and co-regulation can also help foster innovation as they lower compliance costs, freeing up valuable resources which can be used in the innovation process.

- **Do the proposals create any potential trade-offs?**

The benefits of a particular government objective may only be achieved by accepting costs elsewhere. For example, increased regulatory requirements designed to promote consumer protection may lead to firms focusing on a more limited number of new technologies and products, limiting future consumer choice. Policy makers and analysts need to be aware that these trade-offs exist and take them into account when assessing the costs and benefits of new proposal.

- **Are the proposals likely to be updated frequently?**

Proposals which need to be revised frequently or updated too soon may encourage firms to focus on short-term compliance rather than develop superior technological and non-technological solutions in the long-term reducing the benefits of innovation to the economy in the long-run.

## Implications for regulators

The UK has established a number of independent “horizontal” agencies and bodies whose role is to provide advice on, and apply, new and existing regulatory proposals introduced by government across all sectors of the economy<sup>31</sup>. These include:

- The Office of Fair Trading (OFT)
- Competition Commission (CC)
- Health and Safety Executive (HSE)
- Environment Agency (EA)
- Food Standards Agency (FSA)

The OFT and CC are responsible for ensuring that the UK competition and consumer protection regimes are functioning effectively while the HSE, EA and FSA work to ensure that all businesses in the economy comply with regulations that have social objectives such as health and safety or environmental quality. At the same time, the UK government has created a number of independent bodies responsible for enforcing regulation in specific sectors of the economy:

- The Postal Services Commission (Postcomm)
- The Water Services Regulation Agency (Ofwat)
- The Office of Gas and Electricity Markets (Ofgem)
- The Civil Aviation Authority (CAA)
- The Office of Communications (Ofcom)
- The Financial Services Authority (FSA)
- The Office of Rail Regulation (ORR)
- The Pensions Regulator (TPR)

Table 3 overleaf reproduces, in part, a table from the House of Lords Select Committee report, *UK Economic Regulators*, which sets out some of the statutory duties of the regulators. Many of them have the promotion of competition as their statutory duty or are required to consider the degree of competition in the markets in which they operate in order to properly inform their work. A large number also have promotion of the interests of consumers as a statutory purpose.

The Regulator’s Compliance Code<sup>32</sup> makes no specific provision about considering innovation but it does include a duty to consider the effects of regulatory interventions on economic progress. Paragraph 3.1 of the Code states that:

31 The horizontal regulators differ significantly in the extent to which they implement and enforce regulation on behalf of government and provide advice. For example, the OFT and Environment Agency only implement and enforce new and existing regulation while the Health and Safety Executive and Food Standards Agency are also involved in developing new regulatory proposals.

32 Regulator’s Compliance Code: Statutory Code of Conduct for Regulators, BERR, 2007. URN 07/1707 <http://www.berr.gov.uk/files/file45019.pdf>

**Table 3: Summary of Regulators' Statutory Duties**

	Ofcom	Ofwat	ORR	Ofgem	CAA	Postcomm	FSA	TPR	OFT
Further/protect interests of consumers	YES	YES	YES	YES	YES	YES	YES	YES	YES
Further/protect interests of citizens	YES	NO	NO	NO	NO	NO	NO	NO	NO
Protect specified vulnerable groups	YES	YES	YES <sup>33</sup>	YES	NO	YES	NO	NO	NO
Promote competition	YES	YES	YES	YES	NO	YES	NO	NO	YES
<b>Facilitate market innovation</b>	<b>YES</b>	<b>NO</b>	<b>NO</b>	<b>NO</b>	<b>NO</b>	<b>NO</b>	<b>YES</b>	<b>NO</b>	<b>NO</b>
Encourage market investment	YES	NO	YES	NO	YES	NO	NO	NO	NO
Maintain security of supply	NO	NO	NO	YES	NO	NO	NO	NO	NO
Maintain the competitive position of the UK	NO	NO	NO	NO	NO	NO	YES	NO	NO
Implement the five principles of good regulatory practice <sup>34</sup>	YES	NO	NO <sup>35</sup>	YES	NO	NO	NO	NO	NO
Facilitate the development of self-regulation	YES	NO	NO	NO	NO	NO	NO	NO	NO
Promote public awareness	YES	NO	NO	NO	NO	NO	YES	YES	YES
Carry out impact assessments	YES	NO	NO	YES	NO	NO	YES	NO	NO
Provide advice to the government	NO	NO	NO <sup>36</sup>	NO	YES	YES	NO	NO	YES

Source: House of Lords Select Committee (2007) *UK Economic Regulators*

33 According to ORR, this is based on the assumption that this refers to disabled groups.

34 The five principles are proportionality, accountability, consistency, transparency and targeting.

35 ORR state that they have adopted an approach to focused and effective regulation which draws on best practice and the five principles of better regulation

36 ORR's approach to focused and effective regulation also encompasses the identification of opportunities for regulatory withdrawal or greater self-regulation where this is wanted by the industry and there is sufficient resource and capability to ensure it delivery.

*“Regulators should consider the impact that their regulatory interventions may have on economic progress, including consideration of the costs, effectiveness and perceptions of fairness of regulation. They should only adopt a particular approach if the benefits justify the costs and it entails the minimum burden compatible with achieving their objectives”*

As noted earlier, innovation is one of the essential drivers of productivity and a consideration of how a regulation affects innovation may be one of the ways in which regulators can demonstrate compliance with the code. As can be seen from Table 3, only two economic regulators at present, Ofcom, and the FSA, have facilitating innovation as one of their statutory duties. However, discussions held with many of the independent regulators uncovered a number of examples where they have promoted innovation in their work. A selection of these can be found at Appendix 2<sup>37</sup>.

***Implication 3: A voluntary checklist of principles should be developed which regulators and practitioners could use to help promote innovation.***

Many of the guidelines for policy makers and analysts set out above apply equally to regulators who implement and enforce new proposals and existing regulation on behalf of government.

The short paper, *Helping Regulators to Promote Innovation*, published by DIUS alongside its first Annual Innovation Report (AIR) sets out a voluntary checklist of principles for promoting innovation through regulation which regulators and practitioners may find helpful to consider in their work. These are reproduced in Box 6 and are based on the aforementioned discussions with many of the independent regulators and the evidence presented in this paper<sup>38</sup>. As can be seen, they mirror closely the proposed guidance for policy makers and analysts.

Regulators could consider the innovation process in the industries which they regulate – in particular, the barriers and bottlenecks, market failures and commercial opportunities – and ensure that they respond to the emergence of new technologies and markets, removing regulatory interventions which become obsolete, acting where new markets and market failure appear and altering the way in which current regulations are formulated and applied to ensure that the benefits continue to outweigh the costs.

37 Discussions were held over summer 2008 with Ofcom, Ofgem, Ofwat, PostComm, The Competition Commission, The Pensions Regulator, Office of the Rail Regulator, Office of Fair Trading, Civil Aviation Authority. Further to these discussions, a number of regulators submitted further examples. Ofwat state they have taken steps to promote innovation in the context of their climate change policy. In July 2008, they published a wide ranging policy statement setting out where climate change will affect the water and sewerage sectors in England and Wales. This provided a long-term policy framework, facilitating long term adaptation and innovation to meet the major challenges for the sector. According to Ofgem, although their primary statutory duties are to protect consumers and promote competition, they see it as part of their role to remove the barriers to innovation. They have brought forward proposals to facilitate microgeneration by removing certain market and regulatory barriers to their deployment and over the last several years they have introduced price control incentives on the network companies to innovate. They state they have also taken steps to encourage market investment. For example, to ensure that companies can finance the activities that they are obliged by licences to provide, this has meant that recent network price controls have authorised massive increases in investment by the network companies.

38 The findings were tested in two workshops with them and three key regulators without a specific economic remit: Health and Safety Executive, Environment Agency and Food Standards Agency.

## **BOX 6: CHECKLIST TO HELP REGULATORS PROMOTE INNOVATION**

### **1. Consider how regulation may impact on beneficial innovation activity**

Regulatory interventions can impact on different parts of the innovation process, influencing decisions on innovation inputs (e.g. R&D investment) and outcomes (e.g. characteristics of new products). Innovation can also be a response to avoid regulation. Consider how the incentives established or influenced by the regulation are likely to promote innovation which achieve better outcomes and aim to avoid, as far as possible, responses which may in themselves be innovative but do not achieve better outcomes.

### **2. Consider how interaction with the stock of existing regulations may affect innovation**

New regulatory interventions may complement existing ones in strengthening the incentives to innovate or they may interact in a way which leads to unintended consequences or actions that prevent innovation or create distortions in the innovation process. Consider how this may happen in developing and consulting on regulatory proposals and where possible, favour approaches that do not hinder or distort the ability of the markets to innovate.

### **3. Favour regulatory approaches that are outcome-focused and technology neutral**

A prescriptive stance allows regulators to decide on an approach or technology for the market. This provides certainty but locking the market into a particular technology risks 'picking winners' and a sub-optimal approach being chosen or preventing the market being able to take advantage of better solutions coming along later. A more outcome-based approach and one that is technologically neutral gives firms and the market greater freedom to innovate.

### **4. Consider how implementation and enforcement can promote innovation**

People responsible for implementing and enforcing regulation on the ground often look for very prescriptive guidance – it avoids the risk of criticism if something goes wrong – and in some cases, for example in food safety, this is justifiable. However, strict application of rigid guidelines also tends to preclude innovations which may ultimately lead to better outcomes. Consider how the knowledge of those on the front line can be used to frame guidance to manage risk effectively whilst not precluding innovative approaches.

### **5. Consider the effects of timing of regulation on innovation**

Regulations may be viewed periodically or in response to changed objectives or innovations in markets or products. The frequency of review may itself have an impact on the incentives to innovate, for example too frequent review of price regulation may undermine the returns to a particular company on investment in technological innovation. In reviewing regulation, consider the effects that doing so at a particular time or frequency may have and aim to avoid disincentives to innovation where possible.

***Implication 4: Further evaluation work should be carried out on the effects of regulation on innovation and the impact that innovation has had on policy outcomes using some recent examples of (de-) regulation as case studies.***

A review of the work which has been done on regulation and innovation has revealed four significant gaps in the literature:

- First, there is relatively little good quality high-level analysis of the various ways in which regulation may impact on innovation with the majority of the literature comprising anecdotal case study evidence on the impact of specific pieces of regulation in particular sectors of the economy
- Second, the focus of analysis has so far been on the effects of environmental policy and to a lesser extent competition policy and intellectual property rights on innovation with relatively less attention paid to the impact of other types of regulation such as, for example, health and safety regulation, employment law and planning
- Third, only a very small proportion of studies have analysed the impact of recent pieces of regulation on innovation. Many of the studies, while providing useful insights, relate to the innovation effects of regulations introduced in the 1970s and 1980s
- Fourth, a large number of studies focus on the effects of regulatory stringency on innovation and the impact of using a performance-based – as opposed to prescriptive-based – approach to regulation. There is relatively less evidence on other characteristics of regulation which can affect innovation including uncertainty and timing of changes to the regulatory framework, compliance costs and the interactions which exist between regulation and other government market-based and regulatory policies.

There is therefore a clear need for further research aimed at building up the evidence base in those areas where significant gaps in the literature still exist. It may be useful to evaluate from a purely innovation perspective a number of specific regulations drawn from different areas of policy. Given that the innovation process is a slow and gradual process with benefits only appearing after a lengthy period of time, these regulations would need to have been implemented for a sufficient number of years. The evidence gathered from these case studies would give policy makers and analysts a better understanding of the different ways in which regulation can affect innovation and help ensure, in line with good policy making that regulation promotes, or at best avoids hampering beneficial innovation.

# Appendix 1: Findings from a selection of studies looking at the impact of regulation on innovation

Authors	Sector	Findings
World Business Council for Sustainable Development (2002)	Cement	<p>Found that environmental regulations have encouraged innovation. However, they also found that standards in the industry can act as a barrier to new innovation but that these can be overturned if there is a strong desire for change by industry.</p> <p>Research based on interviews with cement company managers found that, "regulations have pushed cement companies to introduce pollution control devices and change many practices. In some cases, cement companies have adapted pollution control technologies from other industries (e.g. flue gas de-sulphurisation devices from the electric utility industry have been adapted and installed in a few cement plants).</p>
Mahdi et al. (2002)	Chemicals	<p>A review of the literature found that : 1) the effect of regulation on innovation varies across different chemical sub-sectors and firm sizes; 2) there is no unambiguous evidence that the European chemicals industry is lagging behind that of the US and Japanese in terms of innovative performance despite Europe having a more stringent regulatory regime for chemical notifications; and 3) in the short-term new regulations to have a measurably negative impact on the rate (i.e. quantity) of new innovations introduced.</p>
DIN – German Institute for Standardisation (1999)	Economy	<p>Using information on the number of published standards and technical rules contained in the database, they found a significant correlation between the number of patent registrations and existing rules: more new standards were published in highly innovative sectors than less innovative ones. They also found some evidence to suggest that the stock of standards has a positive influence on Germany's innovation potential.</p>
Porter and van der Linde (1995)	Economy	<p>They argue that restrictive standards can encourage innovation as firms find more innovative ways of meeting them but there is some evidence that this is only achieved at a high cost.</p>
Standards Australia (2007)	Economy	<p>They find that if regulation and standards are too prescriptive then they may hinder innovation, particularly in industries with rapid technical change. This is because they do not permit sufficient flexibility for firms to choose the technology, product or process solution which helps achieve their goals.</p>

Leone (2000)	End-of-life vehicles	Paper noted that that voluntary industrial agreements and the threat of new regulation led to the specific product, process and organisational innovations during the 1990s. These included a) creation of recycling departments and competencies in car companies; b) creation of dismantling and recovery/recycling networks; c) advances in design for dismantling; d) advances in design for recycling; e) adoption of life-cycle analysis; f) material regime simplification in car production; g) material competition and substitution; h) advances in automotive plastic recycling; i) research on innovative automobile shredding residue (ASR) recovery technologies; j) cooperative research initiatives at the industrial level.
Glachant (1997)	Energy	Market liberalisation and de-regulation has led to electricity generators switching from using coal to gas and other less expensive energy sources. This has spurred technical innovation in the form of more efficient gas and oil generators resulting in greener electricity since gas is environmentally cleaner than coal.
Canals (1993)	Financial services	Moves to de-regulate the US financial services sector has resulted in new financial products being brought to the market which have helped facilitate innovation in high-tech industries which use them.
Avermete and Viaene (2002)	Food industry	Regulations aimed at improving food safety and quality, environmental standards and better labelling of food specialities in the Belgian food industry led to non-technological innovation in the form of improved organisational structures and better networking and communications between retailers and final consumers.
Feller and Sink (1984)	Food industry	In the US food industry, the introduction of new process regulations had stimulated technological innovation in processing equipment, with food processors making use of new technologies and those which had been applied in other sectors.
Millstone (1994)	Food industry	Noted that the 1990 Food Safety Act had accelerated the adoption of monitoring equipment in food manufacturing and processing. Interestingly he found that product regulations appear to have little influence on product innovation. Comparing regulation and innovation in two highly-regulated sectors – artificial additives and artificial sweeteners – he noted that there was more innovation in the latter owing to the market being relatively larger and experiencing more growth which increased the rewards from investment.
Steg and Whitelegg (2000)	Medical devices	Firms interviewed expressed different views about the impact of standards on innovation. On the one hand, standards were judged not to be a barrier to innovation to as they were voluntary and provided a useful benchmark against which products could be compared and improved if necessary. However, some believed that standards hampered innovation since products were being tested against obsolete standards based on existing technologies, the current state of technology or technologies which were state-of-the-art several years previously.

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Katz (2007)	Pharmaceuticals	Study suggests regulatory framework in the US drug industry may encourage innovation by certifying the quality of new drugs – something which may not be easily achieved through private market-based mechanisms.
Elamin (2005)	Plastics processing	Foodproductiondaily.com found that regulations aimed at reducing the use of harmful chemical ingredients in the manufacture of plastics and ensuring that food packaging use biodegradable and environmentally friendly materials have spurred innovation. For example, Denmark-based Danisco has launched a plasticizer produced from hardened castor oil and acetic acid which is completely biodegradable.
Buchinger <i>et al.</i> (2000)	Recycling	Found evidence to suggest that environmental regulation has encouraged innovation in the electric and electronic equipment, construction and demolition and plastics sectors.
Frei <i>et al.</i> (1998)	Retail banking	Financial institutions have developed new financial products and services and organisational structures. This has been driven by several factors including liberalised domestic regulation (e.g. weakening of restrictions relating to interstate banking and relaxation of the Glass-Steagall restrictions on banking holding companies which have enabled banks to merge across product lines) and the explosive growth in information and communication technologies which have enabled banks to offer services through the internet.
Baltagi <i>et al.</i> (1994)	Transport	De-regulation in the US airline industry has promoted non-technological innovation with airlines adopting more efficient route structures (e.g. flying a specific fraction of flights from two or three major airports).

# Appendix 2: Regulators as promoters of innovation

Economic regulator	Impact on innovation
<p>ORR – Rebate mechanism for investors in large scale enhancements</p>	<p>Following responses from industry to a consultation on the investment framework, ORR proposed a mechanism whereby investors in large-scale track infrastructure enhancements can recover from users a fair proportion of the costs incurred in funding an investment scheme that is accessible to competitors.</p> <p>The mechanism forms part of the investment framework for the rail industry. It addresses the case where an investment by one party is used by a competitor such that the investing entity could feel itself to be at a competitive disadvantage. This can reduce the incentive on the original entity to invest meaning that a beneficial enhancement may not go ahead. The mechanism seeks to remove the barriers to investment and was developed in response to indications that a number of potential projects had stalled as a result of the problem.</p>
<p>Ofcom - R&amp;D</p>	<p>Ofcom uses part of its budget to research spectrum technologies. This money is used to research areas which current research does not currently cover but which may be important for future spectrum use and efficiently.</p> <p>Gaps can exist because companies or research institutions do not prioritise a specific area., or the economies surrounding particular research do not support commercial exploration.</p> <p>One such gap is in propagation characteristics at high frequencies. As lower frequency spectrum becomes scarcer and technology unlocks higher frequencies for commercial use, these characteristics will become essential in developing communication tools. Ofcom is investigating these both to inform forward looking policy, and to inform the market to encourage these frequencies exploitation.</p>
<p>Ofgem – RPI at 20</p>	<p>Ofgem is currently conducting a review of its RPIX pricing. The “RPI at 20” project is looking at the incentives provided to invest by the current RPI system in the energy market, its successes and its limitations.</p> <p>Ofgem is exploring potential alternatives that may provide better incentives to innovate and increase productivity. This is work is being carried out in the context of the future requirements of the sector both in terms of technology investment, and the green agenda.</p>
<p>Civil Aviation Authority</p>	<p>Airline regulation in Europe has been successfully relaxed since the early 1990s. The resulting emergence of no frills airlines has increased competition not only in the airline market, but has also stimulated significant growth of and competition between regional airports. In the UK, regional airports are considered competitive, which is reflected in the regulatory approach. In 2008, the Secretary of State decided that Manchester Airport should cease to be subject to price control regulation, leaving only the three largest London airports (Heathrow, Gatwick and Stansted) subject to price control regulation</p>
<p>Ofgem - LENS</p>	<p>LENS is a forward look at future demand and supply energy scenarios (to 2050). This is a highly consultative project aimed at ensuring that the energy market is prepared for the potential structural changes that may be needed in the coming decades.</p>

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