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GES GROUP ON GROWTH

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The views expressed within this report are those of the authors and should not be treated as Departmental or Government policy

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Overview and Summary

As the UK economy returns to growth, our performance on innovation, a key driver of long-run prosperity, is receiving renewed attention from policy and analytical audiences. In light of this, the GES Group on Growth commissioned a review of the evidence base on the effectiveness of public policies to foster innovation and the role of knowledge diffusion – building on the comprehensive analytical review of innovation published alongside the 2011 Innovation and Research Strategy.

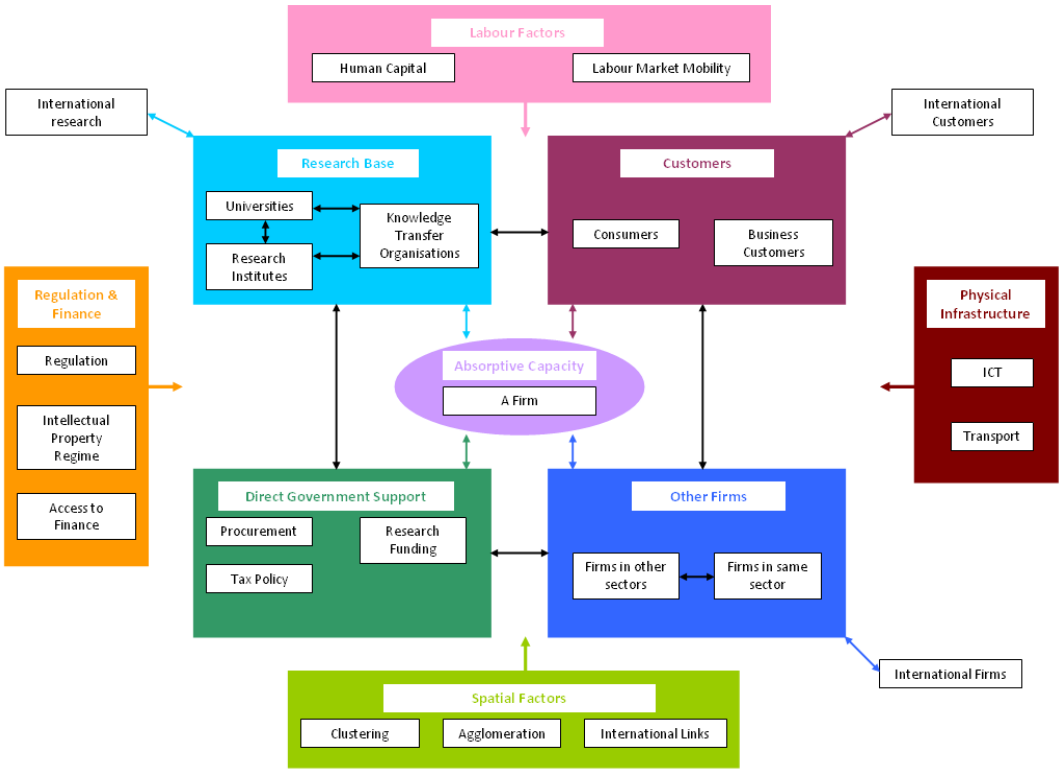
The review is intended to be a contribution to the debate over UK innovation policy – incorporating the views of the authors on the state of the evidence base at the time as well as inputs from external experts. As such it should not be regarded as the Government's definitive view or a guide to the likely direction of future policy.

Introduction

The available evidence points to the innovation system as being characterised by a set of complex interactions between a wide variety of different actors; with continuous feedbacks between them. The creation of new knowledge and its transformation into innovation is a non-linear process which makes studying the effectiveness of innovation diffusion and innovation policy challenging.

For the purposes of this project, a simplified view of the innovation system was used in order to break down some of the key high level interactions. Figure 1 illustrates the approach from the perspective of a firm.

Figure 1: Innovation System



Source: GES Group on Growth

It must be emphasised that this representation is not intended to give a complete and comprehensive view of the innovation system, but rather provide an aid to thinking and identify areas for further examination.

Starting from base principles, the rationale underpinning public support in innovation is based on two main market failure arguments:

- **Innovative activity generates knowledge which has the characteristic of a public good**. It "spills over" to benefit individuals and firms who did not make the initial investment. Because these benefits are not taken into account by the investor, society as a whole under invests in innovation activity.

- **Investments in innovation are highly uncertain and may also involve long developmental timeframes.** Investors often cannot quantify the likely returns to an investment, which may lead to inefficiency and difficulty in distinguishing good investments from the bad. Under-investment in innovation may therefore occur.

It was not within the scope of this paper to review the primary market failure rationale for intervention, system failure arguments or a comprehensive assessment of all aspects of the innovation system in the spread of knowledge (These have already been set out in the analysis supporting the 2011 Innovation Strategy) Instead it focuses on two key areas: **innovation diffusion** and **public policy effectiveness.**

Innovation diffusion

The recent innovation literature has highlighted the importance of not just the creation of new knowledge, but the process by which these ideas are transmitted or 'diffused' throughout the economy.

In thinking about innovation diffusion the paper distinguishes between the role of the **research base (Chapter 1)** as both a generator and communicator of new knowledge and how the UK fares in terms of **absorptive capacity (Chapter 2)**. That is, the ability of firms to absorb new knowledge and in turn commercialise it into new innovation.

Public policy effectiveness

The analysis of public policy effectiveness is broken down into five broad types of policy instrument; **tax and spend** (Chapter 3), the balance between **push and pull policies** (Chapter 4), **procurement** (Chapter 5), **access to finance** (Chapter 6) and **regulation** (Chapter 7). It focuses on the extent to which policy encourages:

- **Innovation** - including encouraging UK innovation and the movement of research / innovative activities from abroad into the UK.

- **Diffusion** - the spread of innovation through the economy, amongst universities, firms, customers and others (hence being closely linked to the innovation diffusion element of this project).

- **Commercialisation** - the extent to which research and ideas are successfully brought to market in the UK.

Common themes from the report

As the analysis progressed, a number of common themes emerged from this project; which are covered in turn below. These are:

- The link between the research base and firms' capacity
- The UK has led thinking, but has often lagged in application
- An Innovation system of interacting components
- How the state can (and should) help shape markets
- Evidence gaps and a lack of metrics
- The importance of policy experimentation

The link between the research base and firms' capacity

There is a **strong complementarity between the activities of the research base and firms' absorptive capacity**:

- **The research base plays a fundamental role in generating knowledge and innovation**, which then leads to impacts through a variety of channels. Many of the benefits of the research base are long-term, and not of immediate financial nature.

- **Absorptive capacity represents the ability of firms[1] to understand and apply the results of research and innovation carried out elsewhere**. It determines a firm's success in capturing value from innovation, and is both path-dependent and firm-specific (i.e. current absorptive capacity depends on previous investment, and absorptive capacity is not easily transferrable across firms).

Industry and academia exchange knowledge through a wide variety of channels and the more easily quantifiable commercialisation activities actually constitute only a small part of pathways to impact by academics. As a result taking a long term, holistic view of both parts of the innovation system is crucial.

Although the UK has a relatively low R&D intensity in terms of expenditure (in part driven by the smaller share of UK share of value-added in R&D intensive sectors), the UK's research base has performed strongly, punching above its weight in terms of measured research outputs. However, as has recently been outlined in a report looking into the comparative performance of the UK research base, it is unclear how long this good performance can be maintained with low R&D intensity.

Research represents a key national economic strength in the face of intensifying global competition, and both **continued investment into research and evaluation of pathways to impact are important**. In the context of this, collaboration between universities and businesses (e.g. through start-ups, co-creation, spin-outs and IP) is vital. Policies which facilitate knowledge exchange should reflect the diverse nature of universities in the research base and the role of informal channels.

UK performance on absorptive capacity is mixed; though much of the picture is unclear because of a lack of available direct proxies (see 'research gaps' section below). There is

[1] This is underpinned both by processes within the firm as well as the human capital which is embodied in their employees through education, on the job training and learning by doing.

potentially room for **improvement (and indeed further research), on management practices, human resources, geographical distribution of absorptive capacity and small firms' apparent lack of the necessary precedents for developing it**.

Because of the path-dependent and firm-specific nature of absorptive capacity, government intervention should incentivise persistent, rather than one-off, investment and should ideally target firms that both lack absorptive capacity and are at a 'tipping point' in terms of growth. This ties in with a long-term approach to investment in the research base. However, identifying such firms is difficult.

The UK has often led thinking, but struggles in application

Looking at innovation incentives offered by the government to the research base and to firms (e.g. in the realms of tax and spend, procurement, push & pull policies, access to finance, regulation), it has often been the case that the UK government has been a leading thinker in many fields, and that overall evaluation of many policies displays good returns. However, the actual application of these ideas has sometimes been problematic, and the impact on innovation could and should be considered more when shaping new policies.

The private R&D element of the research base, as well as firms' absorptive capacity, is influenced strongly by incentives provided by government to conduct R&D. The options available to governments here are tax measures and direct spending.

- The OECD finds that in 2011 the **UK had roughly equal balance between direct (spend instruments) and indirect (tax instruments) funding for innovation**.[2] Over time, however, the relative emphasis of public support in the UK has shifted from direct spending to tax measures.

- **Evaluations of the actual growth and productivity outcomes of tax and spend instruments are limited**, although there is a range of evaluation evidence that points to positive impacts on the level of R&D activity. In terms of UK evidence, evaluations and research studies have shown evidence of output additionality (GVA) for direct support measures and input additionality (increased R&D spending) from tax credits.

With the UK government spending over £200bn on procurement every year, clearly the way in which **procurement** is conducted influences firms' behaviour and how innovatively they conduct themselves.

- Interviews with stakeholders revealed that the UK has been a **leader in thinking about innovation and procurement, but application of these ideas has been weaker**. In particular, there is often a tension between making short-term cost effective purchases and fostering innovative solutions that take time to pay-off. In general the former appears to win out over the latter – particular during periods of fiscal restraint.

- The UK's procurement system is much more aggregated than other countries', but individual **procurers still lack the incentives to consider the wider spillover benefits of procurement that foster innovation and operate within a risk-averse culture**. The fact that it is aggregated may disadvantage SMEs – but whether this is good or bad for innovation is unclear.

[2] However, it is worth noting that level of the Technology Strategy Board (TSB)'s funding, which is the main UK direct spending instrument, is currently less than half of the overall cost of UK tax credits.

Whilst many of the wider problems SMEs face in obtaining finance are outside of the scope of this paper, **there are strong theoretical reasons to expect that (small or large) innovative firms find it harder to obtain finance**. Empirical evidence is largely supportive of this proposition, **but it is less clear what effect this has on innovation and growth**. Two policy initiatives looking to address problems related to access to finance worth highlighting include:

- The Business Bank (and its role in adding new funding and streamlining programmes and management)

- Work by the IPO looking at the lack of use of intangible assets for debt finance. This is a major barrier to gaining external finance for innovative firms. The IPO's proposals are worth further consideration as potentially highly cost effective, structural interventions by government.

Finally, whilst the regulation policy agenda is focused on reducing regulation, and in many cases this may be beneficial for innovation, the evidence indicates that **the impact of regulation is not always negative.** Neglecting these considerations may lead regulators to favour regulations with lower static costs, but that are less likely to incentivise radical innovation. These findings should be considered in the context of regulatory policy.

The challenges for policy design across all forms of regulation are how to take more consideration of innovation, what being more 'open' to innovation would mean, and how to be more sensitive to the specifics of particular industries and technological developments.

An innovation system of interacting components

The **focus of recent innovation research has tended to be on the innovation system as a whole, and less on how its individual components interact.** In particular there is limited evidence on the differing impacts of particular interventions (e.g. R&D Tax credit, Grants) on different sectors or types of innovative activity and how these interventions interact with one another.

Overall, both in public policy discussions (as well as in academia) there appears to be **relatively little analysis as to how different fiscal policy instruments and spending policies relate to and complement each other**. Examples of the need to understand the interaction between innovation system components include:

- **How tax credits and direct spending interact, and what an optimal policy mix could represent**. Issues to consider here include the interplay between R&D policies and corporate tax rates; in the context of widespread tax planning by multinational companies and the simultaneous influence on R&D of many other factors, such as access to local markets.

- The **interaction between government procurement and firm's behaviour** (including their absorptive capacity), has not been sufficiently explored. The evidence that does exist suggests *how* government procures can impact on the level of innovation undertaken by firms.

- The **appropriate balance of demand (pull) and supply (push) policies for innovation and how this varies both across sectors and different stages of the development cycle**. There is little apparent evidence that policy design in the UK has taken this into account and Government could do more to take a holistic look at its

support in different sectors. However, this would require further concrete evidence on the innovation impacts of alternative policies.

- **The relationship between regulation and innovation is complex**. For example, some product market regulations can hinder innovation by imposing costs and restricting entry – but regulations can also incentivise innovation, by setting new standards, creating new markets and supporting consumer confidence. The right regulatory approach depends on the specifics, including industry context and stage of technological development.

How the state should shape and create markets

There are arguments that in the past governments have successfully acted as a "market shaper" and an essential risk-taker. This implies that when considering the role of the state we should go beyond traditional market failures perspectives to take a **wider, more activist view of Government's role** in leading the development of new technologies and addressing 'grand challenges'.

Many innovations will fail, and in practice this means taking a 'portfolio approach', recognising that failure is part of the process. The skewed nature of the returns to innovation means that government should maintain an appropriate appetite for risk as one 'big win' can more than outweigh the costs of other failures**.** It is worth investigating further whether current approaches are overly risk averse.

Whilst the state often takes a lead role in shaping and creating markets, and is pivotal to the generation of many crucial innovations that would otherwise not be undertaken by the private sector,[3] to date arguments around the state expanding its role in these areas have been based on case studies rather than detailed empirical evidence. As a result, these arguments would require further analysis in order to be regarded as robust.

Evidence gaps and lack of metrics

Many of the chapters find that quantitative evidence of how different components contribute to the innovation system (for example, absorptive capacity, regulation) is difficult to find, in part reflecting significant measurement difficulties. Examples include:

- On the **research base**, further research is required to determine what 'good' looks like, in terms of successful collaboration.

- Understanding the potential role for government intervention on **absorptive capacity** is likely to be complex, as it is not clear in some cases why firms may be unwilling to invest to develop their absorptive capacity. In addition, it is difficult to even find proxies and metrics with which to measure absorptive capacity.

- On **innovation diffusion** in general, there are gaps in the evidence base on the effectiveness of firm activities to draw on the research base, the usefulness of conferences and research publications and how the UK universities perform on consultancy activities. Furthermore, it is currently difficult to identify those firms that not only lack in absorptive capacity but may also be at a 'tipping point' in terms of growth (i.e. which are on the brink of expansion).

[3] This argument has more recently put forward forcefully by Mazzucato (2013).

- On **procurement**, key questions include:
    - Why DARPA in the US has been so successful in producing innovative products that have been commercialised. What barriers exist to replicate this success?
    - What challenges the NHS faces in procuring innovative products, given the nature of the market it operates in. Is there scope to learn lessons from procuring innovation in the private health sector?
    - How possible tensions when procuring between making efficiencies and encouraging innovation are being handled in government, perhaps by surveying government officials and firms, to assess whether this is an issue?
    - What data is needed to be able to undertake the impact evaluations of spend programmes that support procurement of innovation activity?
- On **access to finance**, it would be valuable to have a better understanding of the link between finance constrained firms, innovation and growth – distinct from the role of small and young firms in driving growth. Empirical studies could cover:
    - Impact on innovation growth: does access to finance lead to higher levels of innovation or growth? How do government backed schemes affect innovation and growth? How does this compare with the other sources of finance?[4]
    - Quality of Firm: What are the characteristics of innovative firms that struggle to obtain finance? Which firms have inherent weaknesses which inhibit ability to grow, whether they obtain access to additional finance or not?
    - Quality of Innovation: What is the 'value' of the innovation generated by firms that are finance constrained, using policy experimentation to see the effect of different interventions on firms' outcomes (e.g. employment and turnover).
- On the **balance between tax and spend**, further research is needed to identify the contribution of different levers to innovation outcomes and how they interact with each other. Nesta (2013) have suggested linking firm-level administrative data from R&D tax claims and direct government subsidies for R&D as a useful base for future research.
- What would be required to embed a more strategic approach to innovation across departments in terms of procurement, 'push and pull' policies, access to finance, etc.?

Policy experimentation

Finally, a broad lesson that can be drawn (and one that we have also heard from academics we have spoken to as part of this project)**, is that more policy experimentation is needed** to examine what policies do, and do not work**. Greater investment in evaluating policy over longer time horizons would also be useful**.

Three particular areas where policy experimentation may be beneficial include: **tax and spend**, **procurement** and **push and pull instruments**. This is because they often involve large enough sums of money to conduct meaningful experiments and because further evidence will only become available with further experimentation.

[4] One important aspect outside of this paper's scope is how financial regulation and corporate governance structures' short-termist nature negatively impact on innovation finance. This is covered by the recent LSE Growth Commission.

Chapter 1: The Spread of Knowledge – The Research Base

Summary

- **The Research Base comprises Higher Education Institution, Government, Business and Private Non-Profit Organisations.**
- **Whilst the UK has a relatively low R&D intensity in terms of expenditure, it punches above its weight in terms of measured research outputs.**
- **Knowledge can be diffused in many ways – through publications and citations, human capital (education), business interaction (IP, spinouts, etc.) or other channels.**
  - **There is evidence of good academic-corporate knowledge flows through** publications and citations**. The impact of Open Access, for which a cost-benefit analysis framework is currently being developed, should continue to be evaluated within feasibility constraints.**
  - **The UK has relatively large** researcher and graduate populations**, who have a significant impact on growth, productivity and innovation.**
  - **The UK is relatively strong at focusing on** start-ups and spin-outs**, but relatively weak at income generation from** IP**. Significant barriers to** business-academic collaboration **remain, which publications such as the recent Witty Review attempt to address. Policy should place an emphasis on the** benefits beyond immediate financial returns**, given that investments can take a long time to see a positive return.**
  - **Because of the diversity in the** nature of the universities' knowledge bases **(e.g. research-intensive universities tend to have more IP-related income generation, teaching-oriented universities have more direct commercial interaction with firms), policies need to be more flexible in order to help develop a variety of approaches to knowledge exchange .**
  - **A lot of knowledge exchange occurs via** informal channels**. These are not as easily quantifiable as commercialisation, but often equally important.**

Introduction

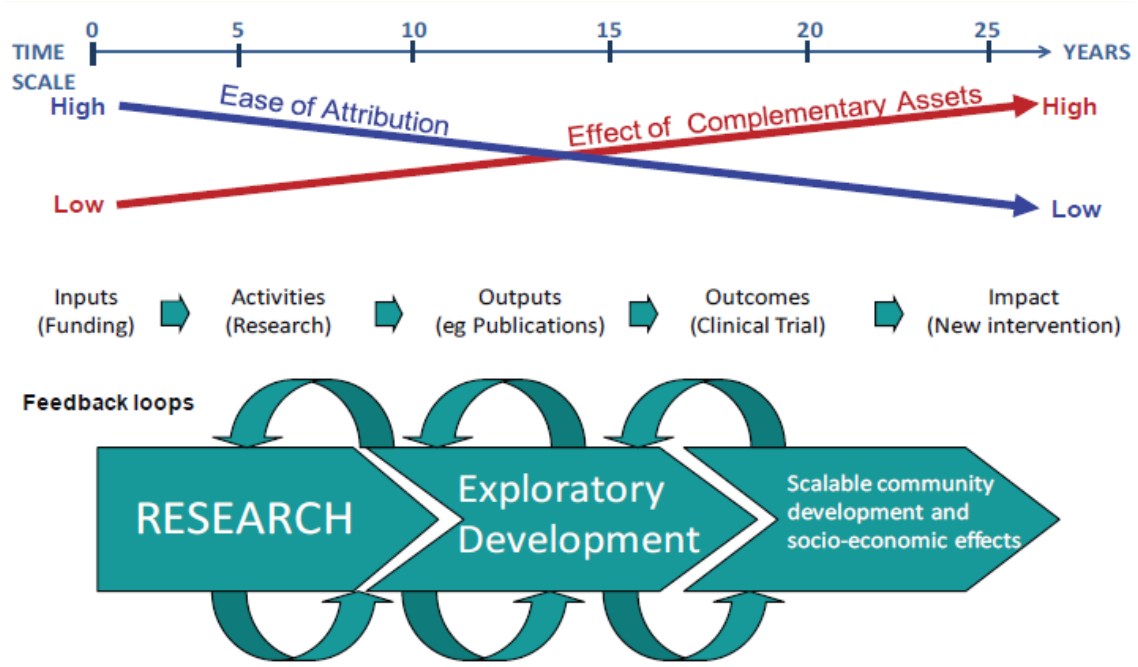
The OECD 'Frascati manual' (OECD 2002) defines R&D as comprising 'creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.' R&D performers include Higher Education Institutions, but also Government, Business and Private Non-Profit Organisations.

Innovative knowledge takes many forms (e.g. direct R&D, informal processes of learning). Various organisations integrate these different forms of knowledge to create new products, processes and systems, which can lead to economic growth.

As Figure 2 below illustrates, there are numerous ways in which research leads to impact, and as time progresses, it is diffused more widely.

Traditionally this is conceptualised as research leading to the creation of new knowledge along with the embodiment of this knowledge into researchers in the form of human capital. This is then transferred to other researchers, students, firms and other organisations through a variety of formal and informal channels. The application of this knowledge by these 'users' then ultimately leads to an economic impact.

Figure 2: Ways in which research leads to impact



Source: Hughes, 2012

This chapter discusses the major knowledge exchange channels from the research base. As is moves through them, there is a shift from more traditional to more complex channels of interaction, and it is the latter which has received increasing focus in innovation literature within the last decade or so. For each channel we discuss the economic importance and evidence of use within the UK. This chapter concludes with a section focused on policy recommendations and potential further work.

Rationale for Intervention

The rationale for government intervention in innovation stems from the need to provide a socially optimal amount of research funding and knowledge diffusion.

- **Socially optimal research funding:** Research is a public good with positive externalities / spillovers that contribute to national innovative capabilities. Organisations are unable to capture the full benefits of their investment into research, so it is under-provided by the market. In order to correct for this problem, the government can either engage directly in knowledge production or offer subsidies to universities/institutes/firms engaging in research (IPO, 2010). Governments can also correct for market failures preventing innovative projects

(such as risk aversion, informational asymmetry, coordination failures, natural monopolies, the 'Valley of Death', etc.) (Nesta 2012).

- **Greater diffusion of knowledge:** The government can help reduce barriers to successful collaboration between the research base and businesses (and between businesses themselves), ultimately increasing the impact of research. Barriers include informational failures, coordination failures, lack of understanding around IP ownership and other inherent risks associated with collaborative activities (e.g. project drift, asymmetrical motivation, reduced flexibility, etc.) (Nesta 2012).

Knowledge Creation: Research output

The main purpose of the research base is the production of knowledge (through the research process). The academic literature on economic growth (such as Solow (1957)) has long considered technological improvements, through increases in productivity, as the key long-term driver of economic growth. As the generator of the knowledge necessary for technological change, a highly-performing UK Research Base is essential to improving the UK's long-term growth prospects.

UK Evidence

The UK has a relatively low R&D intensity in terms of expenditure. It spent 1.77% of GDP on R&D in 2011 (5th in the G8, 12th in the EU, 19th in the OECD). As the main source for the UK's comparative performance of the Research Base, BIS (2013e), notes, whilst the UK Research Base uses its funding efficiently, **it is unclear whether its good performance can be sustained with relatively low levels of R&D intensity.**

Funding for R&D in the UK mainly comes from Business Enterprise (44%), although this is a lower share than most countries (G8 average: 60.7%; EU average: 53.2%).

Conversely, 18% of UK R&D funding comes from abroad and 5% from the private non-profit sector, which is far higher than other countries. Together, they account for 23% of GERD, against a 5% G8 average, and an 11% EU average.

In terms of *performers* of R&D, the Business Enterprise sector also takes up a lower *relative* proportion (although it accounts for 61.5% of the total), but the UK's Higher Education sector's proportion is significantly larger than in other countries (27%, against the G8's 17% and the EU's 24%). This reflects the **importance of the UK's Higher Education sector in its Science and Research ecosystem**.

Science infrastructure is a key strength of the UK innovation system (BIS 2011b). While the volume of UK articles is growing at a slower rate than the global average, the UK punches above its weight in measured research outputs (BIS 2013e). It produces 6.4% of the world's scientific papers, accounting for 11.6% of global citations (an indicator of quality and impact), and 15% of the top 1% most cited scientific publications (second only to the US).

On the basis of Field-Weighted Citation Impact (citation per paper, adjusted for subject-specific biases) the UK scores 1.61 (i.e. the average UK article gets 61% more citations than world average).This implies that UK produces better quality research than average (and is the highest-performing G8 member). (BIS 2013e).

UK researchers also generate more articles and citations per researcher per unit of public R&D spend than other major countries, including Canada, China, France, Germany, Italy,

Japan and the US (BIS 2013e). However, this compares outputs with expenditure in simultaneous years, when in reality it takes many years for R&D expenditure to translate into publications and citations. There is limited evidence on average time lags (which would inevitably vary by subject area and type of publication), which means realistic comparisons are not at present possible.

UK researchers are highly internationally collaborative, with 48% of UK academic publications in 2012 co-authored with a foreign institution-affiliated academic – second only to France among comparable research-intensive nations. The UK also has a highly mobile researcher population. 72% of researchers who are or have been affiliated with UK institutions have published articles whilst working at non-UK institutions (BIS 2013e) between 1996 and 2012.

Collaborations with non-UK researchers tend to produce a greater number of citations, irrespective of where the UK author resided. Internationally mobile UK researchers are significantly more productive than their non-mobile counterparts. The correlation between international mobility & collaboration, and research performance (most recently documented by the OECD (2013)), suggests that they are key factors underpinning the successful UK research performance.

Knowledge Diffusion: Publications and citations

Whilst publications and citations are commonly used as a metric for research performance, they are primarily a method of knowledge diffusion within the academic sector and beyond. Citations measure quality and impact, indicating high usage. Measures of co-publications between the academic and corporate sectors, as well as cross-sector citation patterns, may indicate knowledge exchange. Article downloads, whilst harder to interpret than citations, may indicate the extent of article usage.

Digitalisation of publications, combined with the spread of the internet, has allowed academic publications to become largely non-rival goods. This has enabled the recent rise in Open Access, which is the ability to download, read and print electronically published refereed journal articles (BIS 2013c). By making academic publications more freely accessible, Open Access has the potential to increase the impact of research on technological change, productivity, and consequently growth.

UK Evidence

With 0.8% of all publications, academic/corporate co-authorship is relatively low in the UK, compared to other research nations (3.8% for Japan and 2.6% for the US). However, given the high correlation between share of corporate / non-corporate co-authorship and patenting, this may be partly explained by the industrial structure of the UK not lending itself as well as others to patenting. Although the UK's share of patents granted (in WIPO) in 2011 was only 1.8%, its share of patent citations was 10.9%, which suggests that UK research is highly used in patented innovation worldwide.

62% of downloads of corporate-authored publications were by academic users. 53% of downloads by corporate users were of university-authored articles (BIS, 2013e). This suggests large academic-corporate knowledge flows.

Data on UK uptake of Open Access (the free provision of published research) is not available, but a recent study estimated that Europe was ahead of other continents in terms of Open Access coverage (Laakso *et al.*, 2012). Open Access was estimated to cover 10% of global 2010 publications, growing at 20% a year (Laakso *et al.*, 2011). Open Access

comes in many forms (depending on embargo periods and source of funding), but there is no cost-benefit estimate of Open Access. BIS have commissioned a feasibility study, but it evaluating the impact of Open Access is extremely difficult (BIS, 2013c).

Knowledge Diffusion: Human Capital

One way in which universities transfer knowledge to firms is through training and increasing peoples' skills. A more skilled workforce should lead to greater productivity and innovativeness within firms, and increase their capacity to absorb academic knowledge (IPO, 2010). Understanding how the economy absorbs this knowledge via graduates is crucial. The wider economic benefits are expected to extend beyond graduates' individual gains (e.g. higher incomes). However, a large graduate workforce by itself is not a sign of a strong research base if graduates fail to find employment within their field of specialisation or their skills are being underutilised.

STEM (science, technology, engineering and maths) graduates are of particularly high importance to economic output and innovation (House of Lords 2012). Furthermore, STEM graduates' higher wage premiums than many other subject graduates are evidence of their value to firms and public institutions (BIS 2013b).

UK Evidence

The UK has the 4th largest Research Base in the OECD in terms of researcher population, and the 2nd largest in the EU. After a period of high growth between 2000 and 2005 (46% over the period), researcher numbers have grown by only 0.9% annually. This is below the 2.9% growth rate within the G8, but higher than the OECD and EU averages. Between 2007 and 2011, PhD numbers increased at a pace of 3.4% a year, which is slightly lower than the OECD and G8 averages (4.5% and 5%, respectively), but higher than the EU. (BIS, 2013e).

Researcher affiliation data in publications showed that between 1996 and 2012, over 10,200 researchers moved from the academic to the corporate sector. Over that period over 8,700 researchers moved in the other direction (BIS, 2013e).

BIS Research Paper 110 (BIS 2013a) found that a 1% increase in the share of the country's workforce with a university degree will lead to a 0.2-0.5% increase in long-term productivity. This implies that the increasing proportion of the UK workforce with a university degree has accounted for around one third of labour productivity growth recorded in the period 1994-2005.

Employed people are more likely to have a STEM degree than the overall population or the graduate population. According to the Labour Force Survey, 11% of the working age population in total has a STEM degree, but 14% of employed people do.

The UK Community Innovation Survey (BIS, 2009) found that businesses that are considered to be "innovation active"[5] have more than double the share of employees with degrees than businesses that do not innovate.

[5] Innovation-active firms are businesses that have either a) introduced a new or significantly improved product (good or service) or process for making or supplying them, b) engaged in innovation projects not yet complete, or abandoned, or c) spent on areas such as internal R & D, training, acquisition of external knowledge or machinery and equipment linked to innovation activities.

Knowledge Diffusion: Business Interaction

The direct effects of knowledge discoveries can be formalised and commercialised through so-called 'third mission' activities such as knowledge transfer (in the form of intellectual property/licensing sale), via the creation of spin-out companies, through providing problem-solving services (e.g. consultancy) or through co-creation.

Spin-outs are seen to align with a number of broader university aims, such as "enhancing the HEI's enterprise agenda, making a local economic contribution, and laying the potential for long term relationships with research-focussed firms" (Minshall and Wicksteed 2005). Spin-outs are costly to universities and financial gains often accrue over a longer time horizon. They often provide significant positive spillover effects to the regional and national economies.

The research base produces **intellectual property (IP),** transferrable to external stakeholders in many ways. Soft forms of IP include copyright, open source and trademarks. Hard IP includes the use of patents. IP rights provide incentives to productively utilise invention resources and disclose ideas, incentivise markets for information and technology and provide institutional support on codifying and enforcing rules (IPO, 2010).

Formal IP protection, particularly through patents, copyright and trademarks, is required for certain types of knowledge to be exploited effectively. However, applying IP rights too early can stifle knowledge creation and innovation as it prevents an optimal number of R&D performers from exploiting and developing knowledge (Aghion et al, 2005). Furthermore, some types of knowledge are not amenable to IP protection (e.g. immaterial innovations), and in many cases the IP application process can be more costly than the benefits.

The research base also acts as a 'problem solver' for the corporate sector through the provision of **consultancy services**. Consultancy services allow firms to access new university-generated skills and processes and target them at specific business problems (Russell Group, 2010). Consulting benefits universities through income generation and the strengthening of links with the business community.

In the past decade or so there has been a growing literature on **co-creation,** where parties collaborate to 'tackle market challenges and capitalise on opportunities […] since there are synergies between businesses accessing university knowledge and co-creating knowledge with universities' (Big Innovation Centre, 2013a). Previously seen primarily as a source of knowledge, universities are now considered a key partner expected to participate in the exchange of knowledge and resources between firms and government agencies. However, 'successful and mutually beneficial co-creation activities require a complex co-incidence of wants on the part of both the business and the university' (Big Innovation Centre, 2013a).

Moreover, the global setting for research and innovation is being recast as an increasingly multi-polar scientific world. A recent article in Nature (Adams, 2012) points towards the rapid rise of co-authorship, both within countries and between countries. There is a growing importance of **open innovation,** which concerns the increasing potential of firms to innovate and co-create when they are opened up to new ways of working with external partners. A source of sustained competitive advantage for advanced economies such as the UK is the presence of active networks that facilitate and sustain knowledge flows.

A BIS 'Big Science' impact report (BIS, 2013d) found that large scale facilities had an impact on innovation through both their research and construction. They frequently require such cutting-edge equipment that significant supplier innovations are required. These feed into other markets, with wider economic benefits.

UK Evidence

Knowledge Diffusion through IP:

A recent IPO report (IPO, 2010) makes several conclusions on the diffusion of knowledge from the research base to the wider economy via IP. It argues that only those universities which produce sufficient patentable research outcomes can justify the costs involved with creating an external commercialisation company. Open source is relatively more prevalent for smaller institutions.

In general, research-intensive universities produce a wider variety of IP, while teaching-focused universities produce less output but seek greater commercial interactions. The biggest obstacles facing the flow of knowledge were found to be transparency, contract negotiation and locating IP users.

With respect to transparency, the main obstacles facing universities are inherent difficulties in assessing whether IP is original, a lack of clarity with respect to the IP documentation, and most importantly, difficulties in determining the economic value of IP. With respect to contract negotiation, the major obstacles identified are associated with the difficulties in negotiating both the price and the terms of the IP.

Knowledge Diffusion through Spin-outs:

Around two-thirds of businesses which interact with university spin-out companies found the process to work well (Big Innovation Centre 2013a). In 2009-2010 the UK produced 273 spin-out companies, but it is very difficult to calculate the value of these firms or their contribution to GDP (BIS 2011b). Furthermore, due to international differences in tracking, regulation and reporting, it is difficult to compare the UK's performance with other countries.

Limited research by Knowledge Transfer Organisations (KTOs) finds that countries such as China and Japan focus almost entirely on start-ups and spin-offs, with very little income generated from IP sale. The US produces a significant amount of IP income. The UK is somewhere in the middle, albeit with a strong focus on start-ups and spin-outs over IP generated income (BIS 2011a).

A recent AIM/EPSRC study showed that a key priority for both large and small companies in the UK was access to the **problem-solving capability** of expert academic research (Russell Group 2010). Relative to spin-offs, UK academics show a much greater predilection to involvement in problem-solving activities such as consultancy, but also prototyping and testing, contract research and informal advice (BIS 2011b). Unfortunately, there is little evidence in the literature of international comparisons with respect to consultancy activities by universities.

The Big Innovation Centre (BIC) notes that, on the whole, relationships which require some degree of **co-creation** rather than basic knowledge access by firms are more difficult and prone to failure, given their relative nascence and complexity. Firms engaged in direct knowledge access from universities are successful in achieving their strategic objectives (between 60-80% success rate), while those firms engaged in more complex

co-creation with universities find a much lower success rate (30-50%) (Big Innovation Centre 2013a).

A number of key barriers to successful university-business collaboration were originally identified by the Lambert review in 2003. These included confusion over IP ownership within research collaboration (leading to costly and protracted contract negotiations deterring many smaller companies), some universities exaggerating the value of their IP and the variable quality of university technology transfer offices (TTOs) (IPO 2013). Whilst the 'Lambert toolkit' was designed to address these obstacles, only 10% of all firms used it. BIC (2013a) recommends efforts to make it more widely used, as well as refinement to take account of more complex co-creation activities developed since the toolkit's original implementation.

The BIC paper also highlights a number of other barriers to business-university collaboration, including SMEs focusing on short-term goals and universities on long-term goals, universities' lack of strategy over IP and bureaucratic processes within universities. According to BIS (2011b), there are continuing concerns over coordination between business, government and organisations in the wider knowledge infrastructure. The Wilson Review points towards weaknesses within the supply chain between universities and businesses (Wilson 2012), which are largely attributed to university structure and management, as opposed to academics' lack of entrepreneurialism.

According to the World Economic Forum's (WEF) Competitiveness Report (2013), the UK is fifth in the world for university-industry collaboration. This is based on the subjective opinions expressed in the WEF Executive Opinion Survey, however.

In her review of the UK science and innovation system, Allas (2013) noted that while the UK scores well on collaboration in the WEF rankings, its performance on other indicators such as SME collaboration with Higher Education institutions is only average, and the number of Academic / corporate co-authored publications is well below key competitors.[6]

Various schemes have been set up by the UK government to help boost collaboration between the research base and the corporate sector. The Knowledge Transfer Partnership (KTP) programme helps promote knowledge transfer and the spread of skills to firms, enhance the skills of recent graduates, and improve business research, as well as provide the supporting infrastructure.

The KTP programme is judged to have been broadly successful, generating significant additional sales, GVA and jobs. It has also helped provide academics greater insight into the corporate world and opportunities to develop new research themes (Nesta 2012).

The Witty Review (2013) recommended that Local Enterprise Partnerships (LEPs) direct more European Structural and Investment funds towards universities and research centres for innovation funding. This would include universities supporting local innovative SMEs, and LEPs facilitating university collaborations.

Knowledge Diffusion: Other channels

Whilst considering formal indicators, it should not be forgotten that a large but frequently unquantifiable amount of knowledge exchange occurs through informal contacts and discussions between academics and external organisations. Many forms of knowledge cannot easily be commercialised and research does not only have impact through

[6] BIS (2013e) Insights from international benchmarking of the UK science and innovation system, Annexe.

commercialisation. Many key benefits of research are non-monetary (e.g. health and environment improvements).

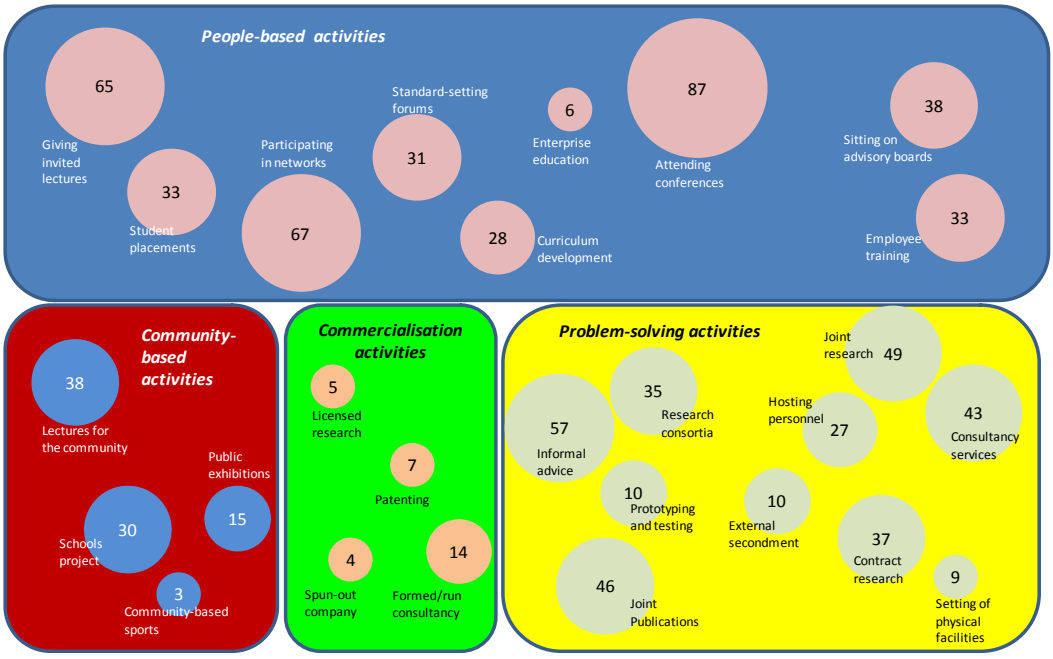
UK Evidence

Hughes and Kitson (2012) find that **commercialisation activities actually only constitute a small part of pathways to impact by academics**. A large scale survey of UK academics conducted by the authors found that other activities grouped in categories of 'Community-based', 'Problem-solving' and 'People-based' (in increasing order of importance) were reportedly much more prevalent forms of impact for UK academics (see Figure 3).

This does not inform us as to the relative value of these different forms of impact to the economy, but illustrates the breadth and complexity of academic interaction with the private sector and wider society.

The same survey of UK academics found that only 24% of activities with external organisations were initiated through the university Knowledge Transfer Office (KTO) or another university administrative office. Instead, other forms of contact were far more prevalent (over 60% of academics), notably mutual actions following either formal contact (such as at a conference or meeting) (62%) or informal contacts (69%). In addition, 36% of academics reported they had no contact with their KTO, and another 21% were not aware of these services.

Figure 3: Pathways to impact



Source: Hughes and Kitson (2012)

Conclusions and areas for further work

UK expenditure on R&D is relatively low compared to other major research nations, and declining as a share of GDP. Combined with a low growth in researchers, it is unclear whether it can maintain its strong research standing, particularly given the increase in expenditure in other countries, most notably in emerging economies.

However, within this trend there are a number of conclusions to keep in mind in the context of UK policy:

- Whilst the UK, by and large, has a Research Base which performs well and uses its funding efficiently, it is unclear whether its good performance can be sustained with relatively low levels of R&D intensity.

- The Research Base has various channels of impact beyond immediate financial returns, including publications & citations, human capital and informal routes. This should be kept in mind when evaluating its impact. Even when focussing purely on business interaction (e.g. spinouts), there should be an emphasis on long-term benefits, because investments can take a long time to see a positive return (Minshell and Wicksteed, 2005).

- IPO (2010) notes that because of the diversity in the nature of the universities' knowledge bases and the variety of ways of transferring knowledge, policies need to be more flexible in order to help develop a variety of approaches to knowledge exchange (e.g. research-intensive universities produce a large variety of research output and therefore various kinds of intellectual property, while teaching-oriented universities tend to produce less output from basic research but have a larger variety of commercial interactions with industry).

- The Witty Review (2013) recommended that the government put in place several measures to help universities facilitate economic growth, of which several are also relevant to innovation. It suggested a £1bn funding stream for 'Arrow' projects that would support the research base in funding projects that feed into growth. It encouraged universities to make 'facilitating economic growth' a core strategic goal. It recommended the further development of indicators, e.g. citation-based measures of research strength by sector. And it called on the Government to make a long-term commitment to the Higher Education Innovation Fund, increasing it to £250m a year and thus incentivising universities to engage with innovative SMEs.

- To help promote increased co-creation between universities and businesses, BIC (2013b) highlights a number of recommendations for policy makers. These include maintaining funding for programmes such as Catapult Centres, expanding funding for university-business placements, expanding research into IP protection strategies for university-business relationships and developing new platforms to help bring businesses and academics together.

There are clear knowledge gaps in how successfully companies draw on the global research community to source knowledge, how useful conferences and publications in diffusing knowledge to companies, and international comparisons of university consultancy activities – more scoping could be conducted to see if research in these areas is possible. In addition, **understanding the link between research inputs and outputs (pathways to impact) is an on-going challenge which further research may tackle**. Whilst the UK performs well on publications and citations, how this specifically translates into innovation and growth is not entirely clear.

A further key challenge for the government is to strengthen the sharing and dissemination of knowledge, support a coherent and integrated knowledge infrastructure, encourage business investment in all forms of innovation, and improve the innovative capacity of the public sector.

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Chapter 2: The Capability of Firms

Summary

- **Absorptive capacity is firms' ability to recognise the value of new information, assimilate it and apply it for commercial purposes, and is key to driving innovation. Understanding the potential role for policy intervention is complex and intervention needs clear market failure rationale.**

- **It is both** path-dependent **and** firm-specific**, so any intervention should:**
  - **Incentivise** persistent investment in absorptive capacity**, e.g. support for R&D should encourage investment over time rather than focussing on a single year's R&D expenditure.**
  - **Identify those firms that not only lack absorptive capacity but also** may be at a 'tipping point' in terms of growth**. Evidence to be able to do this is currently lacking, so the feasibility of additional research into how to segment firms in this way should be explored.**

- **Human capital is an important precedent for successful absorptive capacity:**
  - **Overall, the evidence suggests that the UK's education base provides a relatively strong foundation for the development of absorptive capacity.**
  - **Whilst there is a need for a diversity of skills, research suggests that policies that support the development of skills and qualification in** science, technology, engineering and maths **may be particularly important for innovation.**

- **By several absorptive capacity measures, the UK performance is unclear or poor:**
  - **Small firms often lack some of the necessary precedents for successful development of absorptive capacity.**
  - **The role of management practices is key; a better understanding of the** role of government in embedding 'good' management practices **in UK firms is required.**

- **While there are some small regional differences, in general there is not a particular class of firms in high-tech, science-intensive sectors concentrated in particular geographic settings consistently driving innovation in the economy. In other words,** high innovation firms are found throughout the country.

Introduction

Absorptive capacity has been identified as a key issue in determining a firm's success in driving innovation. It is defined as 'the ability of a firm to recognize the value of new, external information, assimilate it and apply it to commercial ends' (Cohen and Levinthal, 1990) and places an emphasis on the role of organisational practices that enable the effective transfer of knowledge and the creation and implementation of new ideas.

A firm's absorptive capacity is therefore more than the sum of the individual employees' absorptive capacity: external and internal networks, communication processes and the character and distribution of expertise within the organisation can all influence a firm's ability to innovate.

Since the concept was introduced, there have been numerous papers exploring the necessary precedents for successful absorptive capacity at the firm level, most notably Zahra and George (2002), which distinguished between:

- **Potential absorptive capacity** – the acquisition and assimilation of knowledge. Potential absorptive capacity depends on the availability of relevant knowledge sources and the type of cooperation partners that a firm can access.

- **Realised absorptive** capacity – the transformation and exploitation of knowledge. Realised absorptive capacity depends on the extent to which firms can appropriate the benefits of technological advances.

To be successful, firms need to have capability in both potential and realised absorptive capacity. Absorptive capacity has also been explored in the context of regional policy. In Nesta's recent regional analysis (Nesta 2008), its 'AC/DC' model made a similar distinction, identifying:

- **Innovation absorptive capacity (AC)** – the ability to draw in good ideas. This depends on a region's capacity to access networks of knowledge and innovation, to anchor external knowledge from people, institutions and firms to a specific region, and to diffuse new innovation and knowledge into the wider economy

- **Innovation development capacity (DC**) – the ability to use the ideas to create products and services that can be commercially successful.

There may be factors beyond the capability of individual firms that influence a region's ability to draw in and use ideas, for example better transport or communications networks that make access to relevant national and international sources of knowledge easier.

Key factors for policy

A number of key issues that may be relevant to policy emerge from the literature on absorptive capacity.

Absorptive capacity is cumulative and path dependent, therefore prior knowledge determines current absorptive capacity. This stems from the fact that when a firm has relevant expertise, it is better able to evaluate the importance of external, intermediate technological advances and more accurately predict the commercial potential.

This path-dependency gives rise to the potential for absorptive capacity 'lock out' as if a firm does not invest in absorptive capacity it may not appreciate new opportunities because it will not be aware of relevant external information. Since low investment in absorptive capacity makes investing in subsequent periods less attractive, lack of investment can be entirely rational. Thus path-dependency can set up patterns of vicious or virtuous circles of innovation effort (Cohen and Levinthal, 1990).

Absorptive capacity is idiosyncratic and highly firm specific (Jansen et al., 2005). It is difficult to 'buy-in' absorptive capacity because knowledge needs to be integrated into the firm-specific environment. To develop absorptive capacity, it is insufficient merely to

expose an individual briefly to the relevant prior knowledge. Instead the intensity and persistence of knowledge exposure are important. Diversity of knowledge in an organisation also plays a key role (Cohen and Levinthal, 1990).

Potential absorptive capacity does not create value, it is the realised absorptive capacity that does so therefore firms need to develop their capacity in both areas concurrently (Nesta, 2008).

Whilst absorptive capacity may be lacking in some firms, a clear case for intervention needs to be made in terms of market failure. For example, some firms may lack the internal expertise to implement new organisational practices that could improve their absorptive capacity. However, if a firm has identified and understood that it has a problem in this area; it is not clear why it would not be prepared to pay the market rate for that advice and therefore why government intervention would be necessary (Bessant et al., 2005).

For example, if barriers to investing in absorptive capacity are limited, then differences between firms may be an efficient outcome: those firms who are less effective in drawing in and exploiting knowledge are more likely to fail, potentially freeing up resources to be reallocated more effectively.

Bessant et al (2005) provide a framework for identifying when firms might need support to develop different forms of absorptive capacity as they grow. Rather than focussing on firms by size or sector, they identify **key 'tipping points' that all firms are likely to experience as they grow**. These tipping points may occur in a number of areas:

- **People management**: when the firm moves from a founding owner or partners to an employment situation where tasks are delegated and people need to be managed. HR issues associated with this include delegation, leadership, recruitment, training, compensation etc. This tipping point may reoccur as the firm grows e.g. as it operates from multiple locations.

- **Strategy:** moving from an opportunistic approach of accepting whatever work is available to a focussed strategy of focussing on certain types of work or clients, requiring a brand and market position. This tipping point may be repeated when new products, markets, competition or business models arise.

- **Formalised systems**: moving from an informal approach to acquiring customers, storing information etc. to formalised business systems that ensure consistency and accuracy

- **New market entry:** involving new customers, new areas or new products. This includes adapting or replicating the existing business model, scaling up the business and understanding new customer needs. This tipping point is repeated at each expansion event.

- **Obtaining finance:** e.g. moving from reliance on initial funders to outside finance providers. This point is repeated at each significant growth spurt.

- **Operational improvement:** moving to an understanding of process capabilities and best practices.

The framework also considers four levels of absorptive capacity that a firm might have at any point in time:

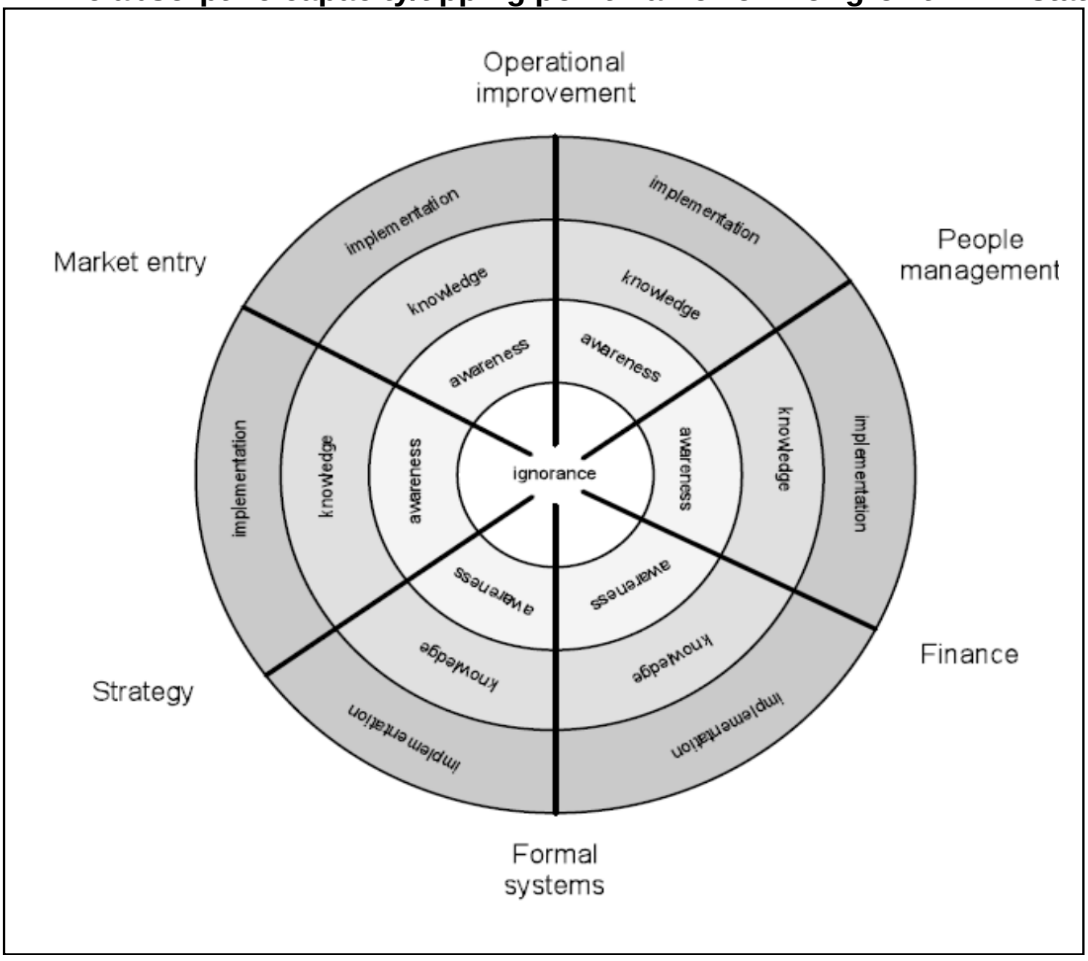
- Ignorance of key issues
- Awareness of key issues
- Knowledge and understanding of key issues
- Implementation of actions to address key issues

The combination of where a firm is in terms of both tipping points and absorptive capacity can then be mapped on to the framework shown in Figure 4 to prioritise where intervention might be necessary.

The framework highlights the fact that there may be some firms for whom intervention is ineffective, for example some firms may have no aspiration to grow. Even where the framework identifies the potential for investment in absorptive capacity, the case for government intervention would need to be made.

For example, for a firm needing to implement new HR practices, the use of a seconded expert might be appropriate but if the firm had identified and understood the need for greater expertise, it is not clear what the market failure is that would prevent a firm investing itself.

Figure 4: The absorptive capacity/tipping point framework for growth firm states



Source: Bessant et al. (2005)

How can we measure absorptive capacity?

Although there is no direct measure of absorptive capacity, numerous proxies have been used to try to capture the effect. These are summarised in Table 1, below.

Table 1: Key drivers influencing firms' absorptive capacity

Driver	Impact on absorptive capacity	Possible metrics
R&D	Firms ability to exploit external knowledge is often a by-product of R&D, therefore R&D not only increases knowledge but also increases the ability to exploit external knowledge	• R&D/sales • % employees engaged in R&D • R&D investment over time • No of patents
Training/skills	Human capital is key to absorptive capacity. Firms need a diversity of skills e.g. scientific/technical skills to absorb external knowledge, process/production/design skills to create firm-specific innovation	• % employees with science/STEM degrees • % employees engaged in R&D over time • % in employment with NVQ level 4 or above • Expenditure on training for innovation
Management practices	Effective management practices enable better transmission of knowledge into and within the organisation	• Use of practices such as job rotation, quality circles, KPIs, targets • Employee participation in decision-making • Use of performance related pay, talent management
Access to external networks	External networks (e.g. universities, customers, suppliers, international links) are key to knowledge acquisition and assimilation	• % of businesses with cooperation agreements • Density of international firms • Rate of FDI investment project successes • Advanced Producer Services Network Connectivity • International co-authorship of research papers • International co-patenting • Industry-financed public R&D
Knowledge exploitation skills	Firms with good knowledge exploitation skills can appropriate the benefits of technological advances and transform/exploit knowledge	• Number of innovation active enterprises • Process/product innovation new to industry or market • Scale of early stage private investment (e.g. VC) • Export of knowledge services

Taking each of these in turn:

Research and Development

Research and development directly increases a firm's knowledge base but may also increase absorptive capacity in an indirect way since a firm's ability to exploit external knowledge is often a by-product of R&D (Cohen and Levinthal, 1990). For example, employees directly involved in R&D are more likely to be aware of external technological developments and to be able to communicate the commercial potential to in-house colleagues.

R&D intensity (i.e. R&D/sales) or the number of patents has been used as a measure but given the path-dependency of absorptive capacity, R&D persistence or the share of employees involved in R&D may be more appropriate (Schmidt, 2005; Bishop et al., 2010).

Training/skills:

Human capital is a necessary precedent for absorptive capacity and diversity of skills is important. For example, scientific and technical skills may be needed to absorb external knowledge whereas process, production and design skills may be required to create firm-specific innovations.

In a German-based study, Schmidt (2005) found that the required skills profiles varied by the type of innovation: e.g. employing staff with science degrees significantly increased the probability of introducing goods product or service product innovation. Conversely, increasing the share of employees with degrees in non-science was associated with a positive increase in service product but not goods product or process innovation.

Recent research for BIS supports the finding that STEM (science, technology, engineering and mathematics) graduates have an important role on firms' introduction of innovative goods and services and shows that they have an impact across a range of sectors, not just traditional science-based areas (BIS, 2013).

Common metrics used in this area include the percentage of employees with science degrees, the percentage of employees engaged in R&D over time and the percentage in employment with NVQ Level 4 or above.

Management practices:

Effective management practices enable better transmission of knowledge both into and within the organisation and have been shown to be associated with higher levels of innovation activity (Schmidt, 2005; Abreu et al., 2008), although it is difficult to ascertain which specific practices are most important and what the barriers to their introduction are.

Studies that have examined the effect of management practices generally rely on survey data that has tried to capture the effects through questions around practices such as job rotation, quality circles, performance related pay, participation in decision-making etc.

Access to external networks:

External networks, be they with customers, suppliers or other businesses, and universities can be key to knowledge acquisition and assimilation. In a study based on a European multi-unit finance company, Jansen found that 'connectedness' (i.e. the density of linkages with both external organisations and within individual units) had a strong positive effect on potential absorptive capacity, especially the assimilation of external knowledge.

The geographical nature of these links can also be relevant: in terms of UK regional absorptive capacity, national and overseas collaboration was found to be significantly associated with good products innovation whereas for service innovation only national collaborations were important (Abreu et al., 2008).

Likewise, the importance of geographical proximity to universities depends on the nature of the collaboration: proximity has been found to be important for firms needing direct assistance in problem solving but for other benefits such as accessing new ideas it is not important for firms to be close to the relevant university (Bishop et al., 2010).

Knowledge exploitation:

Knowledge exploitation can be captured by surveys measuring the number of innovation-active enterprises, the number of new product, process or service innovations, the scale of early stage private investment (venture capital), the export of knowledge services etc.

Evidence for UK effectiveness

International evidence on absorptive capacity[7]

In terms of **human capital**, the UK has a relatively high proportion of the adult population in tertiary education, especially compared to the EU-27 average.[8] The UK also has a higher doctoral graduation rate in science and engineering.[9] However, in spite of this, science and technology jobs are generally not as pervasive in the UK as many other countries (UK index figure of 85 compared to OECD average of 100; EU-27 index of 102).[10]

In relation to **management practices**, Van Reenen's work (e.g. Bloom and Van Reenen, 2010) provides an international comparison of management practices and the link to firm productivity. Using firm-level surveys, the research measures management practices in three different areas:

- **Monitoring:** how well companies monitor what goes on inside their firms and use the information for continuous improvement
- **Targets:** whether firms set the right targets and track the right outcomes and take appropriate action if the two are inconsistent
- **Incentives:** whether companies are promoting and rewarding employees based on performance as well as hire and keep their best employees.

In general, firms that monitor their entire production process in order to collect, process and exploit information, use tough short and long-term targets and use effective rewards and incentives such as bonuses and promotions for high-performers and training for low-performers, outperform other firms. This is across a wide range of outcomes i.e. they are larger, more productive, grow faster and have higher survival rates.

Management practices vary extensively across countries. Great Britain is 'middle of the pack' in terms of its overall management score (see Figure 5 below) and performs better in management practices around monitoring than in targets and incentives.

Most of the difference in the average management score of a country can be explained by difference in firms' performance: lower performing countries tend to have a 'long tail' of badly managed firms as opposed to the top-performing US where relatively few firms appear to be badly managed.

Product and labour market competition is seen as key to boosting average management practices both by eliminating the tail of badly managed firms and by pushing surviving firms to improve their practices. Other factors that may affect management quality include

[7] See Chapter 1 for further international evidence on R&D, external networking capability and the Research Base.
[8] OECD (2013) shows a normalised index of 110 compared to OECD median value 100; the EU-27 average index is 65.
[9] UK index value of 138 compared to an OECD median value of 100. This compares to the US value of 81.
[10] The reasons for this are not discussed here, but some possible drivers are outlined in BIS (2011).

a higher proportion of family-run firms (negative effect), the presence of multinationals, the level of qualifications held by managers, and better general education (positive effect)

Figure 5: Comparison of international management scores

Source: Van Reenan et al. (2010). Worst practice = 1, best practice = 5.

Regional evidence on absorptive capacity

Abreu et al. (2008) found that regional specific effects could not explain the innovation behaviour of firms in the UK. Although regional differences were found, with the Greater South East performing more strongly than other regions, these variations were captured by industry-specific effects and variables that drive absorptive capacity such as employment, management practices, training and the use of collaborative networks.

Industry-specific effects were explored in a study by Nesta (2009), which found that there were differences between different sectors in terms of absorptive capacity. For example, consultancy services and software and IT services sectors showed relatively strong performance in accessing knowledge, building innovation and commercialising innovation whereas the construction industry and accountancy sector were relatively weak. This could explain a large part of the regional differences in absorptive capacity: the Greater South East has the greatest concentration of knowledge intensive business services as well as the greatest concentrations of both universities and public research institutions.

Using its AC/DC framework, Nesta (2008) found a positive correlation between the AC (innovation absorption capacity) and DC (innovation development capacity) components i.e. regions that are good at drawing on external knowledge also tends to be good at exploiting it, although not all regions manage to create the necessary links. Overall, the analysis showed that the majority of UK regions have weak absorptive capacity: outside the Greater South East (including London), absorptive capacity was found to be weak or mediocre, with 5 out of 12 regions have weak knowledge diffusion capacity.

These findings are, however, directly contradicted by more recent evidence from the Community Innovation Survey (CIS).[11] This found that while there are some small regional differences, in general there is not a particular class of firms in high-tech, science-intensive sectors concentrated in particular geographic settings consistently driving innovation in the economy. In other words, high innovation firms are found throughout the country.

Whilst there is a widespread belief that High Innovation Firms (HIFs) are entrepreneurial start-ups concentrated around particularly technology hubs, this analysis does not show particular regions or types of firms being disproportionately favoured. London, for example, is a major technological hub, but has slightly fewer than expected HIFs.

Firm-based evidence

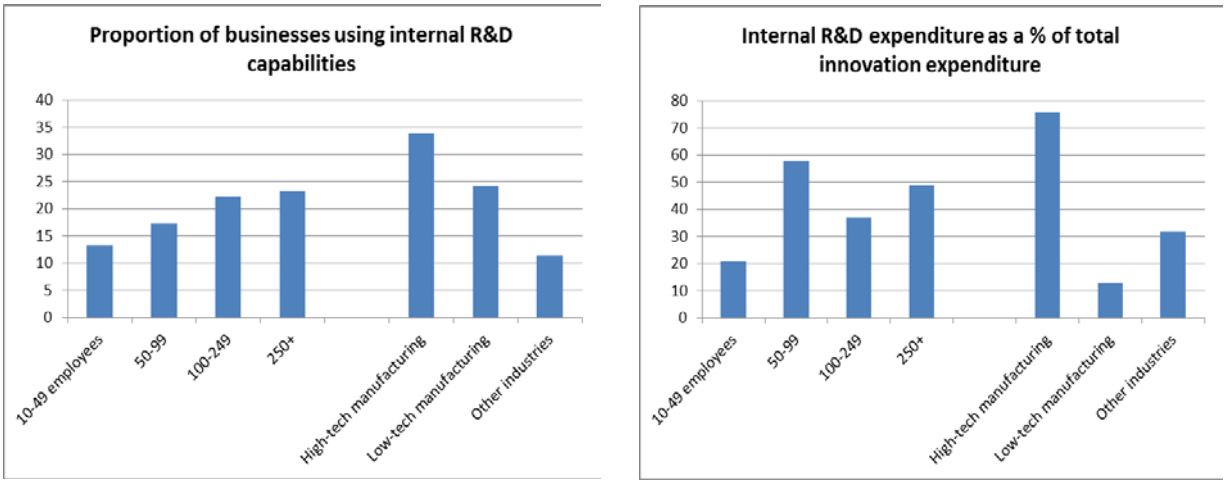
The primary source of evidence on innovation activity at a firm level in the UK comes from the Community Innovation Survey and data on some of the metrics that relate to absorptive capacity are available. The latest version of the survey relates to the 3 year period 2008-2010.

Research and Development[12]

Figure 6 shows the proportion of firms that use internal R&D as part of their innovation activity. The proportion of firms using internal R&D capability increases with firm size. In addition high tech manufacturing firms are more likely to use internal R&D than low tech manufacturing and other industries.

However, looking at internal R&D expenditure as a proportion of total innovation activity expenditure, the results are slightly different, suggesting that firms with 50-99 employees focus more of their innovation expenditure on internal R&D than large firms. High tech manufacturing firms spend over 75% of their total innovation expenditure on internal R&D whereas low tech manufacturing firms spend a smaller proportion than other industries.

Figure 6: Proportion of businesses using internal R&D capabilities, internal R&D expenditure as a proportion of total innovation activity expenditure



Source: Community Innovation Survey (2012)

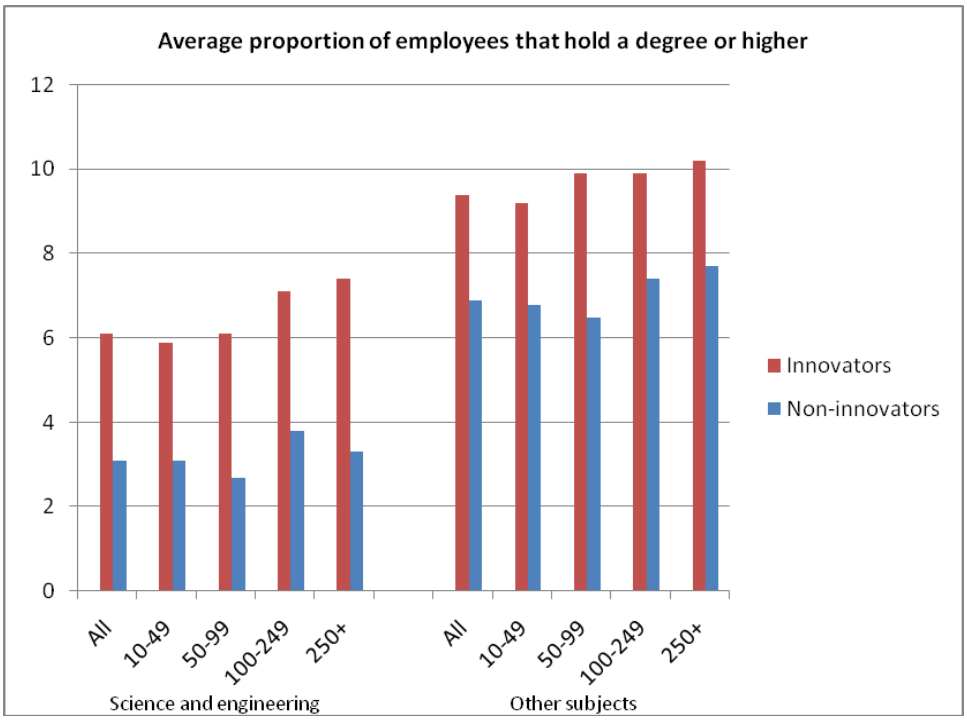
[11] https://www.gov.uk/government/publications/uk-innovation-survey-highly-innovative-firms-and-growth.

[12] R&D is often used as a key proxy for investment in absorptive capacity, in part because there is good data on R&D expenditure. However, investment in traditional R&D is likely to be skewed to manufacturing industries, with the service sectors more likely to invest in 'intangible' assets (Nesta Innovation index 2012)

Training and Skills

Figure 7 shows the proportion of innovators' and non-innovators' employees with a qualification at degree level or above. Across all firm sizes, innovators tend to have a greater proportion of employees qualified at degree level or above.

Figure 7: Average proportion of employees that hold a degree or higher



Source: Community Innovation Survey (2012)

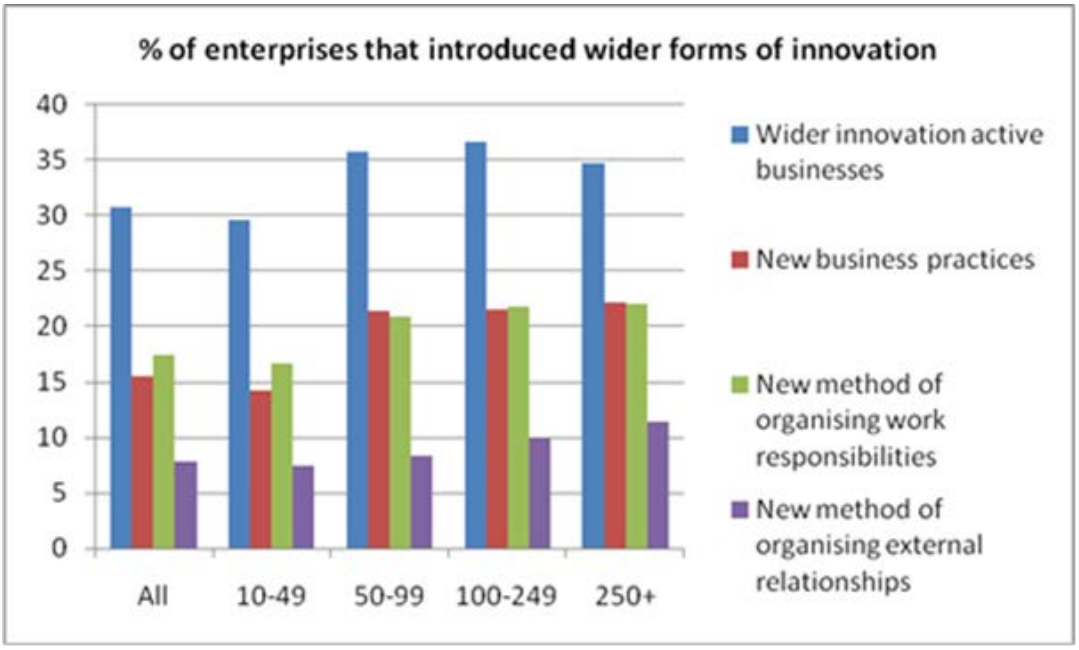
A very small proportion of total innovation expenditure (1.7%) is spent on training for innovative activities, with high tech firms showing even lower proportions of spending (0.5%) and the likelihood of an employer providing training increasing with the size of the business (BIS, 2013). Lack of skills is not seen as a major barrier amongst innovating firms: only 7.5% of firms undertaking broader innovation[13] considered lack of qualified personnel to be a high barrier to innovation. By contrast, more than 20% of such firms considered economic risks, direct innovation costs and finance issues to be high barriers.

Management Practices

In the CIS survey, wider innovation covers new and significantly improved forms of organisation, business structures or practices and marketing concepts or strategies. Figure 8 shows data for those firms undertaking wider innovation.

[13] Within the CIS, broader innovation is defined as the introduction of a new or significantly improved produce or process; engagement in innovation projects, new and significantly improved forms of organisation, business structures or practices and marketing concepts or strategies; and activities in areas such as internal R&D, training, acquisition of external knowledge, machinery or equipment linked to innovation activities.

Figure 8: Percentage of enterprises that introduced wider forms of innovation



Source: Community Innovation Survey (2012)

Access to external networks

Amongst 'high' innovators, the key sources of information were in-firm (39% of firms) and clients, customers or end users (39.5%). Suppliers and competitors were also important but universities and government of public research institutes were only used by around 2% of these firms. Larger firms are more likely to access business support (BIS, 2013).

In terms of the geographical nature of networks, the UK Innovation Survey finds that, for innovative firms with a cooperation agreement, 67% have partnerships at the national level and 52% at the regional level. Far fewer firms have international partnerships (CIS, 2011).

Additional evidence on SMEs

Recent work looking at the internal capacity of SMEs (BIS, 2013) shows that many of the activities required to deal positively with the potential 'tipping points' on their growth trajectory are not present in a large number of SME employers. For example, in terms of people management, 47% of SME employers did not provide any training for managers in 2011-12 and 46% of all SMEs do not undertake strategic planning (as measured by the production of regular management accounts or formal written business plan). Many SMEs rate their ability to deal with these 'tipping points' as poor and the lack of internal capacity was identified as an issue for 67% of microbusinesses.

Conclusions and areas for further work

The evidence suggests that whilst the UK's education base provides a relatively strong foundation for the development of absorptive capacity, by many other measures the UK does not perform strongly. Firms' absorptive capacity is skewed to a few regions (i.e. the Greater South East) and small firms, in particular, lack the necessary precedents for successful development of absorptive capacity.

For successful policy intervention in this area, the key issue is **how to identify those firms that not only lack absorptive capacity but also may be at a 'tipping point' in terms of growth**. Evidence to be able to do this is currently lacking and the feasibility of additional research into how to segment firms in this way should be explored . There also needs to be a clear view of the market failure that any policy is looking to address as it is not clear in some cases why firms may be unwilling to invest to develop their absorptive capacity.

Given the path-dependence nature of investment in absorptive capacity, it is clear that **any intervention should incentivise persistent investment in absorptive capacity**. For example, support for R&D should encourage investment over time rather than focussing on a single year's R&D expenditure. This should continue to be kept in mind in the context of the government's recently-launched 'Small Business: GREAT AMBITION' Strategy.

Human capital is an important precedent for successful absorptive capacity at the firm level. Whilst there is a need for a diversity of skills, research suggests that **policies that support the development of skills and qualification in science, technology, engineering and maths may be particularly important for innovation**.

The role of management practices has been highlighted as a key driver. A better understanding of the role of government in embedding 'good' management practices in UK firms is required.

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Chapter 3: Tax and Spend Policy

Summary

- **Explicit support for private R&D can be broken down into direct spending and indirect tax incentives. From the 1970s onwards, public support seemed to be shifting towards tax incentives, but direct R&D support has seen a resurgence in popularity in recent years.**
- **Evaluations of the growth and productivity outcomes of tax and spending innovation policy are limited (and the evidence is often mixed), although there is a range of evaluation evidence that points to** both tax and spend instruments having positive impacts on R&D activity.
- **Both tax and spend form important elements of a policy suite supporting innovation. Increasing attention is being paid to the interaction between these instruments and what an** optimal policy mix **could represent. Although definitive conclusions are not available yet, issues to consider include:**
  - **The interaction between R&D support policies and corporate tax rates**
  - **How tax planning of multinational companies may reduce the effectiveness of such policies**
  - **The simultaneous influence on R&D of many other important factors, such as access to local markets.**

Introduction

The focus of this chapter is on interventions that take the form of either **direct spending** (to stimulate firms to undertake R&D activity by themselves), or through **indirect tax incentives** (which lower the cost of R&D activity to firms). The emphasis is on policy instruments that are intended to directly incentivise or fund innovation through the private sector. It does not, as such, cover funding for the research base (discussed in Chapter 1).

From the 1970s onwards, with the emergence of tax incentives to stimulate R&D in a number of countries, it appeared that public support was shifting to tax measures rather than direct spending, typically under the guise of measures to facilitate the business environment.

However, following the global economic downturn the increased use of more interventionist economic measures such as industrial strategies, there appears to be resurgence in direct spending measures (which reflect reduced resources to carry out R&D activity among cash constrained firms during a downturn, even when fiscal incentives are available).

For example, in the UK, the small firms R&D tax incentive scheme (which was introduced in 2000-01) costs around £340 million p.a. and the large firm scheme (which was

introduced in 2002-03) costs an additional £740 million. Taken together, tax incentives provide over £1 billion to R&D performing companies. This compares with around £300 million provided in direct support for innovation by the Technology Strategy Board (TSB); though this will increase to close to £500 million 2015-16 following Budget 2013.

This chapter looks at the various tax and spend measures used to stimulate private R&D, the evidence on their relative pros and cons, and what lessons can be drawn for the UK.

Types of Tax and Spend Interventions to Boost Private R&D

Broadly speaking, support for private R&D can be broken down into two main types; Direct Support[14] and Indirect Tax Incentives. Within this, there is significant variation in the types of instruments used across different countries.

Direct support to private investments in innovation can come in a variety of forms, including grants to fund part of the targeted expenditures, soft loans and loan guarantees.

Many examples of direct support for innovation activity have for a long time incorporated a mission-based approach (e.g. DARPA in the US). These programmes are often targeted at correcting specific market failures and also supporting co-ordination between different actors in the innovation process. More recently it has been argued that Governments should extend this approach further (See Box 1).

Tax incentives to support innovation can take the form of tax allowances or tax credits, or can be volume-based or incremental, incentivise R&D by reducing the cost of R&D after it has been incurred. As Table 2 shows, countries' approaches to the design and application of tax-based incentives vary widely. There are also other, non-financial forms of support – such as the facilitation of networks to generate knowledge transfer, which have an important role in integrating national innovation systems.

[14] Spending can also be used to provide **indirect support for innovation**, for example by fostering greater interaction between firms and external research, as well as business-to-business interaction through collaborative programmes (joint ventures), science parks and incubators. This is not discussed in detail here.

Table 2: Design of fiscal incentives

Design of the R&D tax incentive scheme	*Volume based R&D tax credit*	Australia, Austria, Belgium (capital), Canada, Chile, Denmark, France, Norway
	Incremental R&D tax credit	United States (mostly)
	Hybrid of volume based and incremental credit	Ireland, Italy, Japan, Korea, Portugal, Spain
	R&D Tax Allowance	Belgium (Capital region), Brazil, China, Chile, Columbia, Czech Republic, Finland, Hungary, India, Netherlands, Russian Federation, Singapore, Slovenia, South Africa, Turkey, United Kingdom
Payroll withholding tax credit for R&D wages		Belgium, Hungary, Netherlands, Spain, Turkey
R&D tax incentive is not refundable		Brazil, China, Chile, Columbia, Czech Republic, India, Italy, Japan, Korea, Poland, Portugal, Russia, Singapore, Slovenia, South Africa, United States (mostly)
Tax incentive does not contain carry-over provisions		Austria, Brazil, Columbia, Italy, Norway
More generous R&D tax incentives for SMEs		Australia, Canada, France, Hungary, Japan, Korea, Netherlands, Norway, Portugal, United Kingdom
Targeting	*Special for energy*	United Sates (volume based)
	Special for collaboration	Hungary, Italy, Japan, Norway
	Special for new claimants	France
	Special for young firms and start-ups	Belgium, France, Netherlands, Portugal
Ceilings on amounts that can be claimed		Austria, Denmark, France, Ireland, Italy, Japan, Netherlands, Norway, Portugal, Singapore, Spain, United Kingdom, United States
R&D income-based tax incentives		Austria (individuals), Belgium, China, France, Hungary, Luxembourg, Netherlands, Spain, Turkey, United Kingdom
Special treatment of technology acquisitions		Poland
No R&D tax incentives		Estonia, Germany, Israel, Mexico (repealed), New Zealand (repealed), Sweden

Source: OECD (2013)

Box 1: Mazzucato, the Entrepreneurial State and Innovation Policy

Uncertainty about future market and technology uncertainty in conjunction with high upfront capital requirements have been cited as justification for government intervention – where they prevent investments being undertaken by the private sector alone.

Mazzucato (2013) builds on this uncertainty argument by calling for an "Entrepreneurial State" to lead in shaping and creating markets by undertaking large long-term portfolio investments focused on specific objectives of societal importance. She argues that the state's role as a shaper and creator of markets has been and is pivotal to many crucial innovations that would otherwise not be undertaken by the private sector.

In principle government is large enough to 'self insure' and as a result can take a wider, longer-term, portfolio view of such investments than private sector enterprises. However, one counter argument is that government does not obviously have an informational advantage over the private sector in terms of choosing the best projects to support which may create significant risk of government failure.

Mazzucato suggests a role for government, underpinned by robust institutions, driving new innovations and new markets that could make a significant contribution to long-term growth. The additional revenue from greater use of clawbacks could also be valuable, given fiscal constraints. However, this thesis is based on a number of case studies (e.g. Apple, DARPA) and there is no comprehensive evidence that:

- Evaluates the impact of these organisations and of the performance of specific innovation systems to identify what the additional benefits have been of 'market shaping' interventions and whether they can be justified on cost benefit terms.
- Appraises how such approaches can be applied in practical terms to the UK.
- Looks at the effect of attempting to implement more use of mechanisms (e.g. loans/equity share) for a direct return to state funding.

The approach that Mazzucato suggests has significant implications, but also raises a number of challenges which would require further exploration. These include:

- Such extensive investments would require analysts to be certain that the private sector would not undertake these investments, requiring understanding of the limits of private investments in a variety of markets.
- There may also be a risk that the willingness for greater public sector investment might inhibit the risk appetite of the private sector, albeit small in particular areas, if it feels that the public sector would take the lead in handling upfront risks.
- Whereas private sector investors could pull out of investments due to shareholder pressure, the state is asked to be a patient supporter, so analysts and scientific experts would need to focus on monitoring to detect signs where the evidence suggests that funding should be stopped.
- Clawback mechanisms would have to overcome legal and accounting difficulties as well as being effective, efficient, predictable, appropriately incentivising and avoiding optimism bias. By reducing private returns there may also be knock-on

effects to private investment as a result of increased uncertainty.

R&D tax allowances and R&D tax credits differ in the sense that:

- **R&D tax allowances** are tax concessions up to a certain percentage of the R&D expenditure and can be used to offset taxable income;
- **R&D tax credits** reduce the actual amount of tax that must be paid.

While the distinction between incremental and volume-based incentives is that:

- **Incremental incentives** involve subsidies related to the increase in R&D spending in a particular year
- **Volume-based incentives** involve subsidies that are related to the size of the R&D spending in a particular year.

Incremental incentives may have a higher focus on additionality as they target additional R&D spending, however, they may be more complex for SMEs and variability of tax relief hinders business planning. Hence there is a trade-off between additionality and simplicity where the introduction of a fiscal incentive is concerned.

Pros and cons of tax and spend instruments

There are a number of advantages and disadvantages associated with tax and spend instruments, which are summarised in Table 3.

Table 3: Summary of key features of tax and spend instruments

Direct Spend	Indirect tax incentives
Pros: • Can be targeted at specific areas of strategic importance or to address market failures • Can be designed in a way to support other structural objectives – e.g. collaborative R&D is a way of encouraging cooperative research between business and academia. • Can target high additionality projects • Can support financially constrained projects • Can be added to other complementary measures, e.g. business support	Pros: • More effective at fulfilling wide-ranging objectives (e.g. with wide scope). • Less prone to government failure • Less costly in terms of administration costs • Simple to implement through tax system • Can be easily changed in size and scope • Easier to administer when dealing with a devolved system of many innovators
Cons: • Less effective at fulfilling wide-ranging objectives • More challenging to administer when dealing with a substantial number of administrators	Cons: • Difficult to identify impact on finances in advance • Complicates tax system • Cannot target high additionality projects

The European Commission (2006) noted the most important difference between direct funding and fiscal incentives is that:

- By using **direct funding**, governments have more scope to make deliberate choices about which projects they want to support. This enables better targeting of projects with greater spillovers.

- **Fiscal incentives**, due to the limited ability to target the incentive, carry greater risks of deadweight loss. However, fiscal incentives are more neutral in that they generally leave decisions of which projects are highest value to the firms themselves. This can be more efficient and effective than direct government intervention when this sort of information is harder for government to obtain.

In terms of flexibility, direct support could be considered to be the more flexible instrument if policy deliberately aims to address important social issues or clearly identified externalities (such as in case of health care, environmental protection, defence, etc.). However, fiscal incentives can also be varied by firm size or sector.

Nesta have undertaken surveys of evaluations of R&D tax incentives and direct support schemes, which, whilst noting that the comparability of different schemes is limited by methodological challenges, consider impacts on:

- **Input additionality** – the additional increase in R&D due to government support.

- **Output additionality** – refers to a mixture of outputs (e.g. new products and services) and outcomes (e.g. increase in productivity and growth outcomes) where additional impacts can be identified as a result of government support.

Nesta (2013) find that where fiscal incentives are concerned, there is significant input additionality in the short run, but there is a lack of clear evidence at firm level where output additionality is concerned.

In a separate study, Nesta (2012) find that where direct spend interventions are concerned, the evidence of both input and output additionality is not clear-cut. However, they note in their review of evaluations of spend interventions across countries that projects being supported, particularly for younger or smaller firms, would not have gone ahead or would have been slower with less depth or less technical sophistication than if the support had not been available.

The OECD (2013) argue that while R&D tax incentives remain a useful policy instrument, direct support measures may be more effective in encouraging R&D than previously thought. It cites new econometric research by Westmore (2013) which is a panel study of 19 OECD countries over the 1983-2008 period, which shows that direct government subsidies can encourage additional business R&D.

However, Westmore finds that this result does not hold when the analysis is conducted on data pre-dating the 2000s; this is consistent with earlier research that did not find a significant relationship between direct R&D subsidies and additional private R&D spending over the period 1982-2001 (Jaumotte and Pain, 2005). He suggests that the estimated increase in the effectiveness of R&D direct support may reflect a shift in the structure of public support, which has become more focused on subsidies for commercial R&D

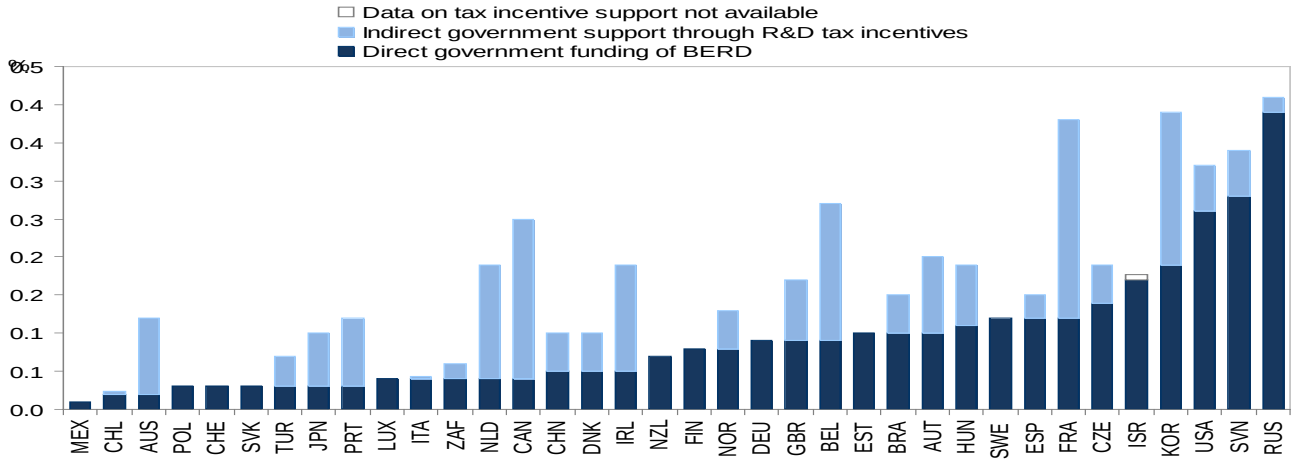
activities and has seen matching grants become a more common feature of government funding programmes (Trajtenberg et al., 2006; Hall and Maffioli, 2008).

The situation in the UK

The UK from a cross-country perspective

According to OECD data, 8.6 per cent of UK business R&D was government-funded in 2011; approximately equal to the OECD average. In 2011, the UK had a roughly equal balance between direct and indirect support for innovation[15] while the Russian Federation, Korea, France and Slovenia provided the most combined – direct and indirect – support for business R&D as a percentage of GDP. In Canada and Australia, indirect funding of business R&D exceeded direct funding by a factor of five.

Figure 9: Direct government funding of business R&D and tax incentives for R&D as a percentage of GDP, 2011



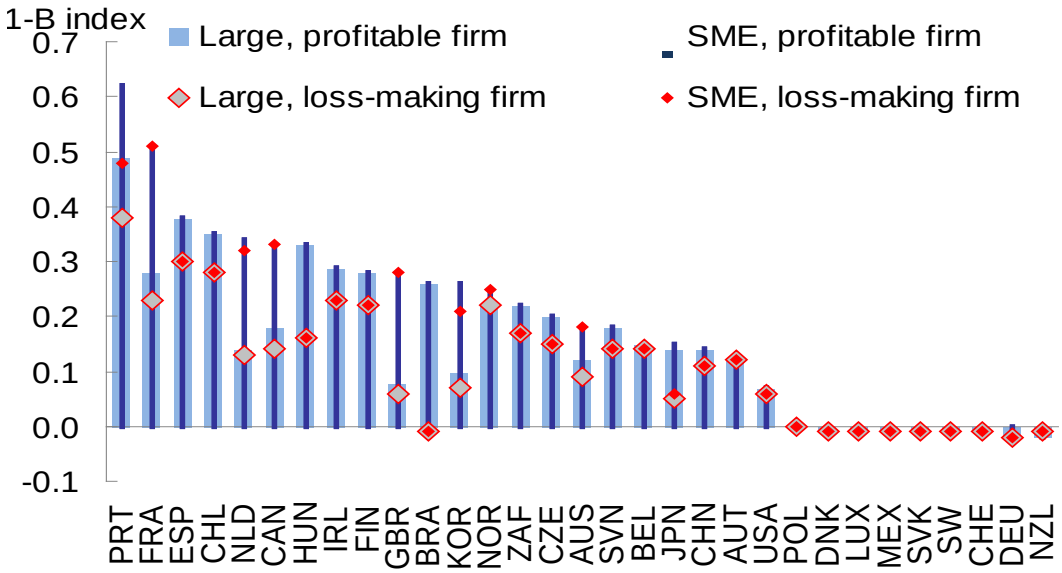
Source: OECD Science and Technology Outlook (2013). This is an experimental indicator – international comparability may be limited. For more information, see www.oecd.org/sti/rd-tax-stats.htm.

Recent analysis from the OECD suggests that the UK is mid-table in terms of the generosity of its tax subsidy schemes, but provides comparatively generous SME support.

Some countries with higher business R&D intensities than the UK – such as Sweden, Germany and US – have much less generous tax treatment of R&D. Their high R&D intensities may be due to different types of R&D support provided – e.g. grants or public procurement – as well as differences in industry structure (e.g. greater share of industry output in R&D intensive sectors) or UK specialism in wider forms of non-R&D innovation.

[15] However, it is worth noting that level of the Technology Strategy Board (TSB)'s funding, which is the main UK direct spending instrument, is currently less than half of the overall cost of UK tax credits.

Figure 10: Tax subsidy rates on R&D expenditures, 2013 [16]



Source: OECD Science and Technology Outlook (2013)

Evaluation Evidence on the impact of R&D tax credits in the UK

The HMRC (2010) evaluation of R&D tax schemes suggested that between £0.41 and £3.37 of R&D expenditure might be stimulated for every £1 of tax foregone. The breadth of the range is largely due to the estimated impact of the small firm tax scheme (Table 4).

Table 4: Benefit-cost ratios evaluated using long-run semi elasticities

	Benefit-cost ratio
Large companies	£0.93 - £1.85
SMEs	£0.41 - £3.37

Source: HMRC (2010)

The study reports very high impacts for small firms. This is due to a very high estimate of the sensitivity of R&D to its price. They are at the upper end of the range for the peer-reviewed literature and may not be wholly reliable. Generally, estimating the impact of R&D tax incentives is difficult and estimates are sensitive to the analytical method used.

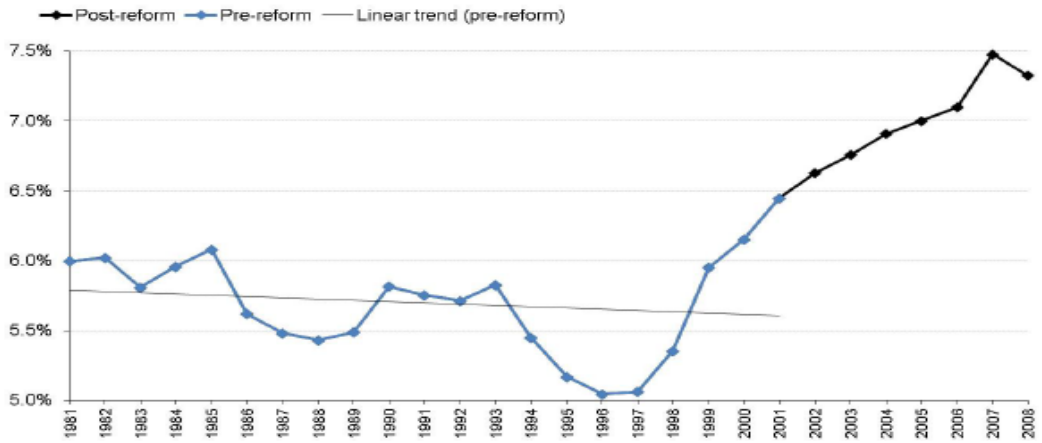
The evaluation included qualitative research, a survey of managing directors, finance directors and directors responsible for R&D, which suggested that in the short-term, R&D incentives did not appear to have impact in individual firm decisions to undertake R&D activity. However, in the long-term, responses suggest that the incentive could have an impact on the resources available for R&D, “as R&D claims are made and received,

[16] United Kingdom: For large companies, estimates refer to the corporate tax credit for R&D (30% R&D enhanced allowance rate, non-refundable, with possibility of indefinite carry forward). The new "above the line" credit (10% R&D enhanced allowance rate, refundable) introduced in April 2013 is not explicitly modelled as it only makes a material difference for companies with worse future profit prospects than those considered in the benchmark loss scenario that has been considered for all countries. Estimates account for SMEs' ability to claim a 125% enhanced allowance rate, which is refundable. Since 2008 and for R&D relief purposes, an SME is defined as a company or organisation with fewer than 500 employees and either an annual turnover not exceeding EUR 100 million or a balance sheet not exceeding EUR 86 million.

confidence grows in the availability of this source of funding which can be invested in future R&D projects."

Taken together, there is evidence that the introduction of the R&D tax credit increased levels of business R&D. This is consistent with analysis produced by the Centre for Business Taxation which showed that UK manufacturing R&D intensities rose significantly after the introduction of the tax credit, and by more than models predicted[17] (Figure 11). However, there is currently a lack of impact evaluation of tax credits in the UK.

Figure 11: Manufacturing R&D intensity trends



Source: OECD STAN and ANBERD databases (NACE Rev.3). For the years 1981-1986, OECD archive data based on NACE Rev.2 is used.

Evaluation evidence of direct spend schemes in the UK

Published Benefit-Cost evaluations using HMT Green Book methodology have shown TSB programmes generate large direct economic benefits to participating companies and their supply chains. These evaluations measure *additional* economic output, taking **account of deadweight** (what would have happened in absence of intervention).

- **Smart** (previously known as Grant for R&D), which provides funding for innovative SMEs, produced additional **Gross Value Added (GVA) £9 per £1 of R&D grant spent**. In terms of additionality, 85% of projects were not expected to go ahead without funding. Of the projects which could have gone ahead, 85% were expected to occur later, 40% expected to be smaller and 38% narrower in scope (PACEC, 2009).

- **Collaborative R&D**, which funds businesses and academic partners to collaborate on R&D projects, generated **£7 of GVA per £1 of project costs**. In terms of additionality, 91% of projects were not expected to go ahead without funding. Of the projects which could have gone ahead, 91% were expected to occur later, 46% expected to be smaller and 35% expected the scope to be affected. Of those projects that would occur later, 21% expected a 3-5 year delay whilst 66% expected a 1-2 year delay (PACEC, 2011).

- **Knowledge Transfer Partnerships**, where recently qualified graduates work under the supervision of business and the knowledge base to improve knowledge transfer and business and technical skills, generate **£5 for every £1 of project costs**. In terms

[17] One puzzle, however, was that R&D intensity increases were concentrated in high tech sectors. This suggests that the credit was of less benefit to low or medium tech industries.

of additionality, 93% of projects estimated impacts that would not have occurred in absence of the KTP. Of this, 24% of projects expected no impact, 21% estimated delayed impact and 48% expected reduced impact without the KTP (Regeneris, 2010).

Conclusions and areas for further work

Tax and spend innovation policies together form a complementary mix of policies to address market failures in innovative activity such as R&D. What constitutes the optimal combination of tax and spend measures is the subject of increasing analytical debate.

Over the past 40 years, there has been a clear shift towards tax incentives, although in recent years particularly with the advent of industrial strategies there has been a renewed focus on spending schemes including support for large firms. Government should continue to evaluate and keep under review the design of tax incentives and spending schemes (particularly the effectiveness of competitive tendering processes).

Some issues are highlighted below which could investigated further.

Considering the balance between tax and spend

There is increasing interest in what constitutes an optimal policy mix between tax and spend instruments to support innovative activity. Nesta (2013) have suggested linking administrative data from R&D tax claims and data on direct government subsidies for R&D on a firm level would provide a useful base for future research.

In their survey, Nesta suggest that R&D tax incentives should be considered together with the overall corporate tax rate, as:

- It is possible that countries with low corporate tax rates need more generous R&D tax incentives to produce similar effects compared to countries with higher tax rates (a tax incentive is worth proportionately more in a country with high tax rates).

- Nesta also point to some empirical evidence that lowering the general level of corporate taxation might have a similar or even higher impact on R&D investment decisions than an R&D tax incentive., citing McKenzie and Sershun (2010) who find for cross-country data higher elasticities of R&D for the level of corporate taxes tax than for the size of R&D tax incentives both in the short and the long run.

When assessing the impact of generous R&D tax incentives, it is important to separate these from out from the impact of other factors, e.g. access and support to local markets. This includes the proximity to both other corporate activities and local customers, access to local science and technology or the availability of a skilled workforce, engineers and scientists, and strong intellectual property rights (e.g. Alcacer and Chung 2007; Branstetter et al. 2006; Thursby and Thursby 2006; von Zedtwitz and Gassmann 2002; Kumar 2001).

These factors **may have an even stronger impact on the location decision for R&D than the existence of R&D tax incentives**. Yet for R&D location decisions of multinational firms **the generosity of a particular R&D tax incentive scheme may be a crucial determinant**, given that all other determinants of their location decision may be equal among competing countries.

Targeting R&D tax incentives

Given changes in the tax treatment of R&D for large firms in the UK announced in Budget 2013[18], the literature suggests that there are some conflicting arguments that could be investigated further:

- It could be argued that supporting R&D activity by large firms may involve significant deadweight, but they tend to be the firms that do a lot of the innovation.

- Nesta suggests that fiscal incentives tend to focus on small firms because they tend to face more significant capital market failures (implying greater additionality). They question whether fiscal incentives for large firms may thus be ineffective – although the spillovers in aggregate may be larger.

- In addition to ensuring better targeting of R&D tax incentives, the implications of tax planning by large multinational enterprises (as they make increasing use of the greater availability of varying R&D tax incentives and differences in overall corporate tax rates across countries to reduce their tax bill) needs to be actively considered, particularly as the UK relies on the multinationals for around half its business R&D.

The OECD (2013) finds that such activities could reduce the cost-effectiveness of otherwise successful R&D tax incentive schemes, by reducing the tax revenue from commercialisation of R&D and lowering domestic spillover benefits (if the R&D is used in foreign production rather than domestic production will accompanying negative impacts on domestic employment). Hence it recommends additional research to better understand spillover benefits stemming from R&D, their source and value (whether it is owned by a domestic company or an offshore holding company) and how they are affected by tax policy.

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Chapter 4: Procurement

Summary

- **Government should consider using public procurement as a mechanism for fostering innovation, because there is a good market failure rationale for it to intervene. Theory and empirical evidence suggest it can be successful in stimulating innovation and can impact firms' levels of innovation, because it:**
  - **Can offer a guaranteed market for firms**
  - **Is the dominant actor in some sectors so can drive demand for innovation**
  - **Can adopt new standards which require an innovative approach**
  - **Can absorb the large fixed costs of investing in some new technologies**
  - **Has an explicit role in pursuing social goals.**

- **The UK's Small Business Research Initiative (SBRI) is an innovative procurement process designed to support firms in developing innovative solutions to public policy problems. Indications are that the SBRI has been successful in fostering innovation; a formal evaluation will report in early 2015. Points for discussion include:**
  - How to improve the SBRI
  - How to encourage policy officials and analysts to engage with procurement officials **at an earlier stage of policy development to consider the costs and benefits of more innovative procurement solutions.**

- **Barriers to increasing innovation through procurement include:**
  - **Possible** tensions between encouraging innovation and demonstrating value for money **over the lifetime of an individual project**
  - **Limits to where in government innovative procurement practises can be used**
  - **Institutional capacity and a risk averse government procurement culture**

Introduction

This chapter considers how the government's approach to procurement can affect the level of innovation carried out by firms and third sector organisations in the economy. It presents findings from the economics literature which argues that there is a good rationale for government intervention in the market for innovative technologies. The literature suggests government can have a role in overcoming potential market failures and use its strategic position to leverage investments in innovative technologies which would otherwise not be made.

Some evidence of the impact public procurement has on innovation is discussed, before the effectiveness of public procurement policies designed to stimulate innovation in the UK and elsewhere are considered.

This leads on to a discussion of which barriers are in place to hold back the success of government procurement policies in fostering innovation and some points for discussion and questions for further research are raised.

Background to government procurement

The UK spent £192bn on current procurement and £37bn on capital procurement in 2012/13 (HM Treasury, 2013); total procurement accounted for a third of total government expenditure in line with previous years' shares. Within this £70bn of current procurement expenditure goes towards health services, while £30bn goes on social protection and £21bn on defence: together these account for nearly 2/3rds of spending in this category.

Much of government spending on procurement happens at the local level: Local Authorities spending is around £40bn (OGC 08/09 figures) and much of the spending on health (£75bn) and education (£22bn) is delegated to NHS trusts and schools.

Although government procurement accounts for around 15% of overall UK demand, in most sectors it is a much smaller proportion of the market. However in some markets the public sector has significant dominance: it accounts for 61% of expenditure in education, 35% in pharmaceuticals and 29% in the medical and precision instruments sector.[19] Analysis of the market categories which government expenditure falls into indicates social care, construction and professional services account for nearly half of all spending (PSPES, 2011). As a result, the way government structures its spending can have a significant effect on innovation.

Some of the sectors which government operates in, particularly defence but potentially also other areas such as pharmaceuticals, are not competitive markets. Procurement practices need to take this into account. In practice this means government has fewer firms (sometimes only one) bidding for procurement contracts, so approaches designed to exploit or induce competition between firms to provide an innovative solution are not suitable in these sectors.

In the context of procuring for innovation (as opposed to more homogenised bulk procurement where innovation is not a key factor), government procurement can be categorised in 4 ways (Warwick, 2013):

- **General government procurement** which specifies some degree of innovation requirement. This can be done by incorporating innovation-related criteria into tender specifications, and can be used for a variety of goods and services,

- **Catalytic,** where government actively targets technologies which are in the early stages of development, and provides market support. This requires procurement officials to have a good understanding of the market, and identify products which would benefit from early market support,

- **Pre-commercial strategic procurement,** where government aims to work with firms to develop new products for the market which do not yet exist. This type of procurement is sophisticated and requires procurement officials to have a deep understanding of the market and technology they are purchasing. It involves collaborating at a very early stage of product development, by purchasing research and development, prototypes and other initiating products or services which would support a firm develop an innovative product,

[19] ONS supply and use tables, from BIS analysis of Government procurement.

- **Commercialisation**, where government supports firms to take their product to market where this would benefit the public once a product has been successfully commercialised and more people have access to it.

These 4 categories are mechanisms by which government can increase the chances they will end up with an innovative product or service, which benefits the public in some way. In this respect the final technology itself is an innovative product. The categories themselves can vary in the extent to which they are innovative *processes* which attempt to create an innovative solution. General government procurement is rarely an innovative process, but it may lead to innovative solutions. Pre-commercial strategic procurement is a more innovative process (in the sense that it is more sophisticated, requires greater expertise and is used less often) which is also used to develop innovative solutions.

Government's role in correcting market failures

The argument that government should take a leading role in the demand for innovative technologies is based on the idea that the market will fail to deliver an optimal level of innovation without government support. Edler (2012) distinguishes between different types of market failures:

- Demand is insufficient to stimulate innovation in the market, which can be because firms are overly risk averse in their approach to procurement,
- When the number of users is too low to enable network effects to operate
- High switching costs make adopting a new technology difficult for firms,
- Failure by users or suppliers to communicate their need for innovation, or the innovative nature of their products, indicating the presence of information asymmetries,
- There are high costs, which are often sunk, associated with entering the market. Capital markets may not work effectively enough to allow firms to borrow the necessary funds for investment in innovative technologies,
- There are positive spillover effects of innovation which benefit society such as improving the quality of public service provision, or the social benefits of some innovations e.g. the internet.

Government may want to correct these market failures and increase the potential for procurement to stimulate innovation; but without a credible rationale as to why they would be successful they should proceed with caution. The consensus[20] in the literature is that in certain areas the government is well-placed to correct these market failures, because:

- Can offer a guaranteed market which reduces risk for firms and encourages investment (lead market argument),
- Is the dominant actor in some sectors, such as defence and education, and so it can drive demand for innovation,

[20] See Edler 2012 for an overview

- Can offer sufficient demand for new goods or services which enables these products to benefit from network effects and eventually become successful outside the public sector,
- Can adopt new standards which require an innovative approach,
- Can absorb the large fixed costs of investing in some new technologies, which overcomes a potential liquidity constraint for firms,
- Has an explicit role in pursuing social goals, and can use social benefits as a success measure.

Government can use its position to demand that the goods and services it procures are innovative, triggering suppliers to offer innovative solutions. When it acts as an intelligent customer it can also respond to new innovations and help to expand the market for innovative products.

The result *should* be that the public service uses more innovative goods and services and so can deliver a higher quality service, while making cost savings over the long-term. Innovative firms and third sector organisations benefit by offering new products which create internal growth, and firms can increase their export opportunities.

However there is also clearly a trade-off, innovative procurement necessarily carries with it additional risks and potential up-front costs. Given their responsibility to ensure value for money to the taxpayer, Government departments have strong incentives to minimise both of these – particularly in the context of a political environment where failure is perceived to be heavily penalised. The danger of government failure[21] is also present, and there is a risk that in trying to foster innovation the government will waste resources if it does not design effective policies that deliver innovation.

Economic theory suggests government procurement should foster innovation, but there are few studies which are able to verify this robustly. One such study by Edler (2011) uses survey evidence from 800 firms and third sector organisations who supply to government. This study found that 2/3rds of firms stated they had made innovations as a result of bidding for or delivering public contracts. Larger firms were found to be slightly more innovative, while providers to central government reported being more innovative than providers to local government and the NHS. Of firms that reported making innovations, half noted this had led to higher sales in the private sector.

When asked to compare the innovation friendliness of private firms and the public sector, 65% of respondents stated they felt public sector organisations were less open to innovation compared to private firms.

Policy Effectiveness – UK Evidence

The UK is perceived as a world leader in developing public policies designed to improve the procurement of innovation (BERR, 2008): only the US has policies as sophisticated and sizeable as the UK. The OECD estimates that fewer than 10% of OECD countries use public procurement as a tool for promoting innovation (Warwick, 2013). The apparent novelty of demand-side policies means that very few effectiveness studies exist. Uyarra's review of studies which investigate the impact of public procurement on innovation concluded that "all evaluations reviewed...fall short of providing a rigorous and transparent

[21] Government failure occurs when government intervention causes a more inefficient allocation of resources

assessment of policy impacts" (2012, pg. 23). The following UK policies have had some form of evaluation, but these have not been systematic impact evaluations.

Procurement principles

Survey evidence from Edler (2011) identified some effective approaches to procurement. This evidence is from a survey of over 800 firms which regularly supply to government. The author found that Innovation is more likely to be fostered when:

- Innovation requirements are explicit in the award criteria,
- There is pre-procurement communication between government and suppliers,
- The process of finding an innovative solution is not too explicit and only the solution itself matters,
- Government asks for sustainable products.

Some of these findings are intuitive (e.g. being explicit about innovation in award criteria), but others, e.g. the *process* of finding an innovation solution not being too explicit), are not. Understanding why some policies are more effective that others, and how they interact with one another, is an important step in improving procurement practice across government. Importantly, approaches identified as being less helpful in fostering innovation can still be appropriate when innovation is not relevant to the procurement outcome. It is also important to communicate these findings so that procurement professionals across government understand what works.

The Small Business Research Initiative (SBRI)

The SBRI is the UK Governments flagship innovation procurement programme and is a type of pre-commercial strategic procurement. The process starts with government identifying a problem which needs a solution; their needs are then communicated to firms. This leads to an open competition where firms can bid for a contract, worth up to £100k, to test the feasibility of their solution (phase 1). Firms which pass the feasibility test can then bid for longer contracts, worth up to £1m, to develop prototypes (phase 2). The final technology is then purchased by government, sold by the firm in the open market or both.

Around 50% of SBRI funding currently supports firms which supply the MoD and 25% goes to NHS suppliers (House of Lords, 2011). This is in line with wider procurement spending patterns.

The SBRI is administered by the Technology Strategy Board (TSB), although it is funded by Departments themselves. Between April 2009 and October 2013 over 1400 contracts were awarded through the SBRI programme, with a total value of £135m. Typically phase 1 contracts are worth between £40k to £100k (average £65k) and Phase 2 in the range £300k to £1m (average £398k) (according to the TSB)

The benefit of the SBRI approach is that government finds a solution to the problem and firms are able to access funding to help them develop their technology and eventually commercialise it, growing and making profits in the process. Firms maintain control of their technologies' Intellectual property (IP).

Government will substantially expand the SBRI among key departments so that the value of contracts through this route increases from £40 million in 2012-13 to over £100 million in

2013-14, representing 0.25% of procurement budgets, and rising to over £200 million in 2014-15, representing 0.5 % of procurement budgets (according to HMT Budget & Spending Round documents for 2013). The key Departments which will share the £100m of contracts in 2012-13 are: MOD (£50m), DH/NHS (£30m), DfT (£7m), HO (£7m), DECC (£3m) and DEFRA (£3m).

No studies exist which examine the impact of the SBRI on fostering innovations, and the benefits these bring to firms, the public sector and society; although an evaluation of the SBRI is planned and will report in early 2015. Bound (2010) was optimistic about the direction of the SBRI after its re-launch in 2009,[22] noting how it has enabled the government to widen its search for solutions – but this was not based on impact evidence.

Tredgett (2013) used SBRI data[23] from 2009 – 2011 to compare the success of the re-launched SBRI with the performance of the American SBRI (see below) in its first 2 years. The authors view the fall in contracts in 2011 for the SBRI as a sign of a 'shaky start' compared to the US in its first few years. More years of data are needed to confirm this assertion. The expansion of the anticipated spending through the SBRI from £40m to £200m is a challenging increase, and it is unclear if this target spending will be achieved.

The authors also note that the SBRI does not have clear, measurable objectives which make evaluating success more difficult. Success measures could be how successful the scheme has been in developing new products (measured by patents or trademarks[24]), how commercially successful these products have been (measured by sales), the extent to which innovative product development has increased exporting activity and what the size of any cross sector spillovers are (perhaps measured by use of patents by other firms or the number of consumers using a new product).

An impact evaluation using these measures will be difficult if the firm level data is not available, or firms are unwilling to share it. Measuring success might also require data on comparable firms which do not receive SBRI (or other government) funding to be used to consider the additionality of the SBRI. Finding these comparable firms may also be difficult. Nevertheless some attempt should be made in the evaluation of SBRI to establish what impact it is having on innovation, and what the economic benefits of this are.

Other UK policies

Forward Commitment Procurement (FCP) is a process which allows procurers to signal to potential providers that they would purchase a product or service that was delivered to them in the future, but it does not guarantee a market. The FCP encourages producers to invest in the development of products which do not yet exist at much lower risk. The idea is to create the incentives for firms to develop innovative products where it would otherwise be too risky for them to do so.

This is a small scale policy used primarily in the environmental sector, and was never rolled out further. With scope to expand the programme, it is unclear why it has not been.

UK Departments were obliged to publish Innovation Procurement Plans (IPPs) which set out how they would use procurement budgets to foster innovation. These have since been discontinued after having had minimal impact on procurement practises.

[22] Prior to 2009 the SBRI was unsuccessful; recommendations made in Lord Sainsbury's 'Race to the Top' (2007) report became the impetus to reform of the SBRI in 2009
[23] Accessed by a freedom of information request to the TSB.
[24] These are the standard measures, but there is debate over how well they might capture innovation performance.

Energy for Growth

Energy for Growth is an innovative procurement project which takes a new approach to purchasing a small portion of HMG's electricity needs. The project uses HMG's purchasing power and guaranteed demand to enter into long-term contracts to purchase electricity.

As the first stage of this, the Government Procurement Service (GPS) entered into a Power Purchase Agreement (PPA) with a renewable energy supplier (Air Products Plc) in July 2013. The PPA is a 20 year contract at a fixed, non-index linked price, for the supply of 37MW of electricity. This contract is estimated to save Government £97m over the life of the contract, as energy prices are estimated to rise significantly above the fixed price they will be paying over the period.

By agreeing a long term contract, the government has provided a guaranteed revenue stream to Air Products, enabling them to build a new 'energy from waste' plant in Teesside, supporting up to 750 jobs. More generally, the security that a PPA offers can be used to unlock the investment needed for a new plant to get built, increasing capacity.

PPAs have been used in the private sector, typically by large retailers, but this was the first PPA that HMG had entered into. As part of the open procurement process, GPS published the draft PPA, which enables other businesses to enter into similar contracts and further stimulate the market.

SMEs

The Government has set an aspiration that 25% of central government procurement spend (by value), flows to SMEs directly and through the supply chain, by 2015. Overall government has increased its direct spend with SMEs from 6.5% in 2009/10 to 10.5% in 2012/13. Figures from government's largest suppliers have also identified £4bn (9.4%) of indirect spend flowing to SMEs (Cabinet Office, 2013).

The Government's aspiration that 25% of procurement expenditure will flow to SMEs by 2015 has been questioned by some authors. Mazzucato (2013) argues that most small firms do not create jobs, and that only a small number of young small firms are driving job creation. She notes how SMEs can often be less productive than larger firms because they are less well managed. Storey (2006) estimated that the equivalent of nearly £8bn of public expenditure previously flowed to SMEs in various forms of financial support, and that the rationale for this support is unclear. There is therefore a risk that support is targeted towards SMEs per se, rather than highly innovative firms (SME or large).

Box 2: Government policy on SME procurement aspiration

The Government's rationale for this 25% aspiration is that SMEs are crucial to economic growth. Data from the Annual Business Survey shows that SMEs produce £7.56 more value (aGVA) to the private sector economy per £100 of turnover than large firms. Despite this, SMEs have historically been shut out of government business. They argue that smaller firms have found bidding for public sector work excessively bureaucratic, time-consuming and expensive meaning that the tax payer has not always benefited from some of the best and most cost-effective ideas that SMEs are capable of delivering.

Central Government has already taken steps to support SMEs, such as advertising all contracts over £10,000, eliminating Pre-Qualification Questionnaires for low value contracts and publishing its sector specific procurement 'pipeline' plans[1], to help pre-procurement dialogue and enable small firms to have sufficient time to plan their future

bids more effectively.

Lord Young (2013) recognised the role SMEs can have in benefiting from public procurement contracts at a local level; his report shows that 70% of all small firms supplying the public sector only supply local government and the NHS. He recommended that government creates a 'single market' for all parts of the public sector by rolling out many of the initiatives already introduced in central government, in order to ensure SMEs do not face overly complex, costly and inconsistent procurement processes. Removing Pre Qualification Questionnaires (PQQs) for contracts below €200k and locating all contract opportunities on the contract finder website should help reduce burdens and create this market. These attempts to create a level playing field are generally welcomed in procurement literature.

Social Impact Bonds

Social Impact Bonds (SIBs) are an innovative new way of delivering public services under which the public sector procures the services of organisations to achieve government objectives. SIBs are unique because they are outcomes-based and reward innovative approaches to tackling social problems. The process by which problems are solved is not prescribed, which allows providers to experiment and find the best local solutions.

A SIB is a way of financing a Payment by Results (PBR) contract. Under a PBR contract, government agrees to pay a service provider if – and only if – it achieves certain agreed results. This means that the service provider must cover the initial costs of delivering services. Many potential providers find this difficult, particularly social enterprises and charities, as they often do not have the capital available to provide services in advance.

A SIB is a way to bridge this gap, enabling socially-minded investors to fund the provision of a service delivered by a social enterprise or charity on the basis that they will receive a return on their investment from government – if the service delivers the results specified in the PBR agreement. The first SIB in the world was established by the MoJ in 2010 in Peterborough, with the goal of reducing reoffending rates. The first full results from this project will be published in summer 2014 but initial results have been encouraging. There are currently 14 SIBs in delivery in the UK. The US and Australia have recently launched the first SIBs outside of the UK.

There are still significant barriers to departments adopting SIBs as a mainstream procurement and delivery model. For commissioners, transaction costs for SIBs are high and, while these should reduce as SIBs become larger and more commonplace, there is concern among some commentators that they will remain too high to enable SIBs in some policy areas or SIBs on a very small scale. Gaining buy-in for a SIB from finance, legal and procurement teams is also tricky and takes time, while accessing the data needed to accurately measure outcomes can also be a significant barrier. These are expected to become easier as more SIBs are developed.

There are concerns that current procurement rules limit the innovation that SIBs can provide because they can favour larger providers, disincentivise providers from suggesting solutions to commissioners and makes co-production between commissioner and provider difficult. Cabinet Office is considering the best way to support commissioners and providers with these challenges to enable innovation.

Policy Effectiveness – International Evidence

Small Business Innovation Research Programme

The UK's SBRI was based heavily on a similar programme implemented in the early 1980s in the US called the Small Business Innovation Research programme (SBIR). This programme is similar to the SBRI, although it has been implemented on a much larger scale, and has been successful in fostering innovation in the US over a long period. The programme uses the same phase 1 and 2 principles as the SBRI, as well as a phase 3 which pools additional private funding at the commercialisation stage. The programme awarded $2.3bn of contracts, exclusively to SMEs, in 2010. Eleven Federal Agencies have been mandated to direct 2.5% of their R&D budgets towards the programme since 1997, this will rise to 3.2% by 2017.

The success of the SBIR has been evaluated more comprehensively than the SBRI, with large scale surveys and studies of how firms receiving funding from the SBIR compare with other firms. Most studies report positive findings. Audretsch (2003) summarises these studies and concludes that the "SBIR has generally accomplished its mission by contributing to the creation of high-technology small firms and enhancing U.S. competitiveness" (pg. 1). One study by Lerner (1999) found that over 10 years SBIR-funded firms grew 5 times faster than other firms, and were more successful at attracting venture capital. Another by Lerner & Colin (2001) found that the survival and growth rates of SBIR recipients exceeded those of firms not receiving SBIR funding.

Connell (2006) identifies how the SBIR has contributed to US economic development by:

- Stimulating the development of new technologies and solutions to help its agencies become more effective and meet their strategic objectives,
- Providing start-up funding for entrepreneurs unable to acquire private investment,
- Allowing University scientists to spin out new technologies into successful firms,
- Ensuring R&D provides a solution to a specific need,
- Reducing the time it takes for technologies to reach the market,
- Accepting that most technologies will not succeed but investing across many technologies to ensure the future successes are given the funding and support they need at an early stage.

Many of Connell's recommendations for what the SBRI can learn from the SBIR have been implemented as part of the re-launch of the SBRI in the UK in 2009.

The most comprehensive evaluation of the SBIR concluded that it was sound in theory and effective in practice (Wessner, 2008). The evaluation looked at how successful SBIR-funded firms had been in increasing sales and obtaining investment finances from other sources as indicators of success. This found that even though most firms were unlikely to become large (only 3-4% of firms had cumulative revenues over $5m) this was to be expected given the nature of investing in risky technologies, and was not a sign of failure. Wessner recommended that:

- More regular evaluations should be undertaken,

- The award size of contracts should be more flexible,
- More focus should be put on commercialisation,
- Better MI data should be collected to improve monitoring arrangements.

Some findings for the SBIR have been less positive. Wallsten (2000) concluded that SBIR programme spending was crowding out private R&D spending; a criticism was that the SBIR was making similar investment decisions as the private sector and not investing in more risky technologies. Other concerns were the way firms receiving SBIR funding were owned by larger firms who should be funding their own research activities

Defence Advanced Research Projects Agency (DARPA)

This US agency was set up to provide the US with technological superiority in certain areas related to defence. One of its key success factors is it flexibility, allowing it to be more 'hands on' with its interactions with scientists and academics and adopting a longer term approach to fostering innovation. Successes include funding computer science departments, contributing to semiconductor research, supporting human computer interface research and overseeing the development of the internet (Mazzucato, 2011).

Block (2008) considers DARPA to be successful because it:

- Is staffed by high quality staff with budget autonomy to actively pursue the formation of innovation communities
- Diversifies its research funding activities across academia and all types of firms
- Helps firms get their product to market
- Makes links across its entire research portfolio

Mazzucato argues that DARPA should be a model for an enhanced TSB in the UK, which would have a wider remit and much more funding, to overcome the 'network failure' of innovation in the UK. The TSB would lead the innovation network in this model.

Other international policies

Uyarra (2012) has reviewed a number of programmes from other countries which have attempted to use public procurement as a tool to foster innovation. The Dutch public procurement network (PIANOo) has over 3000 members and allows government procurement officials to share best practice, and access training and conferences. The primary objective of this network was to improve the general procurement skills across government, to ensure better compliance with procurement rules and value for money of contracts. This has been largely achieved, but its impact on improving innovation has been much more limited, as this was a secondary objective.

The EU's 'lead market' programme has not been as successful as expected. This programme was designed to foster growth in 6 new markets which were deemed to be crucial in fostering innovation. These were: eHealth, protective textiles, sustainable construction, recycling, bio-based products and renewable energies.

Public procurement was seen as one of the levers which could be used to stimulate these markets. Subsequent growth in public procurement in these sectors has been mixed: public procurement for e-health and protective textile has been low, while in recycling, bio

products and especially renewable energy the overall level of public procurement has risen. It is difficult to judge how effective procurement policy has been, given other types of support was given to these 6 markets.

It is important to distinguish between a procurement *process* which is in itself innovative, and a process (which may or not be innovative) which leads to the development of an innovative *product*. This chapter has focused on using procurement processes, some of which are innovative such as the SBRI, to develop innovative products (and to a lesser extent services). There may also be scope for government to use elements of innovative processes to inform the way procurement of products not requiring innovation is done. For instance, understanding why the SBRI is effective could have implications for wider government procurement, if there were organisational or managerial structures which made the SBRI effective which could be adopted as good general procurement principles.

Barriers to success

Tension between encouraging innovation and achieving value for money in the short-term

Following recommendations from the Green review of government efficiency the government has committed to making savings by procuring more efficiently. Efficiency savings will come from buying some services centrally, rather than by individual departments, and renegotiating contracts to make them more flexible. Public procurement policy is to award contracts based on the best value for money, defined by HMT as the optimum combination of cost and quality over the lifetime of the project.

The Government has also sought to reduce the number of wider policy objectives that should be delivered through the procurement process in order to make procurement quicker, less complex and more open to smaller suppliers. Government set out its position on using procurement to foster innovation in its evidence to the House of Lords Select Committee's (2011) inquiry on procurement and innovation.

Box 3: Government policy on increasing innovation in procurement

Government is taking steps to ensure procurement processes are increasingly innovative, e.g. in IT. The Government's cloud computing programme (G-Cloud) has already made it easier for government to procure cloud-based IT services. The G-cloud makes procuring these services easier by simplifying the procurement process and creating an open, competitive and transparent marketplace for services.

This has enabled SMEs to access government IT contracts more easily, increasing competition with incumbent IT firms and offering a much more diverse range of services. There are now over 700 firms on G-cloud and contracts are re-competed every 6 months to ensure government is not locked into obsolete technologies. This innovative process should also lead to innovative products being developed which are tailored to individual needs, ultimately making government more efficient. The success of the G-cloud has not been formally evaluated, but early indications are that is operating effectively.

A government official making a procurement decision needs to understand the life cycle costs and benefits associated with each of their options: this will help them balance short term cost savings against more substantial longer term benefits provided by a more expensive (albeit innovative) option. The extent to which analysis of all costs and benefits goes into procurement decisions is unknown, but there is a risk that pressure to make short term savings could lead to less innovative products or services being procured.

It is unclear whether government departments may be less willing to consider using more sophisticated procurement practises if they are more expensive and take longer to deliver a final product or service. The House of Lords (2011) stressed this as a potential problem, but did not cite evidence that it was occurring. NESTA (2012) cited the low cost of established solutions as one of two main reasons why progress has been slow in driving innovation through procurement (the other was inertia).

Government policy reach

Polices such as the SBRI have shown how government can influence innovation, but even once the SBRI budget increases to £200m it will only account for around 0.08% of total government procurement expenditure. Nesta (2012) proposes 1% of procurement expenditure be channelled to directly support innovation, via the TSB (over £2bn a year).

Edler (2011) argues that government could do more to encourage departments to consider innovation when making procurement decisions. This would involve bringing in more 'spending' departments into the debate, who perhaps don't see the link between their core business (e.g. of educating children) and fostering innovation.

Currently, as noted below, departments have limited incentives to procure more expensive and risky, albeit innovative, solutions. The need for innovation would have to be managed against the need to ensure procurement fulfils its core function of securing needed goods and services on time, which offer good VfM.

Central government has adopted a more stringent approach to fostering innovation through its own programmes, such as the SBRI, but as noted, a large portion of total government procurement expenditure is made at the local level.

The House of Lords (2011) recommended that central government should share best procurement practice with local government to help encourage officials to consider innovation when making procurement decisions. There will be many procurement decisions at central/local government level, which will not need to consider innovation. The task will be to identify spending areas where innovation is a relevant criterion.

Institutional organisation and capacity

Procurement decisions can too often be made in isolation to policy design. Often a policy team develops a great policy and then hands it over to the procurement team to purchase an off-the-shelf solution. This approach is ineffective when the product which is being procured does not exist, or must be adapted to provide a solution to a problem. Policy must be developed in conversation with suppliers.

As part of work to open up public procurement to SMEs and ensure that it stimulates economic growth, Government has placed greater emphasis on the need to conduct proper early market engagement before the formal procurement process starts. Early market engagement enables government to understand what the market is able to deliver, and allows suppliers to understand earlier what government needs are.

The Public Services Industry review noted how poor commissioning skills in government were a barrier to successful procurement. Attention needs to be paid to the whole cycle, including "strategic market planning, project management and evaluation" (Julius, 2008).

A potential barrier in some Departments is that procurement teams are located physically on separate sites, which can further disconnect the commissioning cycle. Procuring innovative solutions requires an even higher set of procurement skills; this includes understanding the technical specifications of the products being procured and an understanding of how the market operates.

Culture and risk

Mazzucato notes that the SBRI has suffered because it is "at odds with the culture of the procurement offices of national government" (2011, pg. 92). Perhaps the most significant, but also most deep-seated barrier is the way government handles risk. Investing in innovative solutions is by their nature more risky than using tried and tested technologies. Individual decision makers in government are generally not rewarded for risk-taking behaviour, in the same way their peers in private firms are. It could be worth exploring how private sector reward mechanisms could be deployed in the public sector.

This risk-averse culture is rational given the incentives faced by procurers and it will be difficult to put the incentives in place to encourage more risk taking behaviour. Some behaviour change can be mandated (such as requiring government departments to devote a proportion of procurement spending to more risky investments), but mostly it will involve a longer term approach to changing department cultures. This can only occur if ministers and senior officials lead this change.

For a culture change to work Departments would need to recognise that risky investments often fail to give returns and they would need to take a portfolio approach to investment.

Conclusions and areas for further work

- It should be looked into whether the TSB could do more to share data on the success of the SBRI and other initiatives, and report on the innovation activity of departments, perhaps in the form of an Innovation audit. Robust evaluations require good data; departments could be encouraged to share their own procurement data such as contract volumes, success ratios and spending levels. This would help establish how successful the SBRI has been in fostering innovation, and encourage other Departments to use the SBRI as a vehicle to increase the flow of innovative technologies.

- Recommendations in the literature to improve the SBRI include: (i) Introducing a US style 'phase 3' into the process so that firms have more help in commercialising their technologies, (ii) allowing some departments or providers, such as the NHS, to be given their own pot of SBRI cash to help embed an internal focus on innovation (iii) ensuring examples of good practice, such as departmental management board activity, are shared across government (iv) encourage investments which are made through the SBRI to be more risky and create an environment where failure is acceptable.

- More work could be done to learn practical lessons from the SBIR and apply them to the SBRI, perhaps by embedding UK officials into the US programme or vice versa.

- Work could be done to encourage policy officials to engage with procurement officials at an earlier stage of policy development, to ensure procurement is not an afterthought but a way of improving the policy outcomes.

- Analysts could provide more support to policy teams and procurement professionals when they consider the costs and benefits of procuring a solution, as part of the option appraisal process. This could include exploring the costs and benefits of more innovative solutions.

- Explore how to encourage risk taking in government by gaining insights from the private sector or other successful risk taking organisations. This could result in adopting a more holistic approach towards procurement, incorporating other points in this section.

- Departments should be more proactive in identifying their innovation needs, where the need an innovative solution to help them deliver their objectives, and consider how their procurement can be shaped to achieve this.

- Government policies aiming to increase innovation should be evaluated more consistently and consider the impact that the procurement process had on fostering innovation, and consider the effect these innovations had on firms and government.

Questions for further research

- Explore how possible tensions when procuring between making efficiencies and encouraging innovation is being handled in government, perhaps by surveying government officials and firms, to assess whether this is an issue.

- Consider how successful Departments with the largest procurement budgets have been in fostering innovation.

- Consider why DARPA in the US has been so successful in producing innovative products that have been commercialised, and what barriers exist for the MoD/Dstl to replicate this success.

- Consider what challenges the NHS faces in procuring innovative products, given the nature of the market it operates in. Is there scope to learn lessons from procuring innovation in the private health sector?

- Consider what data is needed to be able to undertake the impact evaluations Uyarra (2012) notes have not yet been carried out anywhere.

- Compare the success of SBRI and other forms of innovation procurement with Challenge Prizes, and consider what lessons can be learned from offering prizes for procurement innovations.

- Consider if there are lessons to be learnt from the success of innovative procurement processes that could be applied to ‘everyday’ procurement.

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Chapter 5: The Balance between Push and Pull Policies

Summary

- **The appropriate balance of demand (pull) and supply (push) policies for innovation varies both across sectors and different stages of the development cycle. It is not clear that policy design in the UK has taken this into account and Government could do more to take a** holistic look at its support in different sectors**. This could include assessing bottlenecks, materiality, integration and appropriateness of policy instruments. However, this would require further concrete evidence on the innovation impacts of alternative policies.**

- **There are arguments that in the past the government has acted as a "market shaper" and an essential risk-taker. This implies that when considering the role of the state we should go beyond traditional market failures perspectives to take a** wider, more activist view of Government's role **in leading the development of new technologies and addressing 'grand challenges'.**

- **Many innovations will fail, and in practice this means taking a 'portfolio approach', recognising that failure is part of the process. The skewed nature of the returns to innovation means that government should maintain an appropriate appetite for risk as** one 'big win' can more than outweigh the costs of other failures. **It is worth investigating further whether current approaches are overly risk averse.**

Introduction

Policies to encourage innovation can broadly be categorised as either technology (supply) 'push' or market (demand) 'pull' policies.

- **Push policies** are those that support the research, development and demonstration (RD&D) of new or enhanced technologies. Examples include direct grant support, equity funding, and prizes

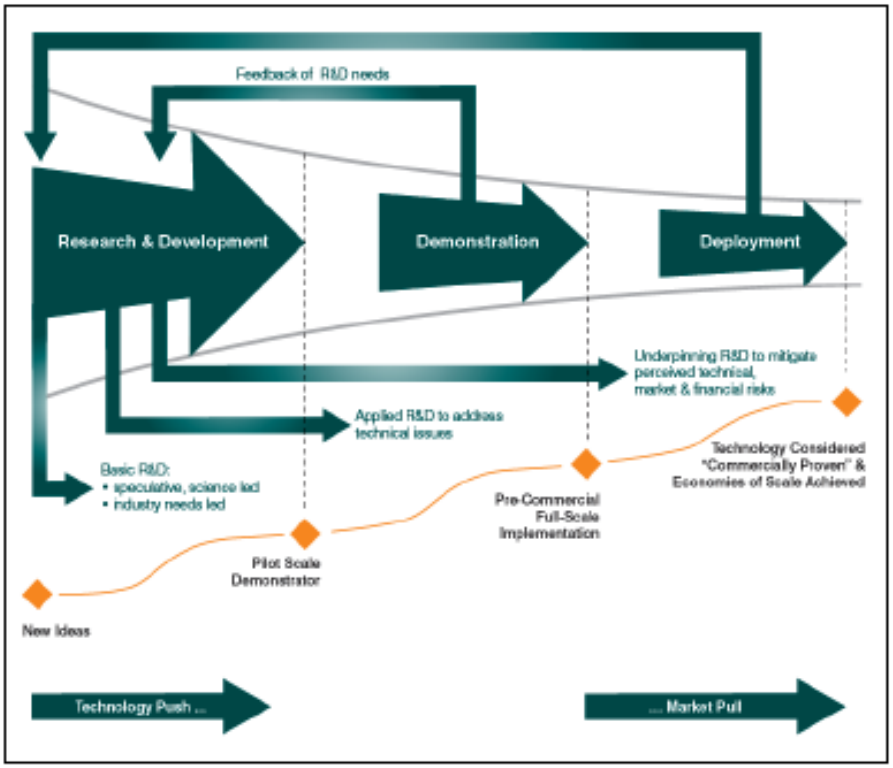
- **Pull policies** aim to provide support for the deployment of technologies as they get closer to maturity, for example through subsidies or regulation.

Figure 12 below provides an illustration of the general process of technology development. This is often presented as a chain, but it is important to recognise that feedbacks occur at all stages and it is not a simple linear process. It should also be kept in mind that there will be differences between sectors / areas of innovation and research.

From a policy perspective, there is broad agreement in the literature that **innovation should be driven by a combination of push and pull policies**. There is no 'one size fits all' solution to supporting technologies, and the balance and necessity of public support will vary from case to case. In practice, while the distinction between push and pull policies can be helpful when thinking about how they work, many policies are a mix of the two.

There is lively debate on the role of the state in driving innovation. On the one hand, there are arguments that reducing state interference will reduce the barriers in the way of prospective innovators, enabling a new wave of innovation (The Economist, 2011). On the other, academics and commentators point to the potential for there to be a targeted, proactive, entrepreneurial state, able to take risks over the long term and so act as a catalyst to innovation.

Figure 12: The innovation process



Source: Energy Research Partnership (2008)

In particular, given the increasing prominence of 'grand challenges' which may significantly hinder growth if not addressed (clean / cheap energy; demographic change, etc.), there are arguments that a more activist approach would allow these issues to be addressed more strategically than with a neo-classical, market orientated approach (Mazzucato, 2011). This debate is unlikely to be settled any time soon, though the challenge that this latter view poses to the traditional market failures cased view of the role for the state in encouraging innovation should not be overlooked.

In the standard view, the need for government support for push and pull innovation will depend on market characteristics, most notably the degree to which there are market failures and barriers present that public involvement can overcome.

Arguably most important are spillover effects stemming from a lack of appropriability – where there are positive externalities due to the benefit to the innovator being less than the benefit to society overall. Other common failures / barriers include high upfront costs and long payback periods, poor access to finance, and path dependency of previous investments due to market power and dominant designs.

Push policies may help overcome these market failures. Demand pull policies are more likely to be required where there are dominant designs (as incumbents benefit from network externalities), high levels of uncertainty or with low product differentiation.

Many policy instruments are available, summarised in Table 5, which will be applicable at different times in the innovation life process. Whatever instruments are used, it is important that they are linked and integrated. Again, it will often be the case that policies in practice have elements of both push and pull innovation, so this should be seen as a simple, indicative list. Also some instruments such as prizes can be formulated as both push or pull policies.

Table 5: Push and pull policy instruments

	'Push' policy instruments
Grants	Increase the amount of investment in innovation that takes place by providing direct funding for specific projects. Useful when market failures mean the private sector will be unlikely to undertake research in a given area, and when government wishes to direct the research
Matched equity funding	Align incentives of the innovator and those providing finance, matched equity funding directly addresses some information problems associated with grants, but problems of its own.
Prizes	Useful in specifying the ultimate outcome of a low carbon technology innovation (rather than how an outcome is achieved). More likely to be implemented when a research effort is required to solve a specific problem
Incubator / value added schemes	Providing professional support and advice to develop both technologies and management teams, progressing technology to commercialisation.
Venture Capital	Can address problems regarding access to finance, if private sector is seen to be overly risk averse. Allows government to maintain a stake in investments. Some difficulties with government accounting rules.
Pre-commercial procurement	Government procurement of immature products / technologies. Likely to be applicable in fairly specific circumstances.
General advice / loan support	To address information failures and/or when requisite skills are lacking
	'Pull' policy instruments
Labelling	Relates more to eco-innovation. Likely to be more suitable for mature product markets with relatively standardised products – encouraging product differentiation in otherwise "dull" markets
Subsidies / Feed-in tariffs	Applicable in certain instances, e.g. in the roll-out of low carbon energy technologies. Unlikely to be widely applicable
Information campaigns	Can be useful where there are information failures hindering deployment that the private sector cannot address alone
Prizes	Useful in directing research towards specific problems by augmenting market based profits with a non-market financial incentive.
Procurement	See Chapter 4
Tax credits	See Chapter 3
Standards / regulation	See Chapter 7

Private investment will always play a crucial role in innovation, and is influenced by a range of factors including: expected returns, the cost of capital, its availability, perceived risks (demand, technological, regulatory and political), and the extent to which firms can enter and exit markets. The correct balance between push and pull is part of the picture, but altogether a 'productive ecosystem' is required to encourage innovation, including conditions in which risks can be understood, managed and anticipated. Government may have a role in providing insurance and guarantees in relation to some of these risks.

A sectoral comparison

While some variation between sectors is expected, it is interesting to note that the balance between push and pull can vary significantly. In general, while push policies appear to be the most common form of support, in the energy sector the opposite is true. Table 6 summarises the forms of support in several sectors. It is intended only to provide an illustration of the difference support 'types' rather than providing any concrete policy proposals, and should be understood as such.

Table 6: Pull and pull support by (selected) sectors

Sector	Current support	Notes
Agriculture	Push	Support has tended to be direct support for R&D. Market failures / barriers tend to be around spillover benefits, high costs and uncertain demand. There is some discussion of pull support in the literature, where funders seek to engage the private sector and pay only when specified outcomes are delivered and adopted (Elliot 2010).
Defence	Both	Government provides both types of support: push through funding for technology development, and pull through acting as a purchaser and providing guaranteed markets. Examples of rapid innovation and technological development in WW1&2, and of technologies such as GPS and the internet which were developed through US military research programmes.
Energy	Both Primarily pull	Deployment support (pull) through the Renewables Obligation forms the bulk of UK support - £2.3bn in 2012/13 rising to £7.6bn in 2020/21. This is compared to around £0.3bn annual total cross-government spend for R&D (push) support. It should be noted that deployment support is focused on meeting EU targets and that innovation is a secondary objective (though several organisations have called for an increase in UK R&D spend). Some argue that the balance of spending should be shifted to push support for the next generation renewables that stand a better chance of being cost competitive.
Health	Both	Traditionally grants from medical research councils on the push side, with pull support coming from the NHS as a purchaser. Over the last decade some new pull mechanisms have been introduced, such as grants for deployment. There is some discussion of potential role for prize systems (Stiglitz, 2007).
Manufacturing	Push	A large sector with significant variation. While this should be kept

Sector	Current support	Notes
		in mind, this is arguably the sector where it is left most to the market (with exceptions), though government still provides active support, in particular through R&D tax credits (see Chapter 3)

The literature on differences between sectors is relatively thin, and in general there is little discussion and evidence on why there is this variation between largely push on one side (e.g. agriculture) and largely pull on the other (energy). In general, and as noted by the OECD in the context of energy policy, there is little concrete evidence on the respective innovation impacts of alternative policies (OECD, 2012).

While a sectoral comparison is interesting, it is important to recognise that the balance of support is also highly dependent on where an innovation is in the technology cycle. It is vital to avoid bottlenecks and to seek to overcome the “valley of death”, where new technologies fail to cross the gap between applied research and technology demonstration due to a lack of funding. There is the risk of short-term thinking leading to a reduced focus on the long-term potential of new technologies and their potential benefits – this reinforces the need for sector / technology experts to be involved in the policy design process.

It is not always evident that the correct push / pull balance has been actively considered as part of the policy process. In some cases it seems that the current approach is simply based on what has been done before. It is beyond the scope of this paper to consider individual sectors in detail. However, four suggested issues for any specific sector assessment are as follows:

- **Bottlenecks** – whether there are inefficiencies in the current approach stemming from a lack of / excess of funding at particular points in the technology development process
- **Materiality** – whether levels of support are sufficient to achieve policy aims
- **Integration** – whether policy instruments are sufficiently integrated and take a holistic approach to support over the entire technology development cycle
- **Appropriateness** – whether policy instruments are the best available to achieve the intended outcomes, and whether non-traditional forms of support would be preferable. This includes whether policies provide the necessary certainty required for private companies to invest.

Handling Risk

Determining the appropriate balance of push and pull support is intrinsically linked to questions around the appropriate level of support. This, in turn, leads to the issue of the extent to which government should be willing to take risks.

Most innovations ultimately fail to reach successful commercial deployment, however the nature of the innovation process is such that one ‘big win’ can more than compensate for numerous failures. In her book, for the US Marianna Mazzucato points to public support for the GPS and the internet, as well as companies such as Apple, Compaq and Intel when they were at early stages of development, as examples of such successes.

In the US, the National Academy of Sciences (2001) examined 17 federal R&D programmes in energy efficiency, estimating that the return on the $300m investment was around $30bn. This was attributed almost entirely to the success of 3 of the 17 programmes, illustrating the huge variability in programme returns.

This lends support to the idea of taking a 'portfolio approach', supporting a range of projects and to not see all failures as a waste of money, but rather an inevitable (possibly even necessary) part of the innovation process. The report also illustrates the benefits that can come from linking policies across the push / pull process, as the significant benefits were largely driven by regulatory standards requiring the adoption of the new energy efficiency, ensuring their wide deployment.

The issues addressed here also link to questions around intellectual property and the extent to which government should seek to maintain a stake in companies and technologies that have been funded. For brevity these are not discussed in any detail here, though their importance is recognised.

International considerations

It is difficult to set UK policy regarding the appropriate push / pull balance in an international context, not least due to the wide variety of sectors and policy instruments. While no international comparison on this specific issue appears to have been undertaken, international comparisons of innovation policy by the OECD (2005, 2008) do highlight some factors of interest. Eurostat and OECD data show that R&D intensity (as measured by gross domestic expenditure on R&D as a share of GDP) tends to be lower in the UK than the EU average. For example, 1.8% compared to 2.0% in 2010.

While the UK is seen to have a relatively generous R&D tax credits framework, this may be indicative of lower levels of push support than in other (similar) countries. Whilst some of this difference is explained by sector, a notable gap still remains.

As noted in Table 6, the energy sector is one of the larger sectors for UK 'push' spending. However, the International Energy Agency suggest that a significant increase in R&D spending is still needed, and call for an increase based on the need for UK funding "*to reflect the country's industrial and intellectual comparative advantage*". The European Commission has also estimated that current EU R&D spending is around one quarter of that needed to deliver the Strategic Energy Technology plan (and the UK is relatively speaking a low spender, compared to other counties).

For venture capital (VC), the UK performs better relative to the OECD average. However, the OECD find that major institutional investors in the UK have tended to invest less in VC compared to their US counterparts, most likely due to financial regulations; which may have played a role in reducing the supply of private equity.[25] Some of this may also be explained by the UK offering a smaller market (thus potentially smaller returns to scale) than the US.

While government funding is just one part of the picture, in some sectors there is a risk that current R&D funding levels may be insufficient to drive technologies through to near-market development. In others, the lack of pull support could mean that near-commercial technologies stagnate and are not ultimately widely adopted. These issues will be best

[25] The 1986 Finance Act excluded the majority of UK pension funds from investing directly in private equity funds. In addition the Minimum Funding Requirement – which came into force in 1997 – required schemes to hold a minimum level of assets, mainly government debt, to meet liabilities.

addressed in a sector-specific manner, though should be given active consideration by policy-makers, with a focus on how policies sit in the wider international context.

Conclusions and areas for further work

In general, there is little concrete evidence on the innovation impacts of alternative policies. Expansions of the evidence base in this area could improve policy design and ultimately increase the UK's innovative capacity.

The argument that the market failures approach ignores systematic innovation issues and that government should (and does) act as a "market shaper" merits further scrutiny. In particular would an activist rather than neo-classical, market-orientated approach allow 'grand challenges' to be addressed more strategically?

We suggest looking in more detail at why the balance between push and pull policies varies so significantly between sectors. Government should do more to take a holistic look at its support in different sectors, perhaps as part of the industrial strategy, with a view to considering whether current sectoral approaches pose risks to the development of new technologies. Within any sector, this could include assessing bottlenecks, materiality, integration and appropriateness of policy instruments

There is also an argument that Government should be willing to take more risks, and we should give appropriate consideration to whether current approaches are overly risk averse through encouraging 'safe bets' rather than high-risk / reward project.

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Chapter 6: Access to Finance

Summary

- **There are strong theoretical reasons to expect that** innovative firms find it harder to obtain finance**. Empirical evidence is largely supportive of this proposition, but it is less clear what effect this has on innovation and growth.**

- **Given this,** it would be valuable to have a better understanding of the link between finance constrained firms and innovation**. Distinct from the role of small and young firms in driving growth.**

- **Two policy initiatives worth highlighting include the** Business Bank **(and its role in adding new funding and streamlining programmes and management) and work by the IPO looking at the lack of use of** intangible assets, particularly for debt finance**. This is a major barrier to gaining external finance for innovative firms. The IPO's proposals are worth further consideration as potentially highly cost effective, structural interventions by government.**

Introduction

This chapter examines the ability of innovative firms to access external forms of finance. An environment in which external finance is sufficiently available is critical to the process of funding investments in innovation. Barriers that inhibit sufficient access to finance could have significant effects on innovation and the wider economy.

This chapter focuses on debt finance in particular, as an issue that has recurred as a particularly problematic theme in the course of research and discussion with stakeholders. Equity finance is an area where the UK does relatively well compared to other European countries and is discussed only briefly.

The economics of access to finance for innovation is briefly outlined, followed by an overview of existing policies. The evidence for a problem in access to finance and its impact on innovation and the wider economy is subsequently discussed. The final section contains a short conclusion and exploration of further areas of work.

The Economics of access to finance for innovation

Firms can draw upon a range of potential sources of finance. These include internal financing from retained earnings or an owner's personal funds and external finance including debt and equity. The use of different sources of finance may vary over the lifecycle of a firm[26] but the critical point is whether a firm facing internal finance constraints is able to access external finance to fund projects. Where a firm cannot, or the finance is too expensive projects that may lead to growth and / or innovation may not be undertaken.

[26] Berger and Udell (1998) propose a lifecycle of different forms of finance. External finance is likely to be used later in a firm's life as the firm faces fewer constraints in obtaining it. Internal financing is in turn more likely for a younger firm for reasons outlined in this section.

A variety of firms' characteristics, including their innovativeness, can constrain their ability to obtain external finance. Generally speaking, the provision of finance to firms can be characterised as a principal-agent problem. Compared to a lender or investor, firms have a much greater understanding of their internal capabilities and the risk associated with their projects.

This asymmetry of information between the two parties can lead to higher premiums being charged for the provision of finance, a requirement for more collateral and / or a track record or in some cases the non-provision of finance. The problem of asymmetric information can be exacerbated where firms are young and / or small.

- **Young firms** in particular will often lack track records by which financiers can judge the riskiness of providing finance.

- **Small firms,** as a secondary issue, have fewer disclosure requirements of larger firms which can exacerbate the information asymmetry.

Innovative can find this principal-agent problem exacerbated in several ways:

- Innovation is often **uncertain and risky**, meaning that often neither the firm nor the financier can make an accurate judgement of likely outcomes. This can raise the exposure of an external financier to losses.

- Many innovative firms may have a significant amount of intangible capital (such as IP, trade secrets or design rights) and relatively **little tangible capital**. This can be problematic where a financier requires tangible collateral to reduce or minimise their risk exposure. Ultimately this is an issue of the difficulty in valuing intangible capital. In such circumstances firms may find it difficult to obtain external finance even in cases where the finance would be serviceable by the firm.

- Judging the potential value of innovation can also require greater **expertise**. External financiers may lack such expertise and this can raise the information asymmetry between firm and financier.

- The nature of innovation as a process that is often high-risk and high-return can lead to a particularly **skewed distribution of returns**. A very small number of large successes can create a good average return even with many failures.

These factors can make debt finance very difficult to obtain and tends to be why equity finance is a better source. However, venture capital and private equity face high fixed due diligence costs for each deal they make, which tends to incentivise fewer larger deals.

This can make it difficult for firms seeking only small amounts of funding, as well as those who may be innovative but unlikely to obtain the very significant returns (or over a sufficiently short enough time period) to be a candidate for equity investment. Many firms are also reluctant to take equity finance as it can dilute future returns as well as cede some control of the firm. These issues mean equity investments, while important for innovation, to only a relatively small subset of firms.

Evidence of difficulties obtaining finance

It is worth noting at the outset that most firms do not seek finance and a majority that do are able to obtain it. For example, evidence from SME Finance Monitor showed that 44% of firms used external finance in Q2 2013. Of those accessing bank loans 58% received

finance between Q1 2012-Q2 2013. In another survey of SMEs only 24% sought finance and of those 34% had trouble obtaining finance with 16% not getting finance from any source (Lee et al., 2013).

The evidence suggests that it is a minority of SMEs seeking finance that face difficulties. Added to this group may be any firms that were discouraged from attempting to access finance. To understand whether there are particular problems in access to finance for *innovative firms* and whether government intervention is value for money requires evidence on two things, each discussed in turn:

- **Are innovative firms less likely to either seek or obtain finance compared to other non-innovative firms?**
- **Is the lack of finance for innovative firms a substantial problem?**

Brief outline of existing UK policies

The government operates a number of schemes aimed broadly at facilitating access to finance for SMEs, where evidence suggests access to finance is most constrained. While many do not directly target innovative firms, most will nevertheless be applicable and of benefit to small innovative firms.[27]

Box 4: Key SME Loan Policies

Enterprise Finance Guarantee (EFG): a loan guarantee scheme to facilitate lending to SMEs that lack security or a proven track record. The government guarantees up to 75% for each individual facility, subject to a cap on total claims from each lender.

Funding for Lending: allows banks to borrow at cheaper rates and creates incentives for additional lending.

Start-Up Loans: provides a loan and mentoring to individuals starting a business. Previously restricted to 18-30 year olds but now open to all. Repayment is at a fixed interest and over a period of up to 5 years. **Business Angel Co-Investment Fund:** government co-invests alongside syndicates of business angels.

Enterprise Capital Fund: designed to assist smaller innovative companies that fall in the 'equity gap' due to the costs of diligence. Government contributes up to £25m or 2/3rds of a fund alongside private investment.

UK Innovation Investment Fund: venture capital fund of funds investing in technology based businesses.

A variety of **tax schemes** that encourage investors including: the Venture Capital Trust Scheme, Enterprise Investment Scheme and Seed Enterprise Investment Scheme.

[27] For more information on SME schemes see '*SME Access to Finance Schemes'* (2013): https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/192618/bis-13-p176b-sme-access-to-finance-measures.pdf

In addition to existing UK policies it is worth briefly discussing a few key policy initiatives that have a significant effect in this area. They each fall into two broad categories: policies to increase the flow of capital to the market through provision of government funding and policies to improve the functioning of the capital markets.

- The first is the **Business Bank** which will, in line with existing government schemes run by Capital for Lending, be able to take into consideration wider social benefits when making lending decisions. This allows for the possibility of investment in innovation that banks would not normally consider. The Business Bank and its subsidiary policies can be thought of as a measure to increase the flow of capital to the market through government funding.

- The second is recent work conducted by the IPO (IPO, 2013) examining **the role of intangibles, particularly in debt finance**. The report finds that knowledge assets are not effectively used in mainstream lending in the UK. This presents a major problem for innovative firms who may lack tangible capital as collateral but who often have significant intangible capital.

Do innovative firms struggle to obtain finance?

As outlined above, there are substantial theoretical reasons to believe that innovative firms struggle more to obtain finance compared to otherwise similar firms. Empirical evidence on this question is somewhat mixed, but it is clear that access to finance, particularly around debt (given its contribution to overall finance), is consistently reported as a problem by innovative firms and SMEs in general.

Debt finance

The Big Innovation Centre (BIC) found that while innovative firms are more likely to apply for finance they are less likely to receive it. Their study found that 44% of innovative firms who tried to obtain finance found it difficult to do so, which compared to 33% of other firms. This is likely to be due to reasons outlined above, including the inherently riskier nature of many SMEs, often lacking a track record, combined with the uncertainty of innovation and the lack of tangible assets to use as collateral. The recession was also found to have exacerbated these issues.

Data from the Community Innovation Survey, summarised in BIS (2011), also shows that small firms (10-250 employees) regard access to finance and the cost of finance as ‘high’ barriers to entry (16% and 17% of firms respectively reported it as ‘high’). Far fewer larger firms report finance as an obstacle, but it is still one of the most cited barriers they face (behind cost and excessive perceived risk).

A report from the IPO (Brassel and King, 2013) examines the issues around using IP (an intangible asset) as collateral for external finance. The report finds that broadly speaking, banks do not accept intangible assets as a form of collateral. It is, however, an important consideration in equity and venture capital. The lack of use in debt finance is problematic for innovative firms who may be able to service a loan but, as noted above, lack tangible collateral that banks require to minimise their risk exposure.

Another recent report from the BIC (Sameen and Quested, 2013) also supports the findings of the IPO. The report found that firms are much more likely to finance their intangible assets through equity rather than debt. This supports the argument that equity investments are much better at valuing and funding intangible assets. However, the report also found that small high-growth firms were reliant on debt finance and that banks were

more concerned with cash flows and repayment of a loan of rather than value of the business. This makes banks unlikely to support innovation.

In contrast, a study by FINNOV (Mina et. al 2011) sampling US and UK firms in 2001/2003 found that:

- There was little relationship between indicators of innovation (including R&D and developing products, processes and organisational innovation) and demand for finance.
- A much stronger relationship was found for innovation and the supply of finance. In particular the development of product and process innovation was positively related to obtaining finance. However, this effect was driven by the US sample, suggesting external finance in the US is better at rewarding innovation.
- The UK sample found little relationship between indicators of innovation and obtaining finance, aside from the development of organisational innovation which had a positive relationship (but was weaker than the US sample).
- Pay-off period of innovation and breadth of IP protection did have negative relationships to obtaining finance but this effect was much stronger in the US sample.

There is as such a somewhat mixed picture about the extent to which the access and cost of finance is a problem. Part of this may be driven by varying definitions of an 'innovative' firm as well as when the study was conducted. The weight of evidence nevertheless suggests that access to finance is regarded as a major barrier for innovation for at least a sizable subset of firms. The evidence also clearly shows that on the debt side there are significant issues with banks not recognising intangible assets as forms of collateral.

Equity Finance

The majority of external finance that is obtained is in the form of bank loans (48%) and bank overdrafts (35%). Equity investments typically make up a very small proportion of the overall market (2%).[28] While small, these investments make a significant contribution to the economy averaging around £450m for venture capital and £1.09bn for angel investments over the last 7 years.[29] As noted above, the BIC has also found that firms are much more likely to use equity rather than debt to fund investments in intangible assets.

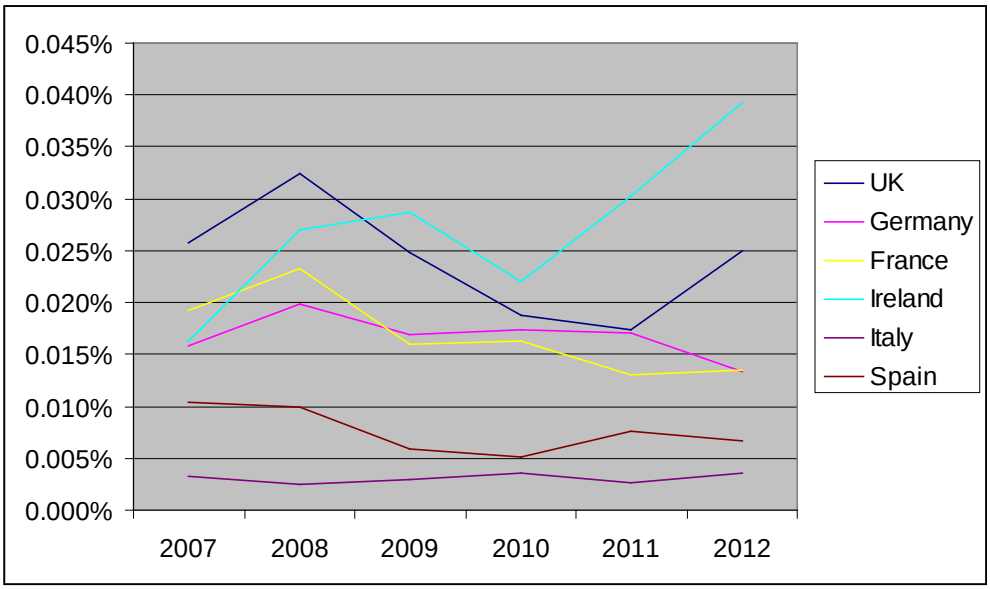
The UK lags behind the US in equity finance but is generally considered relatively strong in the provision of venture capital and equity finance in comparison to other European countries, as demonstrated by Figure 13.

However, as noted above, due to high fixed due diligence costs, equity finance is, incentivised to providing fewer and larger investments. This can create an undersupply of equity investment at the smaller end of the market, reducing financing to smaller firms that may generate substantial innovation and future growth.

[28] Figures are for 2012 and from the Small Business Survey: https://www.gov.uk/government/publications/small-business-survey-2012-sme-employers
[29] Internal BIS estimates.

The importance of equity finance and potential challenges in accessing it implies two potential avenues for government intervention: supporting funding directly through policies such as the Enterprise Capital Fund and supporting policies that help to alter the structure of the market, particularly around lowering due diligence costs. Policies such as the Business Angel Co-Investment Fund have, as one of their stated objectives, the goal of ensuring that deals are well structured to spread best practice. This existing policy may thus help to lower due diligence costs. Further exploration may be warranted on how successful the Co-Fund has been and how new and existing policies can further push structural reform.

Figure 13: Early stage Venture Capital as a % of GDP



Source: Eurostat 2013

Is the lack of finance for innovative firms a substantial problem?

Difficulties among some innovative firms obtaining finance does not in itself mean there is a substantive market failure which requires government intervention. Firms that fail to access finance may not, even with finance, generate significant innovation and growth. Reasons may include other characteristics such as a firm's management capabilities, level of human capital and the 'quality' of innovation, which if poor, could inhibit a firm's growth potential regardless of finance.

Policy design should as such be concerned with identifying where intervention is most cost effective. This includes consideration of:

- The potential of firms being targeted to generate innovation and growth.
- The impact of government intervention on a firms innovation and growth prospects.
- The cost of government intervention.

There appears to be little literature linking the provision of finance to those firms that struggle to receive it and the effect on innovation. There is also only limited indirect evidence of the impact of government intervention on innovation.

What the evidence shows is that at any one time, it is a small minority of firms who generate the majority of growth and that innovation is important to their success. For example, Nesta (2009) found 6% of firms with the highest growth rates generated half of new jobs created by existing businesses between 2002 and 2008. They also found that innovation was a key driver of growth in these firms.[30]

The Nesta study also found that while younger firms are more likely to be high growth, most (70%) are 5+ years old. Most start-ups do not survive and most remain small. A recent discussion (Nightingale & Coad, 2011) of the academic literature also reinforces the point that a very small minority of SMEs and start-ups actually generate significant growth.

These findings suggest that government support might be best targeted at those firms that have the potential to generate substantial innovation and growth rather than broader support for all firms. However, this does not rule out the possibility that at least some finance-constrained firms could generate significant innovation and growth and warrant government intervention.

One indirect measure of the link between finance constrained firms and innovation is evaluation of existing government policy in this area. A recent evaluation into the Enterprise Finance Guarantee (EFG) (BIS, 2013) provides some indication of the quality of firms that are unable to obtain finance through traditional channels:

- **High additionality** – 83% of users indicated they would not have obtained a loan without EFG. The proportion using EFG with collateral available was also lower than other borrowing businesses.

- **Similar performance to other borrowing businesses** – achieving 33% increase in sales over the period (35% for other borrowing businesses) and higher than non-borrowers (25%). Employment growth was only 21% for EFG recipients compared to 31% for other borrowers (and 11% for non-borrowers). Econometric analysis suggests this is down to business characteristics (e.g. EFG recipients tend to be younger) and recipients are not inferior businesses.

- The **default rate for EFG loans is significantly higher** – suggesting that banks may be justified in their caution toward lending to these businesses.

- The **scheme only encompasses 1-2% of SME lending** – meaning net impact on SME finance is likely to be small. Take-up has fallen year on year since 2009 (when the scheme was launched).

The evaluation suggests that those firms being lent finance through the scheme achieve on average a positive outcome, albeit at a lower level than businesses that borrow without the scheme.

The findings reflect all firms who used the facility and do not distinguish between those that might be considered ‘innovative’. This is a key limitation in the context of this paper. However, the scheme’s rationale is potentially highly applicable to many innovative firms that, lack tangible collateral but can service a debt. It may therefore offer a limited proxy of the value of intervention for innovative firms.

[30] It is important to note however that there was no guarantee that firms who contributed strongly to growth in one period do so in subsequent periods.

Conclusions and areas for further work

Overall the literature suggests that while most firms do not seek finance, and of those that do seek it most obtain it – this may not be the case for small and innovative firms. Evidence on the growth impacts of these barriers to finance is much harder to come by however and largely derived from studies of small and young firms.

In considering the role of government policy and the value for money of intervention **it would be valuable to have a better understanding of the link between finance constrained firms and innovation** (Distinct from the role of small and young firms in driving growth). A number of different dimensions could be considered including:

- **Impact on innovation growth**: does access to finance lead to higher levels of innovation or growth? How do government backed schemes affect innovation and growth? How does this compare with firms accessing finance outside government schemes?

- **Quality of Firm:** What are the characteristics of innovative firms that struggle to obtain finance? Other weaknesses of a firm may inhibit its ability to grow even with finance.

- **Quality of Innovation**: Attempting to quantify the 'value' of the innovation generated by firms that are finance constrained. This is a difficult question to answer, but one route may be the use of more policy experimentation and evaluation to see the effect of different interventions on outcomes in terms such as employment and turnover.

- **Finance for Innovation**: We need a better understanding of what types of finance innovative firms actually need. For example it is often assumed that Venture Capital is the most appropriate, but is this actually the case?

Given the limited evidence around the potential impact of policy in this area, the proposals in the IPO's report are particularly worth further consideration as potentially highly cost effective, structural interventions by government. Recommendations include:

- **Robust IP valuation is possible** and processes already exist for some intangibles. These techniques should be developed and adopted more widely.

- Tools to **identify and describe** intangible assets needed to be embedded in the lending process, as does training in due diligence.

- Support for **effective IP markets** to allow for a proper asset class to emerge. Government can help in the registry and tracking of IP.

- **Creating markets for risk mitigation** will help, but it requires demand from lenders who are using IP.

Cutting across both of these areas is the question **how does the UK compare internationally** in terms of access of finance for innovative companies?

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Chapter 7: Regulation

Summary

- Regulation impacts on innovation through a number of channels**, although some such as Intellectual Property Rights (IPRs) are direct concerned with innovation, other impact on innovation through wider market mechanisms.**

- The impact of most types of regulation on innovation is ambiguous**,** and the wide-ranging literature on this topic offers relatively few clear-cut prescriptions. **The net benefit of a particular regulatory approach appears to depend heavily on the context in which it is applied, including both industry characteristics and the stage of technological development. For example:**
  - **In general product market regulation tends to reduce innovation, by imposing costs on businesses and reducing competition**
  - **However, some product regulation can increase innovation (and diffusion) by incentivising firms to meet new standards.**
  - **The relationship between competition and innovation is complex. More competition can spur innovation, but if a firm cannot benefit from (temporary) super-normal profits, it may not be worth incurring the costs of innovation.**

- **These uncertainties imply few policy conclusions. However, broad lessons include:**
  - **Flexible, outcome-based regulations can increase the chances of a positive impact**
  - **Regulators (broadly defined) should be more conscious of innovation. This entails being aware of the risk that some existing regulations could be hampering positive innovation, but also that eliminating other regulations could also hamper innovation**
  - **Experts on the stage of development and future prospects of particular technologies should be involved when policies, including regulation, are designed for innovative industries**

Introduction

Regulation can impact on innovation through a number of channels, these are discussed in more detail below, but broadly they fall into three groups:

- **Firms' incentives to innovate** – either directly through legal penalties for failing to meet regulatory standards, or indirectly through competitive pressures
- **Resources available** for firms to invest in innovation
- **Ease of market entry** and mobility of resources between firms.

Although certain specialist areas of regulation may have particular impacts on innovation (for example the insolvency regime), we focus on the four main types of regulatory activity:

- **Product market and social regulations**[31]
- **Competition regulation**
- **Labour market regulation**
- **Intellectual Property regime**

Product Market Regulation (PMR)

It is useful to divide the impacts of PMR on innovation into **direct impacts** (for example. environmental regulation which seeks to change outcomes directly) and **indirect impacts**. There is no systematic evidence in this area, and significant empirical challenges, as, by definition, we do not observe potential innovations that are prevented from emerging. However, there are examples of regulatory change, in response to new technologies that has contributed to service delivery change (e.g. Brousseau, 2000 and Nielsen et al., 2007). It remains uncertain how many opportunities are missed.

Box 5: Inhibiting disruptive innovation

A Red Tape Challenge on Challenger Businesses (CB) was run in 2011/12. This raised issues facing two potential new business models: peer-to-peer finance and online property portals (that cut out estate agents in the property market).

However, overall, those involved felt it was not very successful in engaging genuine challenger businesses. Many of the respondents were actually existing businesses with quite conventional requests. Whitehall boundaries may also present problems. Disruptive business models will often cross departmental responsibilities, making it hard to find someone to take ownership of reforms. A new CB project is now underway.

There may sometimes be a tension between a desire to identify and deliver straightforward (deregulatory) reforms, and the need in some cases to develop a deeper understanding of the new market and the best regulatory options.

It is possible that disruptive businesses may benefit from new regulation, as well as de-regulation, particularly where lack of consumer confidence might otherwise present a barrier (e.g. mobile commerce platforms and innovative financial products).

Other institutional mechanisms exist to try to capture disruptive innovation. For example the RPC has a Challenger Businesses role, and the MHRA has a Medical Device Technology Forum. However, similar challenges in terms of finding and engaging relevant businesses or potential businesses are likely to apply. The role of industry regulators in adapting to disruptive innovation in utilities is discussed below.

[31] Definitions vary, but here these are taken to cover the regulation of goods, services and production processes including environmental and health and safety regulations.

Direct impacts of product market regulation on innovation

There is a large theoretical and empirical literature on the role of regulation in driving innovation (including diffusion). However, many of the results are quite sector- (or even technology-) and time-specific, so it is hard to draw general conclusions. In addition, though much of the evidence shows there can be (sometimes large) positive effects of regulation on innovation, it provides relatively little useful *predictive* information.

However, some findings are more informative when combined with specific sectoral expertise about potential innovations. The evidence base addresses a number of general aspects of regulation, for which there are more clear-cut answers to some areas than others (see Blind 2012; BERR 2008; Angus et al. 2013).

Findings on the overall impact of regulation on innovation include:

- **Regulation can drive innovation**, though evidence is inconclusive on the extent to which innovation in response to regulation (e.g. environmental standards) displaces other innovative activities. Displacement may be more of an issue for small firms.

- We typically see a difference between short and long term impacts, with negative short term effects but **positive impacts on innovation in the long term**.

- In some cases, regulation, through its impact on innovation, **can be a net positive for competitiveness and growth** (known as “the Porter hypothesis” in the case of environmental regulation). There is some empirical support for this in some cases. However, even if true, it will almost certainly only apply to certain industries at certain times - and predicting which is not possible (at least currently) (Ambec et al. 2013).

Evidence on the features of regulatory design that can favour (or inhibit) innovation shows:

- **Flexible, incentive and outcome-based regulation** seems to increase innovation relative to rigid regulation specifying end-of-pipe technologies. However, if regulation arrives too late in the technical development process, it may not encourage innovation.

- In some cases, there **may be an offsetting effect**, whereby uncertainty about whether an innovation will achieve the desired outcome means companies do not invest.

- The impact of **regulatory delay and uncertainty** is ambiguous. A period of uncertainty can result in greater innovation, and allows regulations to be developed that fit with emerging technical possibilities. However, delay and uncertainty can also lead to inaction, especially if there is uncertainty about which technologies will prove compliant.

- **More stringent regulations** tend to be more likely to induce radical, rather than incremental, innovations.

- **A long interval between announcing and implementing** regulation can allow time for innovation (but at the cost of delaying (some of) the social benefit the regulation is intended to deliver).

Indirect impacts of product market regulation on innovation

In general terms, reducing regulation is likely to support innovation by:

- Reducing costs of compliance and so increasing resources available for innovation[32]
- Smoothing the flow of resources to innovative companies, so they can commercialise and implement new ideas (OECD 2013).
- Improving supplies to innovative firms by:
    - Increasing allocative efficiency in the economy more broadly (Andrews and Cingano, 2012)
    - Increasing upstream competition and so preventing suppliers from extracting rents (which reduces incentives to pursue profitable innovations)
    - Making it easier for firms to enter the market with new ideas, including new ideas that incorporate foreign technology (Westmore, 2013)
    - Increasing competition between firms (though effect may be ambiguous - see below)

It is also possible for some regulations to promote innovation, for example, safety or quality standards may increase consumer confidence in new products, and thus demand for innovation (Blind, 2012).

Competition

Competition is the driving force that promotes efficient outcomes in markets. In general the more competition the more efficient a market will be. Competition between firms can improve efficiency by a combination of 'within firm' and 'between firm' effects:

- **Within firm effects** – Competition provides incentives for firms to become more productive (i.e. more output for the same input) as well as to create new and better products to win customers.
- **Between firm effects** – Competition facilitates the expansion of more efficient and innovative firms at the expense of poorer performers. This process reallocates resources from less efficient to more efficient firms as consumers switch, raising overall productivity.

The role of competition in growth is closely linked to that of entrepreneurship. The latter helps drive disruptive change in markets, as entrepreneurs explore new products and business models, helping to generate the 'churn' needed for effective competition.

[32] See Crafts, N. (2006) - this may apply particularly to smaller firms for whom compliance costs are a (proportionately) larger burden – and as a result reducing costs may also increase innovation by increasing competitive pressures on large firms. See Grabowski et al. (1978) and Thomas (1990).

Competing firms will be driven to innovate (creating improved/new products or processes) to win business and it is the spillovers generated (e.g. new knowledge created that other firms can use) that is a critical driver of *long-term* growth.

Box 6: Competition Policy in Practice

The OfT has, in the past, recommended market interventions partly on the grounds that a lack of competition appears to be limiting innovation in an industry. In addition, OfT evaluations of past interventions demonstrate instances where improved competition has resulted in greater innovation. However, the OfT also recognises that there need to be limits to interventions.

In some cases, mergers can be beneficial for innovation and growth. For individual firms, it is the prospect of ex post profits that motivate innovation. Therefore, successful innovators need to be confident they will be able to realise profits from their innovation.

High tech industries, particularly ones characterised by network effects, may call for different approaches to competition policy to protect consumers and promote innovation. The Competition Commission (CC) notes in its "Guidelines for Market Investigations" that assessing market power in high tech industries may require different tools:

In assessing market power in high-technology industries, the CC pays particular attention to the number of products and/or technologies that are being developed. Another useful indicator in high-technology industries is R&D spending relative to sales. High R&D spending to sales ratios provide a clear indication that competition takes place through innovation. Where R&D investment is high, market power may be vulnerable to future innovations by rivals or new entrants. Substantial shifts in market share over time are also positive signs of a high level of rivalry in innovative or high-technology industries.

However, the link between competition and innovation is not always straightforward, as there is a tension between two opposing forces:

- Competition increases the incentives for firms to innovate in order to move ahead of their competitors and secure more market share ('innovate or die')
- Competition can reduce the incentives to innovate due to the fact that the profits from any new innovation will be rapidly competed away

In theory, the first factor should dominate in firms who are operating close to the technological frontier in their industry, and hence innovation is a critical to maintaining or increasing market share. The second factor should dominate in firms who are operating far from the technological frontier – for whom innovation is not critical to maintaining market share.

The empirical evidence on the impact of competition on innovation is mixed:

- Aghion et al. (2005) find an inverted U-shape – increasing competition from low levels is positive for innovation, but increasing competition from an already high level may be negative. However, this has been challenged (Aghion et al., 2005).
- Amable et al find instead that the impact of competition is monotonic – but whether it is positive or negative depends on R&D intensity of the industry. In R&D-intensive industries (interpreted as those close to the frontier), increasing competition tends

to reduce innovation. In less R&D-intensive industries, it tends to increase it (Amable et al., 2010).

- Griffith et al (2006) analysed the overall impact of the EU's Single Market Programme (SMP). They find it increased competition, which in turn led to increased R&D investment in manufacturing industries. Overall estimate that the SMP increased R&D intensity by 7.3% compared to the counterfactual.[33] They also estimate that a 1ppt fall in profitability is associated with a 0.45ppt increase in R&D intensity, and in turn a 1 ppt increase in R&D intensity is associated with a 0.6ppt increase in TFP.

Labour markets

The UK has a relatively lightly-regulated labour market (The 2013 OECD Employment Protection index of regular and temporary work ranks the UK as having the fourth lightest employment protection legislation; behind only the USA, Canada and New Zealand)

Theory suggests that low levels of labour market regulation / employment protection legislation (EPL) would support innovation. High labour volatility is typical of innovative, high growth industries. Increasing the costs of shedding workers (either because an idea has not worked, because the business has moved into a less labour-intensive phase, or because a different skill mix is needed) reduces the incentive to innovate

A possible counter argument is that strict EPL, by providing protection for workers, may make businesses more tolerant of mistakes and so encourage experimentation, or may raise firms' incentives to invest in human capital (however, it is not clear that the market couldn't achieve the same effect through contract choices)

The empirical evidence broadly supports the idea that low levels of EPL support innovation, though its importance varies by industry. As expected, the impact of strict EPL is greater in turbulent sectors than in those characterised by cumulative innovation, where up-skilling existing workers is more effective as a strategy for accommodating innovation (Andrews and Cingano, 2012). Two specific related findings are that:

- The relative degree of labour market regulation has been important for the diffusion of ICT, with faster diffusion in countries with lighter regulation (OECD 2003); and

- Venture capital markets, especially in volatile sectors, have grown more strongly in countries that insure their workers against labour market risk through unemployment benefits than strict employee protection legislation (Bozkava and Kerr, 2013).

Intellectual Property Law

The intellectual property regime (patents, trademarks and registered designs) is not the only means of protecting ideas available to business, but is the main regulated one.

The impact on innovation of strengthening intellectual property rights is ambiguous:

[33] One group of industries saw lower R&D – high-tech public procurement sectors with economies of scale at EU level. Possible interpretation is that the SMP led to consolidation and rationalisation, so better coordinated R&D – in which case unclear if less overall innovation.

- IPRs (particularly patents), by granting monopolies, increase the financial incentive to innovate or commercialise new products. However, they (by definition) inhibit diffusion.

- In addition, stronger IPRs will tend to block future "sequential" innovations i.e. those that build on existing innovations. The impact on sequential innovation seems to vary by industry/innovation type (Galasso and Schankerman, 2013).

- Empirical evidence suggests that increasing the strength of patent protection may not increase innovation, and in some industries may in fact have a negative effect (Lerner, 2009; Bessen and Meurer, 2008).

Provisions for licensing, whereby an owner of IP can allow another party to use it for a fee, are an important part of the IP system. They enable ideas to be exploited commercially even if the original inventor doesn't wish to take them to market. Some countries operate a system of compulsory licensing in certain circumstances. However, the evidence on the value of this approach limited, and impacts are in any case likely to be context specific (OECD 2013).

The number of patents is a commonly used indicator of innovation. Some of the evidence challenges the link between patents and innovation – most obviously in fields where strategic patenting and patent thickets are a problem (e.g. telecoms).

Ideally, intellectual property rules would vary across types of innovation – but this is extremely hard to do in practice. The recent Hargreaves Review made 11 recommendations covering all aspects of intellectual property, which the Government is implementing. As well as specific changes to the current regime, these include recommendations on the way the patent regime is managed, reviewed and improved.

Conclusions and areas for further work

Overall, the literature, while it covers a broad range of issues, has some significant limitations. In addition to problems with the commonly used measures of innovation, there is a lack of analysis that distinguishes between changing regulations themselves and changing enforcement and, more broadly, challenges in finding indicators that capture differences in the regulatory framework accurately.

There is also a lack of clear findings, as opposed to time- and context-specific evidence, and no evidence addressing the role of an "innovation culture" within regulatory bodies. Finally there is little research that addresses the interaction between regulators and regulated firms. Bearing these limitations in mind, there are however, some broad conclusions we can still draw from this:

- The regulation policy agenda is focused on reducing regulation. While in many cases this may be beneficial for innovation (see below), the evidence indicates that **the impact of regulation is not always negative**.

- Guidance on assessing the impact of regulations does not currently address impacts on innovation, or the possibility of innovation reducing the cost of a regulatory standard. The uncertainties and ambiguities limit the scope for simple policy recommendations. However, neglecting this aspect **may favour regulations with lower static costs but that are less likely to incentivise radical innovation**.

- Costs and benefits of particular regulatory choices depend significantly on the stage of technical development in an industry. There is likely to be value in involving people with in-depth market and technical knowledge in the regulatory process, as well as other areas of innovation policy (Edler, 2013).

- The regulator appeals system is currently slow and expensive, so used by incumbents as a way of blocking or delaying changes to facilitate entry (Reforming this was announced at Budget 2013)

- Regarding working arrangements and focus of economic regulators:

    - Cross-sectoral working is poor. This increases costs, e.g. by preventing suppliers from sharing installation work.

    - Regulators are insufficiently focused on long-term outcomes for consumers and the wider economy, including the potential benefits of innovation.

    - An HMT / BIS study (drawing on other government departments) into how these issues can be tackled will report by Budget 2014.

Ultimately regulations will always have a complex relationship with innovation, as it is difficult to write rules for products and markets which do not yet exist. An infinitely flexible, purely outcome-based regulatory regime is hard (or impossible) to achieve. As a result, a system that is open to application from people with disruptive ideas is likely to be important to facilitate innovation.

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