The Relationship between Standards, Standards Development and Intellectual Property

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Introduction

This report is a study of standards and intellectual property (IP) commissioned by the British Standards Institution (BSI). The standards concerned are those published by standards development organizations (SDOs) such as BSI, ISO and Industry Consortia. The study does not cover standardization more generally. The report consists of four main sections:

1. A review of the existing literature on the subject, mainly from economics.
2. Some new analyses of recently available data from the UK Innovation Survey.
3. Data and analysis from a new survey of SDOs, specifically undertaken for the project.
4. A summary and set of conclusions.

The study also includes a number of case studies, mainly based on interviews with standards and IP experts and respondents to the survey who kindly agreed to further discussions.

Overview and main conclusions

This report has brought together existing evidence with new data and analysis carried out as part of the research. When seen in the context of a science, technology, innovation and growth (STIG) system, these sources deepen understanding of how standards are a catalyst for many aspects of the system. In particular, standards development and use, interact effectively with the IP framework to promote economic performance, for firms and the economy as a whole. Intellectual property rights (IPR) help to stimulate the generation of new knowledge, and standards act to disseminate it. But the catalytic role is wider – in-house R&D, product innovation and associated training, investment in advanced assets including computer hardware and software, are also promoted by standards. Much evidence, set out in the economic literature has demonstrated that national and international standards support the expansion of international trade, which in turn is a well-established driver of economic growth.

Participation in standards development is seen as beneficial, largely through the knowledge networks created and in the ability to influence future standards and their role in the orderly development of markets and technologies. Gaining income from exploiting IPRs through participation is a priority for a minority.

Standards have perhaps increasingly, a significant function in disseminating new technologies and practices, as well as codifying best practice. Their development thus inevitably has to interact with the system of IPRs, whose major role is to stimulate the production and implementation of new ideas. Although there is evidence of some friction in this relationship, especially in certain areas of information and communications technologies (ICT), there is accommodation in the majority of cases.

New evidence from this research shows that the extent of use of standards, and participation in standards development are both higher than expected in services activities, although the breadth and depth of coverage is lower than in production sectors, as indicated by the number of standards relevant to these sectors. Services businesses are also especially receptive to new forms of standards development, such as the BSI's publicly available specifications (PAS) initiative. However, businesses in these sectors are also more likely to be neutral about many of the benefits of the use and development of standards and of IPRs, indicating potential for informational and promotional activity by both BSI and the IPO.

Further, pursuit of standards participation and IPRs as a joint as opposed to parallel strategy is very much a minority position, leading to further opportunities for BSI and IPO to share knowledge such as the mutual relevance of patents and standards in related areas.

Participation in standards development can reduce uncertainty for smaller enterprises, not least because a pooling of knowledge includes that relating to the existing IPR in the field, while development of a standard can lead to a larger overall market. Small enterprises are also relatively more likely to perceive the advantages of the PAS option,[1] which

1 The PAS (Publicly Available Specification) process enables the testing of an idea as the basis for a possible future standard.

further suggests that novel approaches to standards development can widen the attractions of participation. This may also extend to inclusion of IP in standards as an option for smaller enterprises who are deterred by costs from gaining formal IPRs.

Standards and IPR are components of a knowledge infrastructure that reduces uncertainty and encourages the commitment of resources to R&D and other forms of innovation related investment, as well as to creativity and human capital development. They both also allow for the effective diffusion of innovations through the economy so that the benefits are widespread.

There are, though, some gaps in the use of these powerful institutions. A neutral view in the sense of neither agreeing or disagreeing, with propositions about the value and usefulness of standards development activities and the use of IPR was taken by a significant share, albeit a minority, of respondents to our survey. As these are participants in standards development, neutrality is likely to be more prevalent across the economy as a whole. An implication is that there are gaps in the service offerings of standards and IP institutions or in the ways that these are presented, and so there is potential for extending the engagement of firms and other organizations and encouraging more strategic use of the standards development and IP infrastructure. The fruitful interaction between standards and IP institutions may benefit from the joint development of existing datasets in both areas.

The BIS convened the Innovation Infrastructure Partners[2] to promote the configuration of innovation policy to build on the established strengths and connectivity of the knowledge infrastructure. Initiatives could, for example, include bilateral collaboration between BSI and IPO to consider approaches to better meet the needs of businesses and other economic agents, who are currently neutral with respect to the strategic use of standards, their development and the link with IP.

This summary now turns to some more specific conclusions from each of the component parts of the research.

Key points from the literature review (Section 1)

Both standardization and IPR are widely believed to contribute significantly to economic growth in advanced economies through their impact on innovation and investment.

The literature frequently begins with the idea of formal IPR in the form of patents and secrecy as mutually exclusive alternative business strategies but the reality is now seen as more complex and the motivation for patenting may go beyond making it difficult for rivals to imitate and include 'strategic' or 'signalling' reasons and these may be important in the context of standards development.

IPR strategies are increasingly being seen as just one element in a firm's overall innovation strategy which combines types of innovation outcome in delivering new products or services in new ways with a broad conception of inputs that includes organizational change.

Beyond the usual mechanisms for protecting IP, formal standards development is an activity through which participating firms can maintain and enhance the value of their IP in a number of ways, but perhaps most importantly by building a bigger market and reducing uncertainty about future developments in products and processes.

In some standards development contexts, firms and specialist institutions may wish to make use of or incorporate their formal IPR, but participation in standards development is mainly undertaken for reasons other than directly obtaining income from IPR. Evidence from a specially commissioned report for the BRIDGIT project, which aimed at improving the linkages between research and standards development, suggests that market-oriented outcomes and the benefits from networking and influencing the path of future standards, are more important.

Ideally standards development involves the mutually beneficial pooling of IP but there are many variations on this process in which the gains from standardization may be unevenly divided.

2 A group of representatives from BIS, IPO, BSI, UKAS, Innovate UK, RCUK, NPL, LGC, NMRO, the Met Office, Hefce, the Scottish, Welsh and Northern Ireland governments and other agencies in the knowledge infrastructure.

Since standards development frequently requires firms to make commitments to specific lines of research or technological development, this may provide incentives for IPR holders to act opportunistically, e.g. to reveal IPR at a comparatively late stage in the development process. And in certain circumstances 'royalty stacking' may be an issue – where several producers hold standard essential patents resulting in mutually detrimental aggregate payments by users of a standard.

SDOs based on ongoing committee structures are generally able to forestall acts of opportunism by the adoption of formal guidelines which involve ex-ante commitments by holders of IPR to reveal at an early stage. A basis for licensing on FRAND (fair, reasonable and non-discriminatory) terms has been adopted by most SDOs.

Pathological outcomes, including severe disruption of the standards development process or litigation do exist, but the main cases in the literature seem to come from ICT, especially in mobile telecommunications. The literature does not show how far standards committees are able to avoid issues arising from relevant IPR held outside of committee members, but new evidence gathered for this study sheds some light on the issue.

Key points from the UK innovation surveys (Section 2)

Both product and process innovation are important aspects of the business environment of the UK, with just under one quarter of firms reporting one or both types between 2008 and 2012. Product innovation is however the dominant form of innovation, especially among smaller businesses. Around a half of product innovators but only a quarter of process innovators believed they were taking a novel step – introducing a product new to the market or using a process new to the industry.

Whether actually innovating or not, firms reported using a wide variety of the inputs required to support innovation, with nearly 29% incurring in-house R&D expenditures, with even higher proportions acquiring innovation related computing equipment (30%), software (37%), or marketing (34%); smaller percentages reported acquiring innovation related equipment (17%), training (24%) or design (19%). The percentages reporting acquiring external R&D (10%) or licensing IPR (8%) were considerably smaller.

In order to protect the IP in their innovation, firms report both informal methods in the form of lead times, design complexity and secrecy as well as formal IPR (patents, design rights, trademarks and copyright) as important for the competitiveness of their business. The informal methods are rated as important for business competitiveness by larger proportions of businesses, but both firm size and novelty are important in this assessment, with larger firms and those taking a novel step being more likely to favour formal types of IPR.

The UK Innovation Surveys indicate quite clearly the significance of standards in providing a source of codified knowledge for innovators. Moreover econometric analysis reveals that the number of relevant standards available to producers at a sectoral level provides an important additional factor explaining the extent of innovation across sectors, operating over and above a sector's total R&D effort. The analysis indicates that standards are especially important for product innovation, including novel product innovation. Looking at the commitment of resources for innovation, we found that standards are acting as a catalyst, not just in promoting R&D, but also for other innovation related inputs, including creative investments in design, as well as in the promotion of training.

In most innovation contexts, we find that an older stock of available standards acts as an inhibitor of both product and process innovation, suggesting that delay in the issue of standards and the purging of outdated standards are important. But older standards may actually be assisting in promoting training relating to innovation and in computer software.

That standards contribute to business innovation is validated by multivariate analysis which shows that the value that individual firms place on standards as a source of information depends not just on the number and age of standards at a sectoral level, but also upon whether a firm actually innovates. Here both process innovation and novelty are important additional factors. From the input side, the acquisition of R&D, equipment (including computing equipment), training and marketing expenditures are all strongly correlated with the value that firms place on standards.

The information provided by standards also matters for firms' appreciation of the various IPR strategies. As far as patents and other formal methods are concerned, firms are more likely to regard them as being effective when they are in a sector with a larger number of relevant standards and when they individually place higher value on the information contained in standards.

Data on firms which were included in both the surveys studied enabled us to look at the impact of innovation on productivity growth over the period 2010–2012. While process innovation was found to be an important contributor, it did not prove possible to detect a separate influence from product innovation (to which standards are a particularly important contributor). We consider this as largely a result of competitive pressures which ensure that much of the benefit from product innovation is captured by users rather than producers, and ultimately by consumers.

Key points from the BSI survey (Section 3)

Focusing mainly on businesses active in standards development, a new survey commissioned for this report looks into how various agents perceive and implement the interaction between their participation in standards development and their formal or informal protection of IP.

The survey indicated that standards are used in a variety of ways, across all services as well as engineering sectors and while their use in product and service specification is the most commonly cited, other applications, including standards for organization and management, customer service, research and innovation, and in workforce development, all feature strongly.

There was also strong agreement that standards provide support for research and innovation, especially in creating compatibility with other products. Other roles for standards also received majority assent, more clearly in the case where improved marketability was an outcome from their use. While about 25% of respondents believed that standards could constrain the ability to innovate, most of these also believed that standards had innovation enabling effects.

On the benefits from participation, the survey highlighted the importance of standards in both underpinning markets for goods and services and in disseminating knowledge, while also showing the relevance of the various methods for protecting IP, emphasizing the importance of secrecy as a method of protection. Patenting was used less often but was still very important – used by nearly 45% overall and over 60% in production and engineering industries. Patenting was much less likely among small firms, emphasizing both the fixed costs in obtaining a patent as well as the ongoing costs in defending one.

On the possibility that IPR might in some way undermine standards development, relatively few respondents had experience of significant problems. The most frequently cited effect was some delay, reported by around 20%. As far as their own IPR is concerned, a substantial majority (73%) did not see any issues. Small proportions found various types of issue, including 5% experiencing infringement of the respondent's own IPR. Issues arising from others' IPR in standardization were also in a minority, with 67% again reporting no issue. Non-declaration of patents and cross-licensing difficulties were the most frequently cited, at 7%, while only 4% reported 'excessive' licence fees. IPR entirely external to the process of standards development was also found not to be an issue by 73% of respondents. Only a very small proportion reported a termination of the process (2%) but 7% said that the standard involved had achieved avoidance of particular external IP. There was no evidence from this survey that issues were more likely to arise within ICT, but there were some differences according to the level at which standardization was being carried out. International SDO members, for example, were more likely to report legal action arising in connection with other standardizers' IP.

Questions were included to ascertain the relative importance of standards development, including the BSI Publicly Available Specifications (PAS) route and IPR as alternative methods for exploiting individual firm level innovation. IPR was more likely to be cited than standards, especially in engineering and production, but the differences were generally small and the results confirm the significance of both IPR and standards for the innovation system, which embraces both production and service sectors. The BSI's PAS initiative was perceived as important by over a third of respondents, but by 50% in services sectors, implying receptivity in those sectors – currently with a lower coverage by SDOs – to new approaches to standards development. Clear majorities saw both participation in standards development and IPR as strategically important for their unit, a rather smaller proportion (around one quarter) of respondents saw standards participation and IPR as part of a joint strategy.

There was some evidence from the survey concerning the potential for further take up of the standards and IP infrastructure, mainly in the service sectors.

Cooperation, competition and standards development

Competition authorities around the world are rightly suspicious of collaboration and cooperation among firms. As Adam Smith once famously declared, 'people of the same trade seldom meet together, even for merriment and diversion, but the conversation ends in a conspiracy against the public, or in some contrivance to raise prices.' But there are many other reasons for collaboration and cooperation than simply acting as a price-fixing cartel. In today's world, those who are charged with preventing the abuse of market power face a more difficult task since the increasing complexity and uncertainties surrounding innovation make cooperation in research and standards development essential.

The development of standards within the formal committees provides an important case in point. Ideally the collaboration among firms and other institutions in creating standards involves the pooling of a mixture of both proprietary and common knowledge amongst the participants to achieve shared objectives which assist in the development of markets. The openness of the process and the fact that the standards produced are available for all suggests that they should promote competition. But why then should any firm incur the costs involved in participating in standards development? The answer must reside in the temporary advantage that participation brings: influencing the development of standards and belonging to an informed network. The formal rules adopted by standards committees should in principle, guard against the problems foreseen by Smith.

What makes things tricky for policymakers is that competition can sometimes work too well. When innovation requires the commitment of resources, imitation may be cheaper, with the rewards going to the imitator. When combined with the riskiness involved in innovation, a reasonable assumption must be that the necessary resources for innovation will be under-provided by competitive markets. One answer widely adopted is the creation of a legal temporary advantage for the innovator via the patent system, creating a monopoly for the limited duration of the patent. Despite his objection to state patronage especially when it created a monopoly, Smith himself saw the relevance of such an argument when he described the expenses of establishing colonial trade, where 'a temporary monopoly...may be vindicated upon the same principles which a like monopoly of a new machine is granted to its inventor, and that of a new book to its author.' But the key thing for Smith was that on expiry of the monopoly, that 'the trade be laid open to all the subjects of the state' , allowing competition to reassert itself. But how much market power is required to provide the necessary stimulus for innovation, and for how long should it be allowed to persist? These questions are less easy to answer and ones where the appropriate policy balance may be shifting.

The recent increased interest expressed by competition authorities in the activities of standards setting organizations (SSOs) both in Europe and the US has often been about the insertion of patents into standards. Does this create too much market power? The question has prompted the growth of a considerable literature, but how representative is it of standards development today in general? And how far can the rules of SSOs prevent the abuse of market power? This report aims at achieving greater balance. It considers the relevant literature in the next section. Section 2 then uses the most recent UK Innovation Surveys to analyse the use of standards and IPR in the UK today. Section 3 then reports on a specially commissioned survey to explore the use of standards, the reasons for participation in standards setting, and the role of IP in standards development.

1. Literature review

1.1 Introduction

In a modern economy both the creation of IP through research and the creation of standards are recognized as being important drivers of innovation, investment, and ultimately, welfare enhancing productivity growth. Both processes interact with markets in ways that are complex and varied, and both are subject to market 'failure'. In both, policy interventions through formal intellectual property protection in the form of legal 'rights' (IPR) or legally mandated standards (such as for weights and measures), have a long history. In many ways the two processes are of course complementary to each other, with standards providing the necessary underpinning for innovations to have commercial credibility in the marketplace. Only comparatively recently has the intersection and interaction between the two created any substantial literature, and an area of great interest for the competition authorities. Moreover, decisions have to be made regarding the manner in which firms seek to utilize and enhance their IP, and here both the use of standards and the benefits from participation in cooperative standards development are important elements of that choice.

This review briefly discusses the role and impact of IPR and voluntary consensus standardization before considering various models of standards development and the strategic decisions involved in protection of intellectual property; it then turns to the question of how, from a 'systems' perspective, IPR interacts with the process of standardization.

1.2 The role of standards and economic performance

Written standards provide a form of codified knowledge readily available to business and public sector users. By setting out specifications in detail, with supporting documentation and cross referencing to sources and to related knowledge e.g. measurement results and techniques, a standard efficiently encapsulates technical or managerial information which can be used quite directly in formulating products, processes and business practices.

Standards can thus function as a mechanism for the dissemination of either embodied (providing information for example about the specification of innovative equipment) or disembodied technology, where the latter is interpreted as including best practices in areas such as business organization, strategy and management. These are all now recognized as possible areas for innovation.

The next section reports on some 'reduced form' models, that typically use just one indicator – the stock of standards as it has evolved over time – to represent the myriad ways that standards can have an effect on innovation and other measures of economic performance.

Standards and economic performance

Basing itself on methods used in an influential empirical study of the effects of standards and UK trading performance, which indicated the overall trade promoting effects of a larger stock of relevant standards i.e. on both exports and imports (Swann, Temple, and Shurmer, 1996), an early assessment of the contribution of standards to aggregate economic performance (as measured by GDP) was undertaken for Germany (Blind, Jungmittag, and Mangelsdorf, 1999). This study added the number of DIN standards available, as well as patents and licensing payments for foreign technology, as indicators of different aspects of technological change, to the conventional inputs of labour and capital. The study found a growth contribution from standards of 0.9% p.a. for the period 1960–1996. A recent update (Blind, Jungmittag, and Mangelsdorf, 2011) found that this contribution had fallen to about 0.7%-0.8% of GDP p.a. with the other sources of knowledge for innovation assuming increasing importance.

Building on these precedents, a report for the then Department of Trade and Industry (DTI) included three empirical studies of the role of standards in innovation, productivity and growth (Temple et al., 2005). One was a study, using the growth in the stock of standards and of GDP over time, since 1948, which estimated that the elasticity of the growth in output with respect to an increase in the net stock of standards was about 0.05. Although the elasticity itself is small, the rapid rate of growth of the stock of standards leads to an estimate that this growth contributed about 13% of the growth in labour productivity in the UK experienced over the period 1948–2002. In time series studies of economic and productivity growth, technological change from all sources contributed about one percentage point, and the study for the DTI suggests that standards growth accounts for more than a quarter of this. But it is important to note that, due to collinearity between the indicator series, the time series model could not be estimated with both a dissemination – standards – and a new technology – e.g. patents – variable. The authors emphasize that there will in reality be interdependence between them, so that the result needs to be interpreted with appropriate care – standards act *in conjunction* with other factors such as new technology, not least – as we report in Section 2 – in encouraging firms to commit resources to innovation.

Exercises on the lines of the time series analysis in the DTI report have subsequently been carried out for Canada (2007), Australia (2007) and France (2009), using similar methodologies (cited in Swann, 2010). The empirical analysis in Canada also found that standards play an important role in enhancing labour productivity, measured as output per hour worked, accounting for 17% of the growth rate in labour productivity which translates into approximately 9% of the growth rate in real GDP. These are similar to the findings for the UK. Results in Australia were similar again, although the elasticity of productivity with respect to the stock of standards was a little higher than in the case of the UK. The French analysis found standardization contributes an average of 0.8 percentage points to growth per year, or almost 25% of GDP growth, in line with the other results cited here.

Two recent studies have re-estimated the time series relationship in the UK between the growth in the stock of standards and economic performance, including longer periods of time. They have found a rather stronger association between the growth in standards on economic productivity. Spencer and Temple (forthcoming) estimate, using advanced econometric techniques, that standards growth has contributed around 0.5% annual growth in output per hour of work between 1931 (the year in which the British Engineering Standards Association was renamed as the BSI) and 2009. A study for BSI by CEBR (2015) has also re-estimated the model from the 2005 DTI study, finding that a share of productivity growth per capita of over 37% may be attributed to standards over the period 1921–2013.

Spencer and Temple again caution that these results have to be interpreted with care since, rather than acting as a completely independent source of growth, standards catalyse other sources such as human and physical capital accumulation, which are incentivized by the orderly and predictable development of markets offered by standards. Some of these links are investigated in detail – and quantified – in Section 2 using the UK Innovation Survey data and in Section 3 using a new survey of standards developers, carried out for this project.

While indicative, these aggregate studies tell us little about the precise mechanisms by which standards impact upon productivity growth. However, a second project in the DTI report cited above used an estimation technique which aimed at disentangling the macroeconomic effects of the stock of standards from that of patents – with the latter serving as an indicator of new technology – for Germany, France, Italy and UK. The estimated growth in output attributable to a 1% increase in the size of the stock of standards was found to be between 0.02% and 0.1%. A further study in a similar vein that went a little further in a UK context was by Elshamy and Temple (2008) which showed that a significant amount of productivity growth in the small firm sector could be attributed to both aggregate R&D (mainly performed by large firms) as well as the stock of standards available to small firms. Plausibly, adherence to standards provides a low cost way of accessing both knowledge and the market and where intermediaries in the form of testing and measurement activities can provide an important support. Both these studies emphasize the significance of processes of technological diffusion in which standards underpin the development of firm level capabilities.

1.3 IPR and economic performance

While the role and impact of knowledge generation and intellectual property are widely recognized as central to the growth of developed economies, rather less is perhaps known about the specific impact of legal mechanisms for the protection of IP, either at the level of whole economies or at the level of the individual firm. This is of some interest since the extent of intellectual property protection in the form of patents has varied considerably over time and between countries and has often been subject to policy change. The historical study by Moser (2005) is of considerable interest in this latter regard. Looking at exhibits from world fairs (London 1851 and Philadelphia 1876) she observed that countries without any legal protection from patents did not obviously innovate less. Thus at the Crystal Palace in 1851, two of the most innovative economies in the instrument sector were Switzerland and Denmark, economies without any patent protection. In another historical study, Murmann (2003) discusses the development of the synthetic dyestuffs industry in Germany, arguing that the absence of a patent system in the newly unified German state in the 1870s favoured a vigorous process of entry and exit of new firms and selection of the more capable. In his view the patent system in Britain at that time provided too much protection for its pioneering innovators, allowing inefficient firms to survive without the need to develop capabilities complementary to the innovations. By the time a patent law was enacted in Germany 1877, the science had begun to favour systematic large firm R&D. Although, as Greenhalgh and Rogers (2010) note, it is extremely difficult to assess the effectiveness of different IPR systems, some attempts have been made. Falvey, Foster and Greenaway (2006) for example, found that both 'high-' and 'low-income' economies gain from stronger IPR protection while 'middle-income' economies lose out. They argue that the high income economies gain from the higher levels of R&D generated while the low income economies gain from increased inflows of inward foreign direct investment. In the middle, this latter effect is offset by the increased cost of imitating technologies and products developed in the high income economies.

1.4 Innovation, intellectual property, and business strategy

At the level of the firm, the literature generally associates the creation of intellectual property with innovation. As a competitive strategy, the use of innovation is problematic since imitation is a real threat in many competitive situations and which can (and often) does mean that the imitator makes more profit than the innovator. Following Teece (1986) and others, the extent of this threat varies significantly in ways which are described by the so-called 'appropriability regime', a reference to whether formal IPR or secrecy is likely to provide sufficient protection for a firm to profit from its innovation. Clearly the theory distinguishes between product and process innovation in this regard. Whatever the reason, when the appropriability regime is weak, firms have to resort to other means if they are to benefit from innovation. Here Teece employs the concept of 'complementary assets' – proprietary assets in production, marketing, organization and reputation for example – that accompany innovation. These assets may be much harder for rival firms to imitate and may provide more protection for the IP than formal IPR or secrecy. Firms with limited access to these complementary assets may seek to license their IP as the best strategy.

Most discussion of the choice of the form of IP protection assumes that firms with IP will naturally favour secrecy. To favour patenting (for example), the net advantages, which require disclosure of the IP, should outweigh the alternative and mutually exclusive strategy of secrecy. In standardization of course we observe firms voluntarily disclosing IP. This suggests we need a more nuanced view of strategy and consider why firms may choose to disclose. Here Graham (2004) has made a contribution which treats disclosure as an element of strategy in its own right, creating a four way grid and in which patents may be complementary to secrecy or in which a combination of non-patenting and disclosure may be optimal. Motivations for the latter may include pure defence which allow firms to 'reset the clock' in a patent race, or to make it more difficult for other firms to prove 'prior art' when seeking to patent (Baker and Mezetti, 2005). Clearly standards development also may involve a pooling of knowledge which makes it more difficult for those firms outside the process to gain a patent.

Before turning to explanations of the standard setting process in the presence of IP, which usually involves some IP disclosure and may involve a patent, we note the large literature which examines motives for patenting which go beyond the stifling of easy imitation. These include the use of a patent in bargaining or as a signal in situations of asymmetric information (hiring or credit decisions).

1.5 Strategies for the protection of IP at the level of the firm and industry

Teece's framework – and later literature which follows on – points to the difficulties that any firm faces when trying to base competitive strength on innovation alone and indicates that clear strategies for the protection of IP are essential. The precise method however shows significant variation. Ever since the so-called 'Yale 'and 'Carnegie-Mellon' studies on the protection of IP in the US (Levin et al. 1987 and Cohen et al. 2000 respectively), it has been firmly established in the literature that the various ways of protecting and obtaining value from intellectual property – methods that include both formal methods (patents, design rights, trademarks and copyright) and informal methods (secrecy, obtaining a lead, or complexity of one sort or another) – vary significantly across both firms and industries. A common feature of these initial studies was the finding that overall, patents are not the predominant mechanism for protecting intellectual property, and that secrecy and lead time are rather more important. Further studies, based mainly on national innovation surveys, have provided confirmation of this result (see the pan-European study by Arundel et al. (1995) which confirms the importance of patenting in chemicals and pharmaceuticals, as well as for product as opposed to process innovation).

At the industry level, a study of business management of IPRs (Hanel, 2006), supported by a survey of practices, revealed significant differences across industries in patenting strategy. Hanel puts them into two broad groups, 'complex' against 'discrete' technologies, a distinction originally suggested in the Carnegie-Mellon research. Firms in complex technologies patent mainly for negotiations (81%) and cross-licensing (55%) while far fewer firms in discrete product industries use patents for these reasons (33% and 10%, respectively). Discrete technologies with high use of patents include the categories of chemicals, pharmaceuticals, food, textiles and metal products. The main patenting strategy in 'discrete technologies' is to build patent 'fences' around a core invention, patenting to foreclose patenting by rivals. In these industries, patented inventions are frequently licensed but rarely cross-licensed. Electronic and ICT sectors on the other hand typify complexity, requiring the use of patents belonging to many organizations. So the main value of patents here is to serve as bargaining chips for settlement and for cross- licensing. Note though the asymmetry between manufacturers with R&D and specialist services sector technology developers.

Within industries, the literature has revealed significant differences between firms. Firm size is important, partly because of the fixed costs associated with formal IP protection, with large firms making use of several or all methods of patent protection. While small firms may eschew the use of patents for this reason, and may find it difficult to patent for reasons of cross-licensing in complex technologies, where extensive portfolios are necessary, recent research for Finland has suggested that patents may be important for small firms engaged in cooperative research (Leiponen and Byma, 2006).

1.6 Innovation strategies and performance

IP protection is of course just part of an overall innovation strategy. In this regard the study (Frenz and Lambert, 2012) using UK Innovation Survey data finds that the informing aspect of standards can be combined with complementary knowledge sources and investments to form one of a set of complex innovation indicators that the authors have dubbed 'mixed modes of innovation', to refer to a set or bundle of activities which are undertaken together by a firm to bring about and market a new good or service, or improve on production, delivery and business processes. Another mode reflecting in-house technology activities combines formal IPR and informal means of protection such as secrecy.

The modes can be thought of as strategic orientations or styles of innovation. The mode variables pool 'inputs' and 'outputs' to acknowledge that these are typically jointly reinforcing activities and not steps in a linear process. The approach also recognizes that technological and non-technological activities go hand in hand in the development of new goods and services, and this is reflected by using the breadth of measures in the innovation survey. The analysis in Frenz and Lambert uses regression models to relate the innovation modes to performance and growth of enterprises, for a range of lags between the values of modes and the dependent variables. Both the mode that is intensive in IPRs and that based on codified knowledge, including standards, have positive and statistically significant impacts on productivity and growth, even with a lag of several years. The parameter value on the IP based mode is larger in productivity equations, but the estimated values in equations for change in productivity and output are similar. In the codified knowledge mode, standards are correlated with use of publications, information from business and with cooperation. This study also finds a small but statistically significant performance impact from the use of the management standard, ISO 9001.

1.7 Models of cooperative standardization and the pooling of knowledge

The literature recognizes several different 'models' of standard setting and which describe alternative situations requiring the input of IP from two or more cooperating firms.

An 'ideal' model of standard setting requiring the cooperation between firms in standards development involves the voluntary 'pooling' of intellectual property in a way that clearly benefits all participants because they are aiming to reach a 'common objective' and which provides no incentive to maintain secrecy. In the literature of game theory, the voluntary sharing of knowledge is a 'dominant strategy'. Typically in creating a standard, the common objective may reside in creating a larger market by for example defining a producer-user interface, in which the standard leaves all the participants better off. In effect, the gains from a larger market exceed considerations of market share. An important element in this model is the symmetry in the position of the various participants which ensures that the committee process is mainly concerned with achieving the most appropriate standard.

The issue of coordination

A second type of model – prominent in the early literature (e.g. Farrell and Saloner, 1985) recognizes that it may be difficult to achieve standardization because of the lack of a coordination mechanism. This may be particularly relevant in the presence of 'network effects', i.e. when users benefit from the size of the user base, which depends upon the extent to which a common standard has been adopted. These are important not just for physical networks but in many ICT contexts, where specific types of 'hardware' have value only when there is associated 'software'. When alternative standards are available, expectations are very important in determining the outcome, with users either wary of tying themselves to a particular standard and consequently a market failing to materialize, or else creating an inefficient 'bandwagon effect' resulting in an inferior standard. Coordination may be possible through dominant private interests, but setting an appropriate standard through consensus within a committee represents another. The relative merits of committees versus markets as means of achieving standardization also received early attention in the literature, and here Farrell and Saloner (1988) showed that while the committee process is more likely to solve the coordination problem, it is also likely to be slower. They note however that slower may not always be worse if, with nascent technologies, more information makes for a better decision on the choice of standard. Nevertheless, the issue of timeliness of standards has provided a recurrent theme in the literature.

The Selden 'submarine patent', patent pools, and cooperative standardization in the early automobile industry

In 1879, a lawyer and part-time inventor George B. Selden applied for a patent on 'an improved road engine' based on an internal combustion engine whose scope covered much of what was to become recognizable as an automobile. With no motor car industry in sight at the time and with patents limited to 17 years in duration, Selden took advantage of the law in the US at the time which permitted 'extensions' to keep the application both alive and secret for another 16 years until it was eventually granted, and the 'submarine surfaced', in 1895. The claim at that time to have patented a gasoline powered automobile was sufficiently credible to bring together a number of manufacturers under the title of the Association of Licensed Automobile Manufacturers (ALAM) to form a patent pool - with favourable IP licensing rates for members and exclusion for the many other early producers of automobiles. The breath-taking scope of the patent was not tested until openly challenged by one such 'independent' - Henry Ford – who was duly sued for infringement in a case eventually lasting eight years after which, despite an initial ruling in its favour, the Selden patent was over-turned.

But the ALAM did much more than attempt to restrict competition in favour of its members. Acting more as a trade association than a cartel, its mechanical branch brought engineers together for a 'free exchange of fundamental knowledge' that through a technical laboratory and a series of technical reports 'contributed much to the early progress of the industry' in the US. Although the laboratory closed in 1910, the valuable collection of documents was turned over to the Society for Automobile Engineers (SAM). As the industry developed with the introduction of the Model T and which set 'the standard' for popular motoring, SAM became an important contributor to cross-company standardization efforts, and with considerable coordination by General Motors, it helped the latter company outperform the Ford Motor Company during the 1920s. By the eve of World War II, it was General Motors which was selling more motor cars in the US.

Asymmetric situations

In many standard setting situations, the gains may be unevenly distributed among participants. In one model of this asymmetry, it may be that there is more than one possible standard that would leave all the participants better off, but that the precise standard agreed upon does have distributional implications which can at the very least delay standardization. The advantage of formal standard setting institutions in this context resides in the potential for reciprocation and in which the lesser *relative* gain experienced by a firm in one round of negotiation may reasonably be expected to be reversed in a later round. This point has been picked up in a number of studies. Of course this possibility is less likely in committees set up on a 'one-off' basis.

The presence of IPR in standard setting

Standardization processes may involve the presence of formal IPR (a patent) which may create incentives for firms to hold back from revealing their IP or where participants are prepared to do so only if they can be recompensed through the licensing of a patent and/or its incorporation in a standard. Even in these circumstances, firms may have incentives to delay in announcing IP essential for developing the standard to the extent to which other firms are making commitments (sinking costs) in that particular standard. An important role for standards committees is therefore to adopt formal rules which aim at preventing opportunistic behaviour. As technologies in many fields have become more complex, many commercial businesses and other organizations (e.g. universities) have become more specialized in research and, relying more heavily on licensing income, may be posing particular challenges in this regard.

The evolving role of standards

A micro business in audio visual (AV) software is involved in the development of standards in the technologies involved, in an international consortium body. They reported that the standards process has evolved over time from a relatively informal collaboration between the technologists towards a more formal, commercially sensitive committee structure, pointing to a rise in what is often known colloquially as the 'suits to beards' ratio. Part of this evolution has been increased involvement of standards making with IP rights. This can be attributed to the growth in the number of patents in the area. But also standards in AV are seeking to incorporate new technologies, which increases the probability of needing to engage with IPRs. This tendency to increasing interaction has been noted by interviewees from several sectors. But systematic data to quantify this possible tendency is not currently available.

A large engineering based manufacturer also reported that standards development has evolved from consolidation of best practice towards technology leadership. But the main drivers for standards development in the industry remain the design of safer equipment and the creation of a 'level playing field' for competition. This has encouraged participating organizations to be more aware of opportunities for patenting their own technologies that might contribute to a standard. But also of the need to take account of, or incorporate the patents of other participants or those outside of the standards development process. This is partly attributable to the increased need to integrate electronic controls and software into equipment.

Many of the cases in which IP and standards development interact in deleterious ways examined in the literature are taken from ICT, where inter-operability standards are vital for market acceptance and growth. On the other hand, in many ICT areas patenting is essential if firms who develop the new technologies are to earn a return. And standards can fall behind the technology frontier without the input from leading edge research, whether generated by business, universities or specialist research institutions.

1.8 IPR and standards from a policy perspective

The dominant approach to economic policy making is founded primarily on the idea of 'market failure' – the idea that in the absence of a policy intervention – markets will tend to allocate resources in an inefficient ('sub-optimal') way. Research, innovation and the corresponding creation of IP provide important categories in which all the generic types of market failure – indivisibilities giving rise to fixed costs, externalities (or spillovers) and uninsurable risk – are believed to play an important role. Standardization is also an area where market failure is believed to exist, as noted earlier.

The case for intellectual property rights

The economics and indeed political economy of research now has a long history, with justification for policy interventions in the form of IP protection and others (such as subsidies for research, or its direct provision through public procurement) being based on an understanding that there is market failure in the allocation of resources for research and innovation because the innovator is unable to recover the full return from their investments resulting in a tendency toward under-investment. This is partly because markets ensure that typically much of the benefit from innovation flows to consumers, but also because the knowledge embodied in the innovation 'spills-over' to rival firms who may be able to imitate at far lower cost. Policy intervention in the form of IPRs is intended to counter these problems and promote invention and innovation by granting a temporary monopoly in the expatiation of new ideas that add to the sum of commercially useful knowledge. In the case of patents, the holder is required to reveal the content, providing a codified source of knowledge so that others can both avoid infringement and plan alternative lines of research or development trajectories for themselves. The system therefore allows competition to re-establish itself when the patent expires with access to the specifics of the innovation, avoiding the need for duplication of research efforts.

The economics of research therefore recognizes that there is a trade-off between the market distortion created by monopoly power and the stimulus to research and innovation and there is no reason to suppose that an optimal balance is achieved in this trade-off. A question sometimes asked is why policy involves the creation of market power in this way, unlike perhaps a prize awarded by government. A simple answer supplied by economic theory is that this approach more effectively selects 'high quality' innovations, which generate higher welfare for consumers and producers *combined*. Prizes by contrast require much more information – often very difficult to acquire – to make the necessary selection.

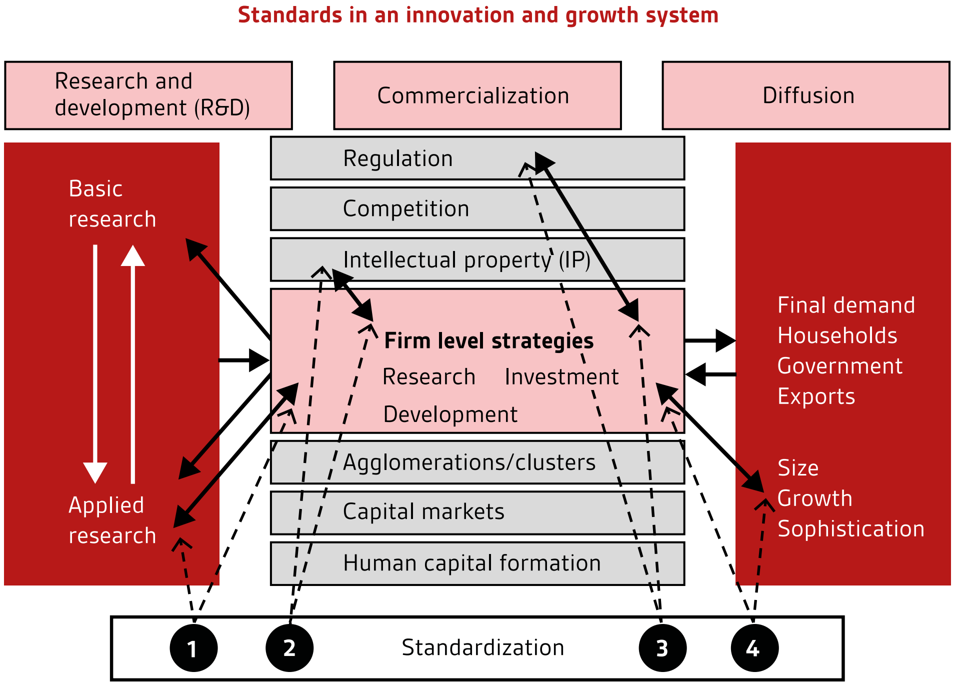
But economic policy has more subtle and difficult choices to make in the field of IPR beyond that between monopoly rights versus other types of incentive. The strength of the patent system can for example be influenced through changes to the scope, duration, or the geographic reach of a patent. At different times different economies have made major changes to their IPR policy. In earlier times Switzerland, Denmark and Holland offered no patent protection at all, while the US has considerably tightened IPR in recent decades and has implemented various measures which, in the view of some, has had deleterious impacts on innovation (e.g. Jafee and Lerner, 2004).

There are therefore at any time important questions for policy – since the nature of the trade-off between the incentive to innovate and the losses to society associated with monopoly power is constantly changing. Two elements of importance in the current context are: first, the enormous increase in the importance of standards which promote the inter-operability between systems, most clearly in the field of ICT, but with ICT increasingly important as an enabler in many other fields as well. The second is the increasing importance of research specialists – businesses and organizations which rely heavily on royalty income from their invention. Both hint at changing dynamics in standard setting and an increasing potential for the abuse of a 'dominant' position in the process. For these reasons it is important to consider both standardization and IPR from a perspective which allows for their interaction.

1.9 Research and standards from a systems perspective

Other approaches to the analysis of innovation and growth have adopted a 'systems' perspective. This has emerged over two decades as a means of considering the comparative economic performance of economies. Under this heading it is possible to detect discussions of different systems of production and corporate governance as well as innovation (Hall and Soskice, 2001). The idea of a system of knowledge generation and transmission which incorporates its translation into commercial innovation allows for a more nuanced view of how elements of the scientific and technology community interact with firms through identifiable institutions – organizations, policies as well as rules or regulations – which impact upon economic behaviour. Observation of considerable differences in these systems across countries has created a considerable literature founded on the idea of 'national innovation systems' (Nelson, 1993) or 'science, technology and innovation (STI) systems or even – to make the link to growth explicit – recently as 'STIG systems' (Aghion et al., 2009). Differences between STI systems at sector level can also be distinguished (Malerba, 2005).

Figure 1.1 – Processes linking science and technology with innovation and growth



Some of the elements of a STIG system which incorporates standards are illustrated in Figure 1.1, which indicates a basic structure centred on role of the firm (including collaborative activities) – the key institution linking the activities of the science base (in pure and applied research) with the set of final demands (both household and government consumption) and exports (which provide the means to pay for imports) which drive welfare. The literature on innovation and growth has examined various features of the business environment which profoundly influence the R&D decision at the level of the firm and its ability to collaborate effectively in cross-firm innovation projects, an increasingly important feature of the industrial landscape. Figure 1.1 shows various aspects of the environment in which there is a policy interest, usually on the basis that there is some market failure. Bringing standardization into the picture can be done in a number of ways, but the diagram is used to emphasize the 'catalytic' effect of standards on innovation – a term used by both Blind in his inaugural lecture at Erasmus University (Blind, 2009) and backed up by Swann in his reprise of the economics of standards (Swann, 2010). This catalytic effect typically strengthens the complementarities between components of the system, although of course, the opposite may also hold, an example of 'systems failure' in which the interaction between elements worsens the performance of the system as a whole.

Standards have impacts at various points in this system as indicated by the numbered linkages. Here we illustrate just four. Catalyst 1 reflects the impact that certain standards have on information and communication costs in scientific research. Some studies also suggest that standards may be able to stimulate innovation through government procurement policy – catalyst 4. For example, in his survey of standards and innovation, Blind (2012) discusses the role of public procurement in innovation, noting the potential for greater participation in standards development, not least in the sophistication of the requirements of the public sector. Catalyst 2 – the interaction between standards and intellectual property rights has become problematic and is discussed further below where we see a potential for so-called 'systems failure'. Catalyst 3 represents the real (or potential) for mandated standards to act as a promoter of innovation in regulation. Figure 1.1 is also helpful in informing us about lacunae in our knowledge and other possible catalysts. For example, given the possible importance of standards for reducing risk and encouraging sunk cost investments, we know next to nothing about the role of standards for investments in fixed capital, via for example, their ability to reduce imperfections in capital markets.

Changing elements in the system of innovation: Uncertainty surrounding standards development

A number of our interviewees expressed the view that the uncertainty surrounding standards development was increasing, with concern coming from both small and large scale business.

One inventor, highly motivated in terms of participation, pointed to the dependence of his business on the orderly and timely development of standards for compliance. Pointing to the importance of intellectual property for the elements in innovation that added value, he thought the lack of data available for committees when embarking on a new work was something which could be remedied in the modern world of technology in which substantial amounts of data for both standards and patents already exist.

1.10 The role of IPR in standards setting

In some respects, standardization is at an opposite pole to IPR, with the underlying aim of enabling more widespread use of knowledge through its embodiment in a form readily available to all. So whether IPRs and standardization complement or are in conflict with each other has important implications for the efficiency of the innovation system as a whole, for example by concentrating on standards which come closer to the pure public good type. This ideal form has been impossible to attain, most notably in the fields of ICT and with particular reference to mobile telecommunications, through the successive phases of development of 2G, 3G and 4G systems. In these technologies, patenting even of small details of the network and handsets and software is very extensive. The development of compatibility standards in the field enables users and suppliers to reap the benefits of network externalities, and also act as a unifying platform for future technological progress. The standards thus need to incorporate the leading technologies which will include those protected by patents. This need in turn can provide an incentive for firms to patent more extensively or to otherwise make strategic use of their patents in the standardization process in order to extract the maximum share of the additional value created by the larger market enabled by standards. The strategic interaction generates potential problems for standards development, which have been well documented in the literature.

A contribution by Tim Frain (2006) has neatly summarized the relationship and the issues arising. He argues that patents play a pivotal role in the framework for achieving open standards as they enable the participants in the standard setting process to openly share their knowledge and make technical contributions to the standard, confident that their technology is protected by a patent application. If patent rights did not apply to standards contributions at all, innovators would have to rely on trade secrets to protect their inventions resulting in more proprietary – and less open – standards. The framework underpinning open standards would be lost and the number of initiatives to create open standards would decrease.

The challenge from a policy standpoint, in the case of an essential patent, is to strike the proper balance between:

- the rights of the patent owner (licensor) to enjoy the full benefits of the patent;
- the rights of third parties (licensees) to make and sell standard-compliant products; and
- the public interest not to lock users into specific technology platforms.

This balance may be shifting over time. To proceed, it is useful first to consider the question of participation in cooperative standards development as an important way in which firms maintain and enhance the value of individual firm's IP. IPR and especially patents may be fostering additional motivations for participation which may lead to unwelcome outcomes, so we then go on to review the literature on whether there is evidence for such effects and whether formal rules within committee based standardization can help mitigate them.

1.11 IP and participation in standards development

Most of the literature on participation has concerned aspects of the overlap or interface between the IPR and standardization systems, with a strong focus on the potential for conflict or at least the inhibition of standards making by the need to deal with IPRs.

Very little has been published on the option of participating in standards development as an alternative to formal IPR, that is, it can be one of the informal types of IP that are known to be relatively attractive to many organizations. Moreover, as noted above, there are certain similarities between participation and the disclosure of IP as a distinct strategy. We also noted that that the literature suggests that more organizations make use of secrecy, design complexity or speed to market than patents or formal design rights. Although standardizing an innovation is not usually included as one of these options, it is well known that many more businesses and other organizations take part in standards making than apply for patents or design registration.

Motives for participation

Very few papers focus on the general motives for participation in standards development. One that does in the case of Germany (Blind, 2006) reports that – unsurprisingly – there is a significant effect of firm size – smaller firms are less likely to participate. Blind also finds an inverse U-shaped relationship between participation, and both R&D and exporting activity, with both export and R&D intensive firms being less likely to participate than those with middling exports or R&D intensity. They explain this finding with the suggestion that participation requires some R&D or other technology sophistication, but for very technology intensive businesses, the advantages of participation are off-set by knowledge spillovers to other members of committees. IPRs do not fully protect important tacit knowledge, so firms particularly dependent on this may pursue secrecy as a preferred IP strategy. Their findings are consistent with the idea that disclosure of IP in standards development may be a strategy for firms who are some way from the technological frontier. Not least, the codified knowledge in standards may make establishing novelty more difficult.

An interesting corollary to the issue of participation and unintended leakage of knowledge is raised by Simcoe et al. (2009). They find in a study of 13 SSOs that patents referenced in their standards have a relatively high litigation rate. Further, the litigation rate by smaller firms increases after the disclosure of a patent. These results give some support to the concern that giving more widespread exposure to a patent through a standards development process is risky for the patent holder, especially smaller businesses (and HEIs, RTOs etc.), to the extent that many high technology businesses choose to avoid SDOs.

Ultimately of course a principal driver for participation should be business performance. A rare study of the issue is that by Wakke and Blind (2012) who investigated the business performance of firms who participate in standards development at DIN, as measured by the number of committee seats. They find that there is in general a positive relationship between participation and performance. One important result of the analysis was that in the case of service sector businesses that develop new technologies for sale or licence, the combination of patenting and standards development seems to have a positive performance impact.

More recent work on the general motivation for participation in standards development has been considered, conducted as part of the BRIDGIT project is discussed further in Section 1.13.

Patents and participation in standards making

IPR in the form of a patent presents another possible reason for participation in standards development in that if the inclusion of a patent in a standard may enhance the value of the patent. There is little evidence that other forms of IPR are important (see for example, Blind et al., 2011). The extent of patenting is however very different across sectors as emphasized recently in a UK context in a recent study for the UK IPO (Hall et al., 2012) who find large differences in the share firms who patent across sectors, with 20% of the firms in the R&D services sector patenting against 1.4% of non-manufacturing firms in general. Firms – mostly SMEs – who are developing technology for sale, are more likely to seek protection.

The concentration of patents across sectors appears to hold also for patents referenced in standards. In their study of the interplay between patents and standards for a number of SSOs, Blind et al. (2011) found that declared IPRs in standards mostly took the form of patents, but that these were confined to a smallish minority of standards, largely within telecommunications and consumer electronics, and with ownership largely confined to a small group of companies. Among major SSOs, they find considerable variation in the percentage of standards including a patent, from under 3% at CEN, to nearly 40% at ITU-T. They note that owning a standard essential patent (SEP) may serve several functions, and not just as a source of licensing revenue. These other functions may include the signalling of technological capability and providing a bargaining tool for access to other firms' IPR. Cross-licensing or reciprocal non-assertion agreements, and to a lesser extent patent pools, are various forms of arrangement that can be found.

Evidence for the enhanced value of a patent included in a standard can be found in a study comparing the referencing of patents included in standards by Rysman and Simcoe (2008) who observe that such patents have a higher rate of citation than the average. They infer that SDOs not only select new technologies for standards but also help to establish them in the market place. The SDOs in question- ETSI, IETF, IEEE, ITU are all in the ICT domain, broadly defined, confirming the high importance of IPRs in these technology areas.

A non-assertion model

A lot of standards development in ICT proceeds without the conflicts with IP holders that are the subject of much of the economics literature. A good example is a Committee of the SDO OASIS working on a standard for messaging, based on a protocol originally developed by major ICT companies but passed freely to OASIS as the basis for the standard.

OASIS includes all the main businesses in the field e.g. IBM, CISCO, plus individuals and smaller firms. The technical committee have adopted the 'non-assertion' rule for IPR relevant to the standard. That is, rights will not be asserted and pursued so long as the patented knowledge is used wholly within the bounds of the standard specification. OASIS has other IPR options in its IP policy, including FRAND.

Value-added services can be developed as additional layers on the standard and these might be subject to IPR and need to be licensed separately. This approach to standards development brings together the classic rationale for standards, of sharing knowledge to establish a sound specification basis for a range of products and services, with the benefit of wide dissemination of new and improved technology.

The participation and patenting nexus has also been investigated in a series of papers, brought together in a PhD thesis by Rauber (2014). This work uses data from a regular German innovation survey and from a new survey of standards participating and patenting companies. One finding from these studies is that firms who have recently introduced a product or process innovation are more likely to join a DIN committee, probably to influence the standard to accommodate their innovation, or to enhance its market value through standardization. R&D intensity itself is not, though, found to be a significant factor explaining participation. But patenting does significantly increase the probability of participation and precedes the participation decision. They also find that innovating businesses have similar motives for participating in standards development and using standards in their own innovation process, pointing to a coherent standards strategy. There is significant variation in behaviour by firm size, with SMEs significantly less likely to participate in SDO committees.

An important side comment is that the average number of patents held by patent holders in the sample at 5 is well below the number for German patent holders overall (31). This echoes a result reported in a study for the European Commission of patents and standards (Blind et al., 2002). A survey conducted for the study found that businesses engaged in standards development, file fewer patents than average, providing some support to the belief that these are to some degree alternative strategies. This substitution effect is more pronounced for smaller firms. IPR and standards development tend to be complements for larger organizations and, as reported above, for the economy as a whole.

Policy changes at the IEEE

One of the world's major SSOs - The Institute of Electrical and Electronics Engineers Standards Association (IEEE-SA) – recently proposed changes to its policy regarding FRAND. The move is of great interest in that it attempts to clarify certain features of the FRAND that many SSOs adopt as guidelines. Should the licence fee for an SEP reflect the contribution of the proprietary technology to the value of the combined product or should, as is proposed, it reflect the value of the relevant functionality of the *smallest* 'saleable Compliant Implementation that practices the Essential Patent Claim'.

In several of our interviews, representatives of large R&D oriented corporations operating in different parts of ICT, expressed concern at these developments. Each company clearly operated strategies to realize value from its intellectual property that was sufficiently flexible to alter its existing commitment to standards development (at least via particular SSOs) and thought they were able to change that commitment if the returns from this activity were to decline significantly. A move back toward greater vertical integration of a company's operations with a step change in the extent of proprietary and exclusive technology may be one possibility. Another may be the attempt to broaden the scope of patent claims or otherwise adopt a more 'hands-off' IP policy as a more advantageous strategy. In the view of these interviewees, the advantage of the existing system was its *flexibility*, and the slow development of FRAND on a 'case by case' basis.

'Suits', 'Beards' and delays in committee work

In his investigation of standards development at the Internet Engineering Task Force (IETF), the economist, Timothy Simcoe, of Boston University Management School, used the idea of 'suit-to-beard' ratios within working group e-mail discussion lists to measure (however imperfectly) the degree to which standards development was commercially sensitive (Simcoe, 2012). He found that commercial sensitivity was indeed a source of delay in standards setting, an idea that rang true with a number of our interviewees who found that the composition of active participants might change rapidly in certain situations. While Simcoe's work emphasized the role of what economists call 'rent seeking' when IP was involved, our interviewees suggested other sources of delay even in the more common scenario where development work does not involve a significant degree of distributional conflict resulting from IP. One interviewee reckoned that the 'suits ratio' was still relevant when the committee was searching for the 'best standard' and that commercial interests might wish to opt for a lower cost alternative to a well-engineered solution. Another source thought that the simple enjoyment of committee meetings might be a source of delay! Nevertheless, the extent to which participation provides job satisfaction for scientists and engineers is no doubt an important consideration for large research intensive organizations.

The results also point to important sectoral differences. More mature sectors, e.g. pharmaceuticals, show much IPR activity but less standardization. A few sectors have little IPR so there is limited scope for conflict in the standardization process. Some cases, e.g. optical instruments, electronics, metrology, have medium levels of both standardization and use of formal IPR. In the case of aeronautics – standards and IPR co-exist – a position bolstered by the industry being relatively concentrated which arguably makes the reciprocation process effective. ICT sectors report a strategy of strong IPR but also a need for standards for network externalities. So there may be potential for conflict but also a pressing commercial need to agree the standard. The survey also found that 40% of respondents had problems with others' IPR.

Many SDOs adopt rules about declarations and licensing terms such as FRAND which are discussed further in this section. While the general perception is that this does not discourage participation, it has been asked if FRAND restrictions can imply royalty rates that may be insufficient to induce participation in standards development by technology leaders (Hussinger and Schwiebacher, 2012; Layne-Farrar et al., 2010), a possibility that has come to the fore with proposed policy changes at IEEE and mentioned by a number of our interviewees (see Box on '"Suit"s, "beards" and delays in committee work').

1.12 Interaction between standards and IPR and the potential for 'system failure'

It is important that IPR and standards coexist and protection of IP by firms is inevitable in standard setting as in other contexts. Indeed in the ideal type of standardization process discussed above, standard setting is a means of enhancing the value of an individual firm's IP. Patents or other forms of IPR are often complementary to the process. However much of the recent literature has been devoted to examining cases of a more pathological nature.

The potential abuse of patent rights in standards development

It is possible that the systems for standardization and protection of IP interact in ways which are deleterious for 'productive entrepreneurship' based around innovation and instead encourage what economists call 'rent seeking' with resources being expended with the sole objective of redistributing existing wealth.

A major form of potential abuse of patent rights in standards development is known as 'hold-up' or 'patent ambush'. In extreme cases, this can arise when the owner of a patent fails to make its existence known to intending users of a standard under development. They may then find themselves locked into use of the standard and facing unexpected demands for high royalty rates by the patent holder.

Further problems are associated with so-called 'royalty stacking' where producers are faced with the need to acquire many licences, so that even though each may be on a fair and reasonable basis, cumulatively the costs are excessive. The use of 'Patent Pools' is a widely used means of dealing with this issue, whereby the essential patent rights holders contribute to a package that may be licensed as a unit.

A number of studies have confirmed that there is not simply an overlap between the domains of standardization and patenting, through standards essential patents (SEPs) but also feedback links – the patenting behaviour of firms is materially affected by the inclusion or potential inclusion of a patent in a standard. In general, they seek more patents, where the quality may be diluted and tend to be more active in litigation. In part, this is one instance of the more general issue of strategic patenting – where the protection is sought not simply to enable the exploitation of the invention set out in the patent but to bolster the firm's market position by raising rivals' costs. Examples include so-called 'blocking patents', not intended for use in production of new products or processes but to constrain the ability of competitors to develop alternatives. Similarly, extensive patenting around a core invention creates 'thickets' that set up a

What is 'Royalty Stacking'? A dilemma for competition authorities?

In some business situations, especially in ICT contexts, there is a belief that so-called 'royalty stacking' may be impeding the take-up of standards because the total cost of the IPR licensing involved, even on reasonable and non-discriminatory terms, may be prohibitive for many potential users of a standard. Economic theory – going back to the 19th century French philosopher Antoine-Augustin Cournot – has recognized that there may be a problem whenever businesses with monopoly power occupy the same supply chain. If each producer charges a monopoly price to the next downstream producer in the chain, without taking into account the impact on the latter's profit, then two things can be claimed in comparison to an alternative scenario in which the entire supply chain were owned by a single monopolist. First, the price to the ultimate consumer will be higher. Second the aggregate profit will be lower. In other words, everybody loses, consumers and producers alike and both would be better off if the producers colluded and charged a collusive (joint profit maximizing) price. Where patents are held in the supply chain, then this adds an analogous monopoly element to even an otherwise competitive supply chain – royalty income will be lower and the price for users of obtaining all the necessary patents higher. A patent pool, organized as single monopolist, and bundling all the licences together to charge a single monopoly price, would be good for general well-being. Should therefore competition authorities approve patent pools? It's not so easy. We would have reached the opposite conclusion if this scenario had not been a supply chain but instead the producers had been competing in the same market – in which case we would be observing a price fixing and quite possibly illegal cartel. In real world contexts, the competition authority's job is far more difficult. In ICT, for example, the same companies will be both supplying to each other product components as well as competing in, for example, applications.

sort of minefield of infringement risks for rival firms and may clearly have a deleterious effect on innovation. Other examples of strategic patenting include the following:

- Padding, which involves generating groups of 'weaker' patents, to enhance the position of the firm in licensing negotiations or in patent pools (Dewatripont and Legros, 2013).
- Coordination. Firms that are members of industry consortia have a higher probability of citing each other's patents in SEP declarations (while controlling for patent and firm fixed effects). But the pattern is consistent with spillover effects – that is, the citations are genuine acknowledgement of prior art by fellow members of the consortium, who are all practitioners and developers of the underlying technologies (Delcamp and Leiponen, 2013).

FRAND

Most SDOs have attempted to deal with the potential negative aspects of the intersection between standardization and patents by introducing an IP policy statement. A selection of these has been reviewed (Bekkers and Updegrove, 2012). The most common element regarding licensing is the inclusion of RAND or FRAND principles, although the policy documents do not provide tight definitions of these terms and some high profile litigation has concerned the interpretation of FRAND, turning on accusations that one or other element has been abused in a patent holder's licensing behaviour.

Uncertainties around FRAND have led to some contributors to the literature arguing that it is not effective and proposing or citing amendments to FRAND or alternatives that could provide stronger safeguards for the integrity of standards that involve essential patents. These include:

- adapting the principle of patent pools in a form of a 'pseudo-pool' which would include: good faith patent declarations during the standards making process and establishing aggregate royalties, to be shared between SEP holders (Contreras, 2013);
- cross-licensing pools, which should be encouraged to reduce the impact of patent thickets (Shapiro, 2001); and
- binding arbitration in setting of FRAND royalty rates (Lemley and Shapiro, 2013).

Reverse hold-up

The patent hold-up problem emphasizes the risks faced by those who develop the standardized technology, but an interesting paper on the risks to the patentees arising from 'reverse hold-up', Geradin (2010) argues that the former risks have been greatly exaggerated in the literature and that there are few, if any, cases where standards development has been harmed by the demand for excessive royalties.[3] Rather, in his view, there is more threat that patent holders will lose value through involvement in standards. Patent holders face significant constraints on royalty setting in the standards making context. Vertically integrated producers, for example, will face the need for cross-licensing agreements, while in formal SDOs, open declaration of relevant patents and RAND pricing principles will inhibit opportunistic licensing. So it is mainly 'non-producing entities' or firms with no current or intended future participation in standards development that are in a position to pursue excessive royalties. The latter condition may not, though be as rare as he suggests, as there is some evidence that the most patent intensive businesses tend to avoid involvement in standards development, leaving them more able to seek licensing terms yielding super-normal profits.

He also makes the argument that the sunk costs of R&D are, for technology developing firms, the mirror image of the high switching costs faced by the standards users in the traditional patent hold up conjecture. There may then be a risk to the rate of innovation if patent royalties of licence only technology firms (often SMEs) are artificially limited in their pricing policy by the pursuit of anti-hold up measures.

3 'In the Qualcomm case, for instance, the complainants, six large vertically-integrated firms, argued that Qualcomm fees were 'excessive and disproportionate' and that they would 'hold back adoption of 3G'. This prediction proved entirely wrong as since 2005 the market for 3G phones has grown tremendously making 3G one of the most successful standards ever adopted.

1.13 Evidence from the BRIDGIT project

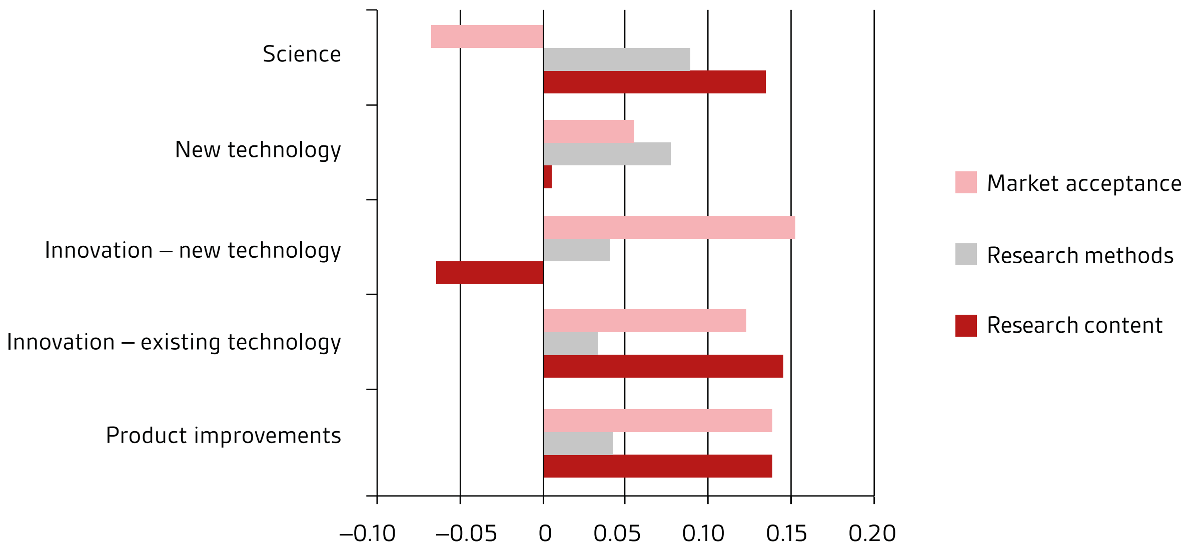
A recent study for the European standards body CEN-CENELEC as part of the BRIDGIT project, aiming at improving the linkages between research and standardization, investigated the reciprocal links between standards and standards development and research in an innovation system (CEN-CENELEC 2015). Some of the evidence from the study provides a helpful context and background for the present inquiry. Surveys of technical committee members and from the research community gathered information on the links and the catalytic roles of standards from researchers and members of CEN-CENELEC technical committees.

The use of standards in research

Major findings from the project included evidence regarding the extensive and intensive application of standards in research. The results of the analysis are summarized in Figure 1.2.

As Figure 1.2 suggests, the use of standards was especially pronounced where the research objectives included incremental innovation in products, processes or services, as might be expected. Standards are considered especially important in specifying the content of research with more incremental innovation objectives. When research is closer to market, standards provide important elements of customer confidence, enabling the establishment and growth of markets. In this case, standards are therefore part of the 'demand pull' side of the innovation system – which in turn creates flows of knowledge from products and markets back into research and innovation. But where research had scientific or technological advancement as an objective, it was also found to use standards for the content and management of the research. That is, standards can influence the way investment in the generation of new knowledge is organized, thus supporting potentially radical innovations where these are science based. In research with specifically scientific objectives, standards are used to facilitate the process of such as enabling effective communication between researchers and supporting for the systematic collection of results and data.

Figure 1.2 – The use of standards in research



Evidence regarding participation in standards development

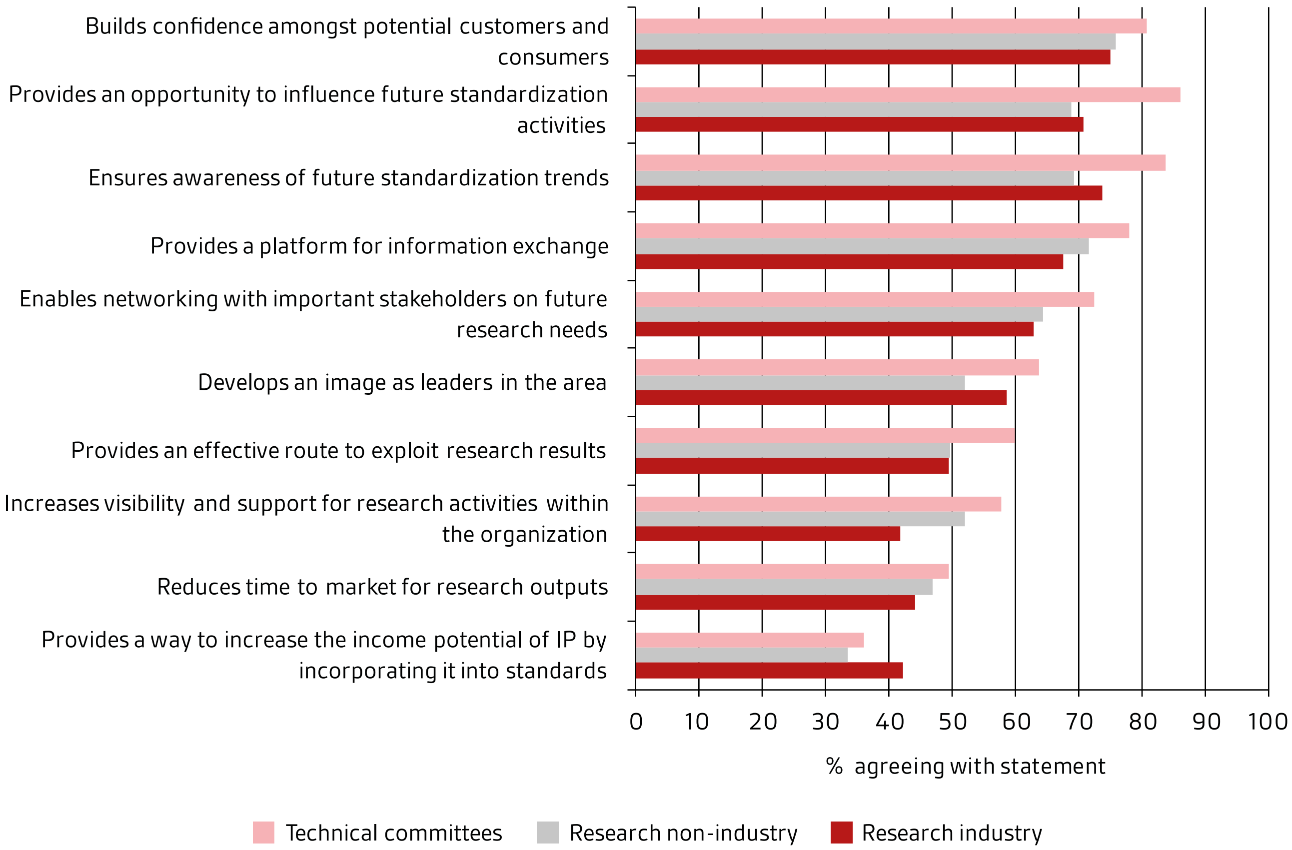
One line of enquiry in the surveys carried out for the study for CEN-CENELEC, concerned the motivations for participating in standards development. This was addressed to all three target groups – industrial researchers, non-industrial researchers and members of CEN-CENELEC technical committees. Whilst there are some differences between the three groups, the general pattern is similar.

From the survey data shown in Figure 1.3, the main motivations for participation in standards development are related to 'networking' benefits rather than simply commercial interests, i.e. that participation:

- 'Provides a platform for information exchange' (overall 73% in agreement);
- 'Builds confidence amongst potential customers and consumers' (78%);
- 'Enables networking with important stakeholders on future research needs' (74%);
- 'Ensures awareness of future standardization trends' (76%);
- 'Provides an opportunity to influence future standardization activities' (76%).

It can be seen from Figure 1.3 that technical committee members seem to have a more favourable attitude to most of the potential benefits. Their most important motivation, perhaps unsurprisingly, seems to be about 'influencing future standardization activities' whereas the overall top response across all three groups was 'builds confidence amongst potential customers and consumers'.

Figure 1.3 – Motivation for participation in standardization



Standards development and IPRs

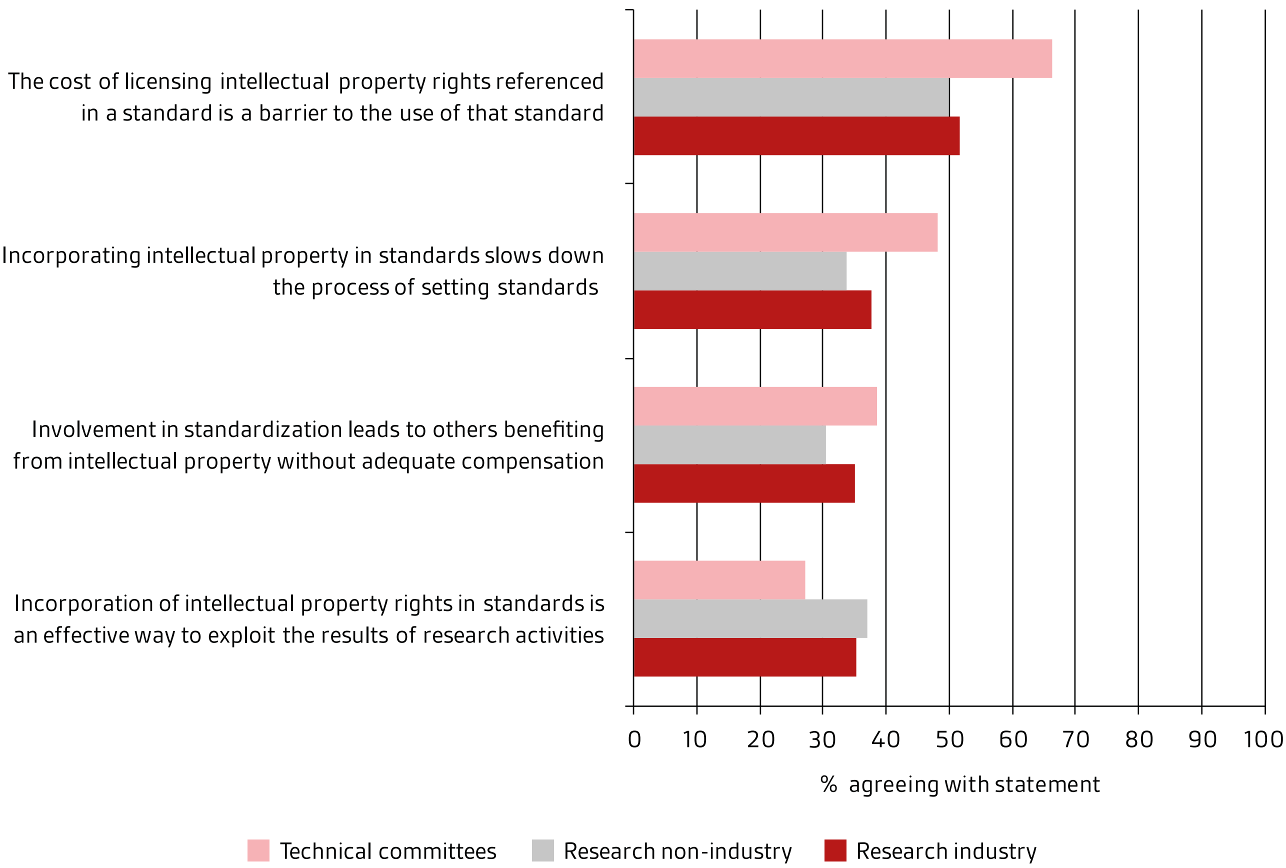
The study, undertaken as part of the BRIDGIT project, also addressed the issue of the role of IPR in the development of standards. The general finding was that IPR and standards co-exist in an acceptable manner in most industry sectors and that the importance of IPR to standards development is limited except in the case of ICTs, where the complementarities are extensive.

The general view from contributors to the study is that IPR and standards essentially co-exist reasonably, although innovators are encouraged to protect IP prior to participation in standards activities.

Neither formal IPR nor standards operate evenly throughout the innovation system. Other means of protecting IP such as secrecy, the creation of a lead time or by deployment of strong complementary assets, for example in manufacturing or marketing are often more widely used than formal IPRs. Some sectors actively pursue formal IPR, such as biotechnology or nanotechnology, where many firms specialize in research and are correspondingly more dependent on income from IP.

Similarly formal standards are not consistently found in great numbers wherever there is innovation. While they are found throughout established sectors, such as manufacturing and engineering in particular, it has already been noted that they are much less prevalent in the service sector.

Figure 1.4 – IPR in standards



2. Analysis using the UK Innovation Survey[4]

2.1 Introduction

This section reports some analysis using the UK Innovation Survey. It considers the following questions:

- What is the pattern of innovation in the UK to which both standards and IPR contribute?
- What IP strategies do firms adopt?
- To what extent do different firms value standards as a source of information for innovation and how does it compare with other sources?
- How do standards impact on the innovation process?
- How is the engagement with, and commitment to, innovation reflected in the value firms place on standards as a source of information?
- To what extent are standards and the firm's perceptions of the value of standards in innovation reflected in their assessment of IP strategy?
- How does innovation and IP impact on firm performance?

2.2 The pattern of innovation in the UK

The last wave of the survey UK Innovation Survey (UKIS8) was conducted for the period 2010–2012 and has recently been made available for researchers. It contains over 14,000 responses from business units with 10 or more employees (excluding 'micro' units) covering various aspects of innovation and innovation-related activities, including both the use of resources and outcomes in terms of innovation (product, process or more broadly conceived forms of innovation). Although the basic structure and questions remain the same, the questionnaire has varied in various ways over time. For this reason, we consider results from the last two surveys and include data for the survey conducted for the period 2008–2010 (UKIS7). The combined sample size consisted of 28,827 'business units' (firms for short), some of which were represented in both surveys, creating the possibility of examining these units' growth between the two surveys. The surveys provide considerable amounts of information regarding both innovation outcomes and the resources used to generate them. For those firms recorded as being 'active' in innovation (not necessarily innovating but observed to be committing resources to innovation) there are additional questions relating *inter alia* to firm strategy and the importance of different sources of information.

Details of the combined sample in terms of innovation are shown in Figure 2.1; it reveals a very similar pattern of innovation across the two samples. There are of course many conceivable ways of defining innovation, and broader definitions are catered for in the survey, but our investigation here is restricted to product and process innovation, where the use of IPR and especially patents are more common. In relation to both product and process innovation, the pattern observed is remarkably similar across the two surveys. In both surveys, nearly a quarter of firms described themselves as either a product or process innovator, with a predominance of product innovation – with over one fifth of firms in each sample describing themselves as product innovators. A majority of the product innovators are innovators in products only but a substantial minority are both product and process innovators (over 42% across both surveys). By contrast, the process-only innovator is a much rarer bird (under 4% of the combined surveys).

4 This section contains statistical data from ONS which is Crown Copyright. The use of the ONS statistical data in this work does not imply the endorsement of the ONS in relation to the interpretation or analysis of the statistical data. This work uses research datasets which may not exactly reproduce National Statistics aggregates.

An important distinction (and certainly in relation to IPR) is whether the innovation is new only to the firm or extends to the market or industry (involving genuine novelty). Slightly less than half of the product innovators in either survey regard their innovation as being new to market (resulting in a 'novel product') and an even smaller proportion of process innovators (less than one quarter in the combined sample) regard their process as being new to the industry. These definitions of novelty are of course self-reported so the responses should be treated with caution as a guide to the inventive step needed say for a patent grant. In the case of process innovation of course, this is going to be even more difficult to gauge, since secrecy is a likely strategy for the protection of intellectual property.

Turning to the input side of innovation in Figure 2.2, it can be seen that only just over a quarter of the firms who declared (less than the full sample) were performing intramural R&D – a figure which does not rise very much if extramural R&D is included. Given the prominence of product innovation in Figure 2.1, it is unsurprising that forms of innovation input relating to marketing[5] are the largest single category. Computer-related expenditures are also strongly represented, with well over a third of units reporting innovation related purchases of software and just under a third for the acquisition of computing hardware. Both these categories increased between the two waves. By contrast with other inputs, the purchase of external R&D, or the use of IPR licences is quite small.

Figure 2.1 – Innovation in UK 2008–2012

	2008–2010 UKIS7		2010–2012 UKIS8		Total	
	No.	**%**	**No.**	**%**	**No.**	**%**
Non-innovator	10,837	75.6	10,970	75.7	21,807	75.6
Innovator (product or process)	3,505	24.4	3,517	24.3	7,022	24.4
Product innovator	3,005	21.0	2,918	20.1	5,923	20.5
Process innovator	1,814	12.6	1,802	12.4	3,616	12.5
Product and process innovator	1,314	9.2	1,203	8.3	2,517	8.7
Product only innovator	1,691	11.8	1,715	11.8	3,406	11.8
Process only innovator	500	3.5	599	4.1	1,099	3.8
Novel product	1,399	9.8	1,326	9.2	2,725	9.5
Novel process	475	3.3	421	2.9	896	3.1

Source: ONS unweighted data

Figure 2.2 – Inputs into innovation in UK 2008–2012

	2008–2010 UKIS7		2010–2012 UKIS8		Total	
	No.	**% of units**	**No.**	**% of units**	**No.**	**% of units**
R&D internal	2,520	27.9	2,638	29.3	5,158	28.6
R&D external	1,038	11.5	745	8.3	1,783	9.9
Equipment	1,514	16.8	1,558	17.5	3,072	17.1
Computing equipment	2,488	27.6	2,995	33.1	5,483	30.3
Software	3,038	33.7	3,628	39.9	6,666	36.8
IPR Licence	858	9.5	584	6.6	1,442	8.1
Training	2,044	22.7	2,207	24.8	4,251	23.7
Design	1,722	19.1	1,688	19.0	3,410	19.0
Marketing (any)	3,038	33.8	2,939	33.2	5,977	33.5

Source: ONS unweighted data

5 Here we have amalgamated the categories in the survey which includes 'changes to product or service design', changes to marketing methods, or 'launch advertising'.

For understanding the pattern of innovation and decision making regarding the protection of intellectual property, the role of firm size is significant, not least because the partly complementary, partly competitive aspect of the relationship between the small innovative firm and the large R&D performer, is an important aspect of an innovation system. In Figure 2.3, it can be seen that in all cases the% of the sample who innovate rises with firm size, but that that the effect is rather larger (in proportionate terms) for process innovation.

Figure 2.4 also reveals significant differences in the extent to which firms of different sizes acquire different types of innovation input. Whereas less than a quarter of the smallest size class (10–49 employees) engage in intramural R&D, this rises to well over one third for those with over 250 employees. It might be thought that smaller firms have greater need to access the market for R&D, but here the increase in the proportion of firms purchasing R&D externally rises even more steeply. By contrast, the acquisition of computing equipment and software is much more evenly distributed, as are marketing inputs, reflecting the relative importance of product innovation among the smaller firms in Figure 2.3.

Having considered some aspects of the general pattern of innovation in terms of both outcomes and innovation related inputs, we turn to a consideration of the methods of protecting the IP created during innovation.

Figure 2.3 – Innovation in UK 2008–2012
(% of firms in sizeband)

	Sizeband (employees)			
	<50	**50–99**	**100–249**	**250+**
Innovator (product or process)	21.2	26.4	28.9	27.3
Product innovator	18.3	22.0	23.9	22.5
Process innovator	10.0	13.7	15.4	15.8
Novel product	8.3	10.5	10.4	11.0
Novel process	2.5	3.8	3.5	4.0

Source: ONS unweighted data

Figure 2.4 – Innovation in UK 2008–2012
(% of firms in sizeband)

	Sizeband (employees)			
	<50	**50–99**	**100–249**	**250+**
R&D internal	23.6	30.2	33.2	35.6
R&D external	7.3	9.5	12.2	14.9
Equipment	14.1	18.6	20.0	21.1
Computing equipment	29.3	31.2	30.9	31.9
Software	34.4	37.5	38.8	40.4
IPR Licence	6.8	7.2	9.0	10.9
Training	21.1	23.3	24.9	29.3
Design	16.2	19.9	21.7	23.2
Marketing (any)	31.3	31.2	34.8	36.9

Source: ONS unweighted data

2.3 The protection of intellectual property in innovation

The UK innovation surveys contain questions regarding the importance attached to the various methods of protecting the value of a firm's IP. These include both so-called 'formal' methods (patents, design rights, copyright, and trademarks) and 'informal' methods (lead-times, complexity and secrecy). The precise question varies according to the survey. In the UKIS8 (2010–2012), firms who were active in innovation were asked as to 'How effective were the following methods for maintaining or increasing the competitiveness of product and process innovations introduced during 2010 to 2012?'[6] It needs to be noted that the question is 'filtered' – only posed to those respondents considered as active in innovation (even if not an actual innovator).[7]

Figure 2.5 indicates considerable variation in the response to the IP question, with fewer than 10% rating three of the formal methods – patents, design rights or copyright – as being of high or medium effectiveness, although in the case of trademarks, this rises to 14%. Non-formal methods are considered much more important, with complexity of goods or services rated as of high or medium effectiveness by nearly 31% of active firms.

It is well documented in the literature that IPR strategies depend on the nature of the innovation, with patents and other formal methods more important for protection of product innovation which are revealed on the market, than for process innovations, where secrecy is likely to be more useful. These differences are illustrated in Figure 2.6. Although it is indeed confirmed that the formal methods are more important in the case of product than process innovation, more striking is the fact that informal methods are more important than formal methods for both kinds of innovation.

	Sample size	%
Patents	7,818	9.7
Design rights	7,772	8.5
Copyright	7,777	8.7
Trademarks	7,815	14.0
Lead times	7,838	24.5
Complexity	7,900	30.8
Secrecy	7,800	16.3

Source: ONS unweighted data

Figure 2.5 – IPR strategies
(% of active firms rating method as of 'medium' or 'high' importance (UKIS8 only))

	Product	Process
Patents	20.6	16.5
Design rights	17.9	15.8
Copyright	18.6	16.5
Trademarks	27.2	24.4
Lead times	46.0	49.4
Complexity	57.0	57.6
Secrecy	34.1	34.0

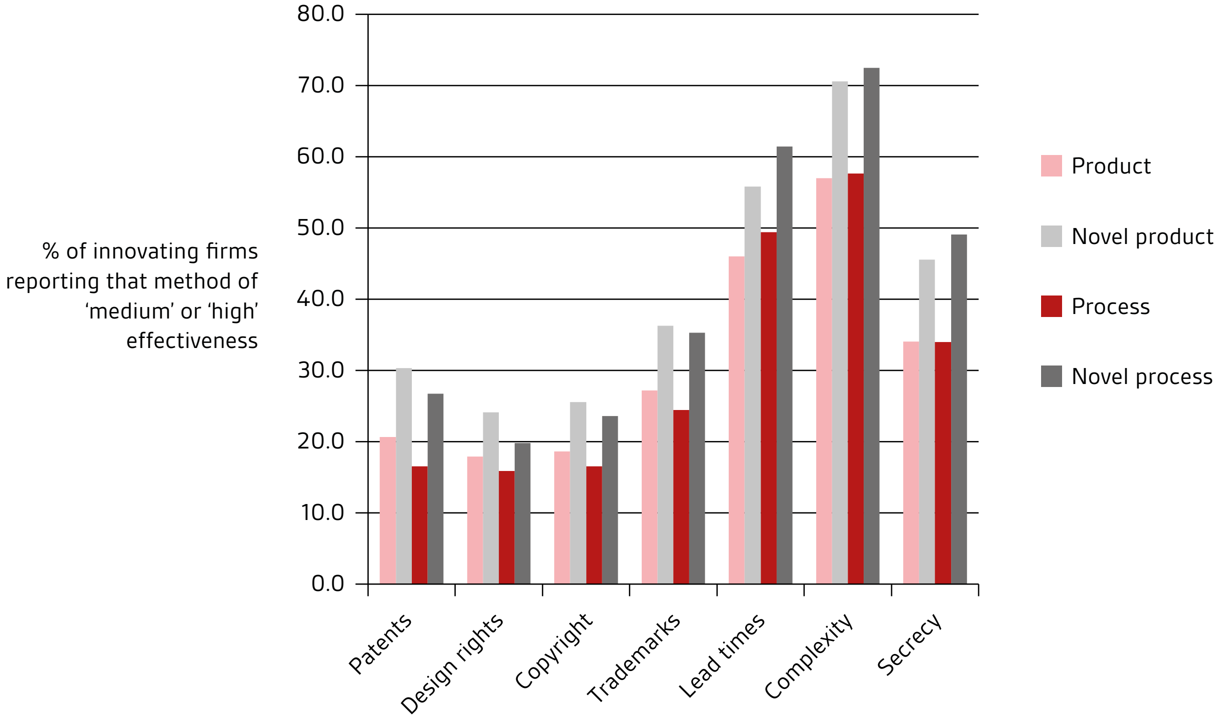
Source: ONS unweighted data

Figure 2.6 – IPR strategies by type of innovation
(% of innovating firms rating method as of 'medium' or 'high' importance (UKIS8 only))

6 The earlier survey asked about the actual use of these methods.

7 For the purpose of this section, innovation 'active' firms are those who record some innovation related activity, including other forms of innovation, even if they did not actually innovate in the survey period.

Figure 2.7 – The importance of novelty



Source: ONS unweighted data

In seeking a patent, a degree of novelty (an inventive step) is required. Moreover we would expect the requirement for IP protection to rise significantly when a product is 'new to the market' (a novel product) or a process is believed to be 'new to the industry' (a novel process). The differences are illustrated in Figure 2.7. The difference between types of innovation is large for all forms of IP protection but in proportionate terms it can be seen that is especially important for patent protection.

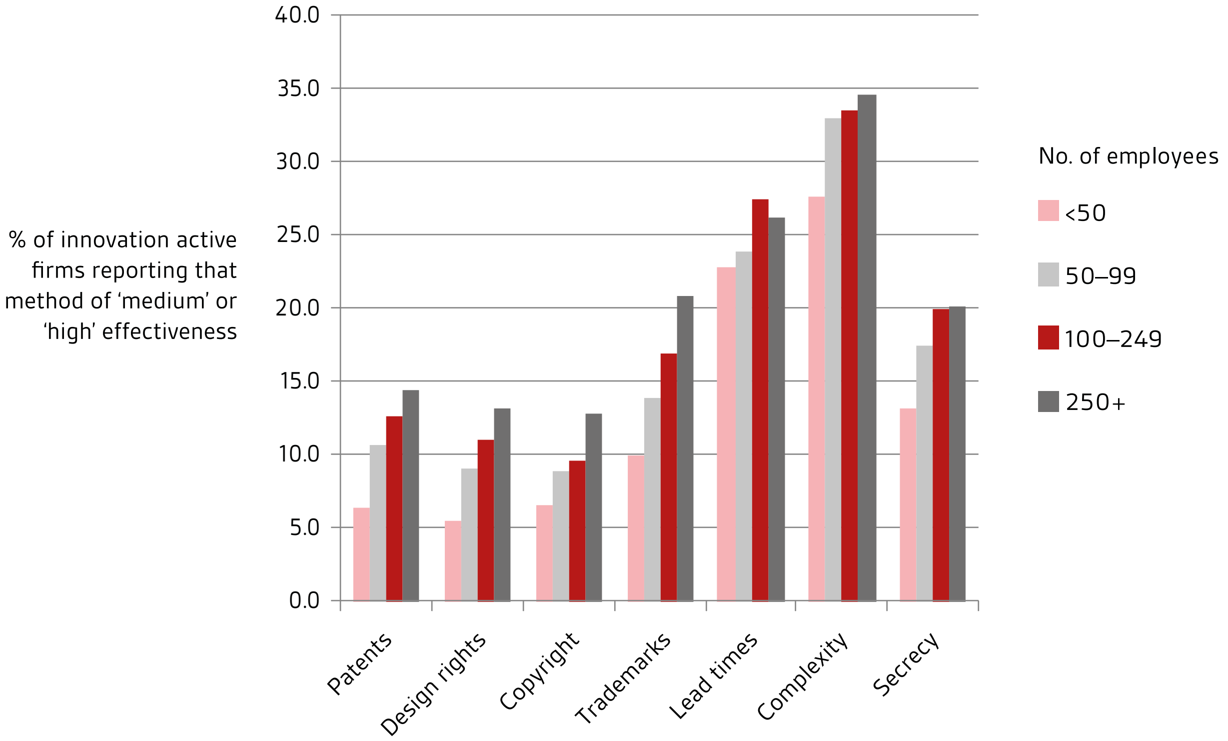
Firm size is also important for all methods, as illustrated in Figure 2.8 but the gradient appears to be much sharper in general for formal methods, and patents in particular.

2.4 The use of standards in innovation

Because of the limited nature of the information available from the surveys as to the use of standards in innovation (and none at all in relation to participation in standards development), we supplemented this information with data relating to the sector in which each firm operates. Here we used PERINORM[8] to generate data relating to BSI standards in order to assess the variation in the likely value of standards to firms by sector. The analysis employed both a count of seemingly relevant standards available to each producer as well as a measure of the median age of these standards. The choice of sectors was determined by the need to provide a broad measure of the variation in the technological opportunities available to producers – accomplished by using ONS data for business expenditures on R&D (BERD) which are available disaggregated on a product basis. This mandated a count across some 28 sectors, as in Figure 2.9, which shows the relevant data for the number of relevant standards by sector, together with the year of publication of the 'median' standard (i.e. 50% of the available standards prior to the year indicated).

8 PERINORM is a database of worldwide standards maintained by a consortium of the BSI, Deutsches Institut für Normung (DIN), and Association Française de Normalisation (AFNOR).

Figure 2.8 – Effectiveness of IPR strategies by firm size



Source: ONS unweighted data

Clearly, standardization is fairly concentrated in the following sectors: Chemicals, Computing and Electronic Products, Machinery and Electrical Engineering, other transport equipment, Building and Construction, and in services, Computing and IT services, and Telecommunications. A notable difference between some of these sectors is the rate at which their stocks have been growing as reflected in the difference in the median ages of the stocks. In Chemicals, for example, 50% of the relevant standards were produced prior to 2005 while for computing and electronic products it was fully five years later.

The main question in the innovation surveys themselves regarding standards is (as with IP protection) restricted to firms who were found to be 'active' in innovation and who are asked about the importance of different sources of information for their innovation.

Figure 2.10 compares the various sources in the survey according to the percentage of firms who regard the source as being of 'medium' or 'high' importance.

Evidently (and unsurprisingly) a vast majority of the respondents regarded their own business or enterprise group as being of importance, followed closely by customers and suppliers. Information coming from competitors was also regarded as being important. Of the other sources, 'technical industry or service standards' was the next most highly regarded category – far more so than other sources of documented or codified knowledge – with 45% regarding this source as being of 'medium' or 'high' importance, a figure which moreover rises between the two waves of the survey. Unfortunately, patents are not included as a distinct source of information, but might be regarded as falling within 'scientific journals and trade/technical publications' – which are rated as important by less than half the proportion which so rate standards.

Figure 2.9 – Standards and their vintage by sector

Sector	SIC 2007 code	No. of relevant standards	Median year of standard stock
1 Mining and oil, gas extraction	05–09	264	2006
2 Food and beverages, tobacco	10–11	1,012	2004
3 Textiles, clothing, leather	13–15	1,162	2003
4 Wood, paper, printing, recording	16–18	717	2006
5 Chemicals inc. petroleum refining (exc. pharma)	19–20	2,644	2005
6 Pharmaceuticals	21	211	2009
7 Rubber and plastic	22	1,467	2006
8 Non-metallic mineral products	23	1,497	2007
9 Basic metals	24	711	2003
10 Metal products	25	697	2008
11 Manufacture of computer, electronic and optical products	26	6,688	2009
12 Manufacture of electrical equipment	27	2,527	2008
13 Manufacture of machinery and equipment n.e.c.	28	4,948	2007
14 Manufacture of motor vehicles, trailers and semi-trailers	29	960	2010
15 Manufacture of other transport equipment	30	4,716	2006
16 Other Manufacturing, repair	31–33	1,022	2009
17 Electricity, gas, water, sewerage	35–36	283	2009
18 Sewerage, waste and waste management	37–39	212	2007
19 Building and construction	41–43	4,160	2008
20 Transport and distribution	45–47, 49–53	1,270	2007
21 Accommodation and catering	55–56	173	2005
22 Publishing, broadcasting	58–60	609	2006
23 Telecommunications	61	1,935	2008
24 Computing and IT services	62–63	1,646	2010
25 Finance, insurance and real estate	64–66, 68	274	2009
26 Legal accounting management consultancy	69–70	342	2011
27 Scientific and technical services	71–75	1,719	2007
28 Other business services	77–78, 80–82	23	2010

Figure 2.11 shows a breakdown of the different sources of information by innovation type. Generally it can be seen that – when compared to the group of innovation active units – both the act of innovation itself (whether product or process) adds to the value of all sources of information. Looking on standards in the bottom row we can see that this premium is especially true for process innovation, but this may for example be the effect of firm size (more likely to be process innovators), pointing to the need for more formal multivariate statistical methods. We now consider the impact of standards in the innovation process using econometric analysis.

Figure 2.10 – Information sources for innovation
(% of innovation active firms rating information source as of medium or high importance)

	2008–2010 UKIS7	2010–2012 UKIS8	Total
Within your business or enterprise group	84.4	88.5	86.7
Suppliers of equipment, materials, services or software	62.9	69.4	66.2
Clients or customers (*UKIS7 only*)	82.3		
Clients or customers from the private sector (*UKIS8 only*)		81.0	
Clients or customers from the public sector (*UKIS8 only*)		38.6	
Competitors or other businesses in your industry	57.5	58.2	57.9
Consultants, commercial labs or private R&D institutes	25.6	31.8	28.8
Universities or other higher education institutes	13.2	16.0	14.6
Government or public research institutes	13.9	14.2	14.0
Conferences, trade fairs or exhibitions	31.4	35.1	33.2
Professional and industry associations	37.1	41.9	39.5
Scientific journals and trade/technical publications	21.7	22.7	22.2
Technical, industry or service standards	42.6	46.9	44.7

Source: ONS unweighted data

Figure 2.11 – Information sources for innovation by type of innovation
(% of innovation active firms rating information source as of medium or high importance)

	All	Product innovator	Novel product	Process innovator	Novel process
Within your business or enterprise group	86.7	91.2	93.0	93.0	94.5
Suppliers of equipment, materials, services or software	66.2	67.6	69.0	74.7	75.7
Clients or customers (*UKIS7 only*)	76.0	86.0	90.2	88.3	90.7
Clients or customers from the private sector (*UKIS8 only*)	81.0	81.0	84.6	78.4	84.7
Clients or customers from the public sector (*UKIS8 only*)	38.6	41.3	42.9	38.6	43.1
Competitors or other businesses in your industry	57.9	60.9	61.3	62.0	61.5
Consultants, commercial labs or private R&D institutes	28.8	28.8	33.1	31.9	41.2
Universities or other higher education institutes	14.6	17.0	23.0	17.2	26.3
Government or public research institutes	14.0	15.4	19.0	16.5	22.9
Conferences, trade fairs or exhibitions	33.2	37.6	44.1	36.7	44.2
Professional and industry associations	39.5	40.7	42.6	43.8	47.0
Scientific journals and trade/technical publications	22.2	24.1	29.1	25.3	32.9
Technical, industry or service standards	44.7	47.6	50.7	52.1	55.7

Source: ONS unweighted data

2.5 The impact of standards on innovation

As with other types of economic activity involving investments, innovation requires the forward commitment by individual firms in both the *search* for profitable opportunities arising from innovation and also in the subsequent *deployment of resources* to innovation related activities, which then may (or may not) result in a recognizable innovation. In this section we develop a simple statistical model of the impact of standards on both these innovation outcomes, but also and perhaps more interestingly, in respect of the commitment to the various types of innovation input identified in the survey.

In this section we focus on influences on firms which originate at a sectoral level, using our data on both the number or 'stock' of standards available to producers by sector, as well as on the median age of the relevant stock, as described in Section 2.4. Since the resource commitments (and outcomes involved) reflect the underlying technological opportunities open to the firm, we add aggregate business expenditure on R&D (for 2010) as an additional explanatory variable in what therefore necessitates a multivariate approach. The sectoral levels of output were also included as an additional control (e.g. controlling for the fact that high levels of measured R&D in a sector do not capture the richness of technological opportunity but instead simply reflect the size of the sector) with an expected negative sign.

Since the dependent variables of interest here are of a binary character (the firm reports a particular type of innovation or innovation activity or not), the logit regression provides a well-known 'standard' method of analysis in which the reported coefficients show the estimated impact of a unit change in the independent variable on the logarithm of the 'odds' – in this case that a firm will either innovate or engage in the stated input activity.[9]

Figure 2.12a shows results which indicate the sectoral sources of variation in the probability that a firm will report that it records one of the various types of innovation outcome recorded in the survey. They suggest that not only the overall level of technological activity (as measured by the aggregate sectoral level of R&D), but also a strong standards environment (in terms of the number of standards), have consistently positive impacts on the odds that a firm will report both product and process innovation. Note also that the coefficient on output has the expected sign and is significant throughout.

As far as the difference between product and process innovation is concerned, it can be seen that both standards and technological opportunities (R&D) predict product innovation more strongly than process innovation. As far as novelty is concerned, they both appear to be important, although R&D is particularly important as a determinant.

It is notable that each innovation outcome is negatively related to the median age of the standards stock, indicating that an older stock generally predicts against any of the innovation outcomes.

Now we look at the impact of standards on the commitment by firms to particular kinds of innovation input in Figure 2.12b. The general pattern that emerges is that standards have an impact over and above that which is reflected by aggregate R&D. The impact is strongest for the intramural R&D itself but also seems to be important for IPR licensing, training, design and marketing.

Finally, there are some interesting effects coming from the age of the relevant stock: a significant and negative coefficient for intramural R&D suggests that (as might be anticipated) a greater proportion of younger standards acts as an incentive to perform R&D. This is also true for externally acquired R&D and for equipment (where the effect seems to be particularly marked) and computing equipment, software and marketing. For training however, the opposite holds and an older stock appears, quite plausibly perhaps, to induce training. This also appears to hold for computer software. No statistically significant impact appears to come from this influence for the licensing of IPR or for design.

When looking at these sectoral influences, it is of some interest to compare the impact of overall R&D with that of standards. As mentioned, the reported coefficients show the impact of a unit change in the variable or impact factor being considered on the logarithm of the odds that a firm will, for example, innovate or undertake R&D. The problem is that these units are quite different across the three variables being considered (number of standards, median age in years, or business expenditure on R&D (£ millions)). A suitable alternative is to consider the impact of one standard

9 I.e. log (p/(1 – p)) where p is the probability that the firm engages in the activity. For example, the coefficient of 0.256 on the logarithm of the standard stock indicates that a unit change in the latter will raise the probability of a firm performing intramural R&D (against non-performance) by a factor of $e^{0.256}$ = 1.29 on the ratio of the probability that it will engage in intramural R&D to the probability that it will not.

Figure 2.12a – Standards and innovation outcomes
(All firms)
Dependent variable = innovation type (1 = yes, 0 = no)
Logit estimates

Sector level variable	Product innovation		Process innovation		Novel product		Novel process	
	Coefficient	**p value**	**Coefficient**	**p value**	**Coefficient**	**p value**	**Coefficient**	**p value**
No. of relevant standards (logarithm)	0.141	0.000***	0.046	0.003***	0.199	0.000***	0.048	0.087*
Median age of relevant standards (years)	–0.050	0.000***	–0.092	0.000***	–0.073	0.000***	–0.076	0.002***
Sectoral R&D (logarithm)	0.221	0.000***	0.138	0.000***	0.265	0.000***	0.148	0.000***
Sectoral output (logarithm)	–0.355	0.000***	–0.341	0.000***	–0.376	0.000***	–0.365	0.000***
No. of observations	22,173		22,173		22,173		22,173	
LR $chi^2(4)$	1,124.20		559.11		891.06		181.69	
Probability > chi^2	0.000		0.000		0.000		0.000	
Pseudo R^2	0.048		0.032		0.059		0.027	

*** significant at 1%, ** significant at 5%, * significant at 10%

Figure 2.12b – Inputs into innovation in UK 2008–2012
(All firms)
Dependent variable = use of input (1 = yes, 0 = no)
Logit estimates

Sector level variable	R&D internal		R&D external		Equipment		Computing equipment		Software	
	Coefficient	p value	Coefficient	p value	Coefficient	p value	Coefficient	p value	Coefficient	p value
No. of relevant standards (logarithm)	0.256	0.000***	0.174	0.000***	0.058	0.001***	0.081	0.000***	0.086	0.000***
Median age of relevant standards (years)	–0.058	0.000***	–0.082	0.000***	–0.179	0.000***	0.019	0.160	0.041	0.002***
Sectoral R&D (logarithm)	0.369	0.000***	0.283	0.000***	0.092	0.000***	0.151	0.000***	0.144	0.000***
Sectoral output (logarithm)	–0.520	0.000***	–0.355	0.000***	–0.509	0.000***	–0.081	0.000***	–0.101	0.000***
No of obs	14,217		14,069		14,132		14,211		14,247	
LR $chi^2(4)$	1,995.81		536.07		1,051.30		168.81		197.57	
Prob > chi^2	0.000		0.000		0.000		0.000		0.000	
Pseudo R^2	0.114		0.057		0.075		0.010		0.011	

Sector level variable	IPR Licence		Training		Design		Marketing (any)	
	Coefficient	p value	Coefficient	p value	Coefficient	p value	Coefficient	p value
No. of relevant standards (logarithm)	0.142	0.000***	0.120	0.000***	0.266	0.000***	0.116	0.000***
Median age of relevant standards (years)	0.014	0.522	0.041	0.006***	–0.011	0.479	–0.027	0.048**
Sectoral R&D (logarithm)	0.189	0.000***	0.156	0.000***	0.237	0.000***	0.220	0.000***
Sectoral output (logarithm)	–0.282	0.000***	–0.175	0.000***	–0.466	0.000***	–0.203	0.000***
No of obs	14,052		14,112		14,092		14,044	
LR $chi^2(4)$	237.49		276.54		1,179.04		487.64	
Prob > chi^2	0.00		0.000		0.000		0.000	
Pseudo R^2	0.03		0.018		0.082		0.027	

*** significant at 1%, ** significant at 5%,* significant at 10%

deviation[10] of each of the variables directly on the probability that the outcome will be observed (i.e. on the marginal probability). These marginal probabilities are shown in Figures 2.13 and 2.14. It can be seen that whereas the impact coming from the number of relevant standards available to firms is never as large as R&D, it is far from negligible in relation to R&D, and very important for novel product innovation, and from the input side, for training and design.

Figure 2.13 – Impacts of standards and r&d on innovation outcomes

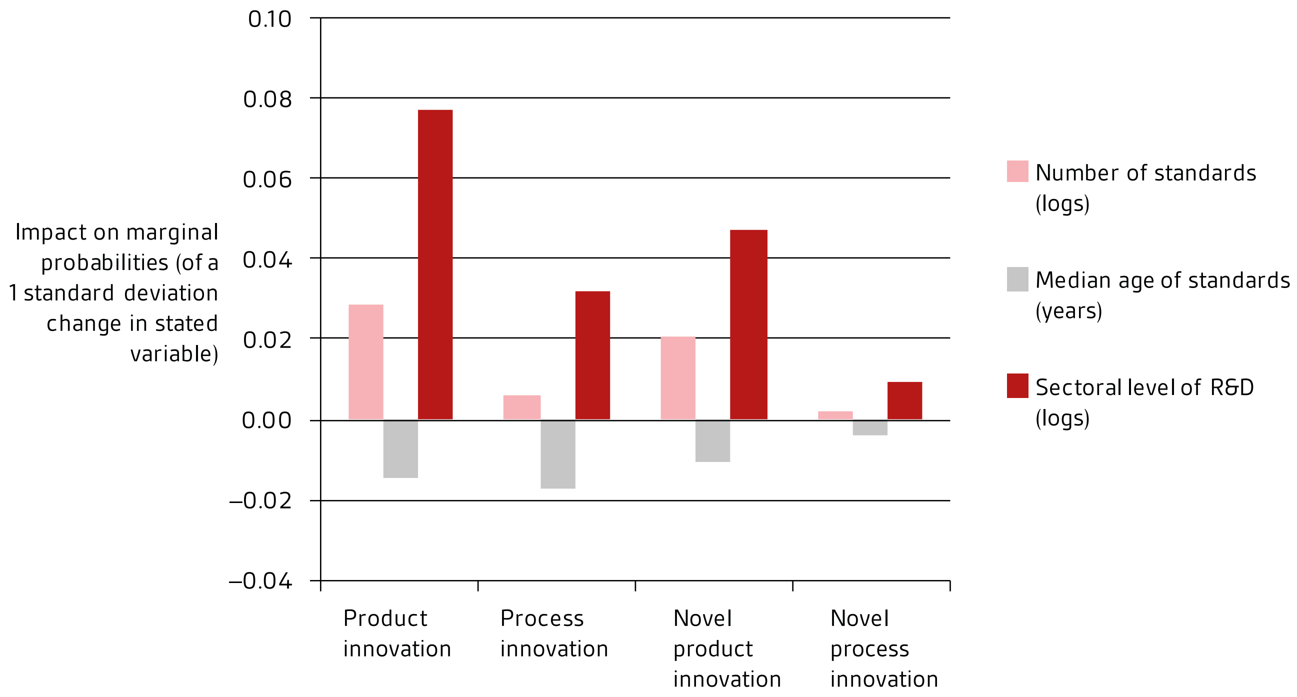
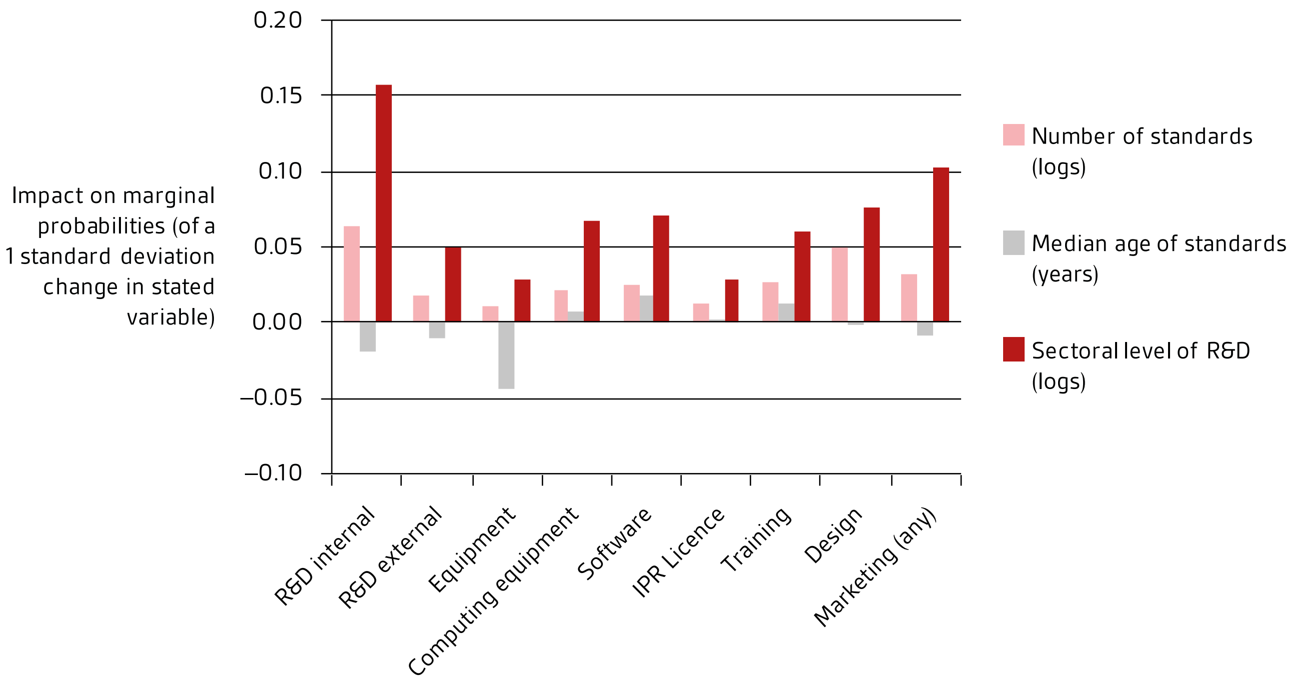


Figure 2.14 – Impacts of standards on innovation inputs



10 These were calculated at the sectoral level.

2.6. Innovation, IP and the value of standards

We saw in the last section that one way of thinking about standards in innovation is that they help firms to make commitments by way of innovation inputs: in R&D, design, training and so on. We should therefore expect these to influence the 'value' (as a source of information) of standards.

Of course, many other factors besides innovation type help to determine the significance of any particular source of information. For example, firm size, as well as the type of innovation input being used, is likely to be of importance. A multivariate approach is therefore called for which includes not only these but the particular importance that each business attaches to IPR strategy as far as its competitiveness is concerned.

Some results from this analysis (for innovation active firms only) are shown in Figure 2.15. As before, logit regressions are performed on a binary variable which takes the value of 1 when a firm finds that standards are of 'medium' or 'high' importance as a source of information (and 0 otherwise).

Figure 2.15 presents three sets of results. The first set adds firm level variables to the sectoral ones used in the analysis of the last section. As expected, the number of standards exerts a strong and positive influence on the value firms place on standards as a source of information; however, the median age of the standards stock has no significant effect. Perversely perhaps, R&D has a small but statistically significant *negative* impact. Firm level characteristics indicate that larger firms are more likely to rate standards as important and that firms which cooperate in innovation are more likely to rate standards as of importance.

Result sets 2 and 3 introduce innovation as an additional factor – first in terms of outcomes (product or process and whether a novel step has been taken) and then by using inputs as a measure of innovation. Result set 2 suggests that process innovators are more likely to rate standards as important than product innovators and that firms introducing a novel product or process (new to market or industry) are more likely to rate standards as important.

Using the input side as a control (result set 3), the indications are that the use of any of the following inputs is a predictor of the likelihood that a firm will rate standards as important:

- The performance of intramural R&D.
- The acquisition of innovation related equipment.
- The acquisition of a licence to use IP.
- The use of internal or external training.
- The use of marketing.

Figure 2.15 – The information content of standards
(All innovation active firms)
Logit estimates
Dependent variable = 1 if business unit rates standards as of medium or high importance as a source of information

	Result 1		Result 2		Result 3	
	Coefficient	**p value**	**Coefficient**	**p value**	**Coefficient**	**p value**
Standard stock available to sector (log)	0.088	0.00***	0.085	0.00***	0.064	0.00***
Median age of standard stock (years)	0.076	0.71	0.083	0.00***	0.078	0.00***
Sectoral R&D (log)	–0.015	0.00***	–0.021	0.26	–0.046	0.02**
Sectoral output (log)	–0.082	0.00***	–0.064	0.00***	–0.041	0.09*
Size_2	0.259	0.00***	0.263	0.00***	0.257	0.00***
Size_3	0.515	0.00***	0.517	0.00***	0.550	0.00***
Size_4	0.591	0.00***	0.584	0.00***	0.567	0.00***
Firm cooperates in R&D	0.793	0.00***	0.711	0.00***	0.599	0.00***
Product innovation			0.004	0.95		
Process innovation			0.243	0.00***		
Novel step			0.167	0.01***		
Firm does intramural R&D					0.224	0.00***
Firm buys extramural R&D					–0.123	0.10*
Firm acquires equipment					0.176	0.00***
Firm acquires computing equipment					0.151	0.03**
Firm acquires computer software					–0.028	0.68
Firm acquires a licence for technology					0.171	0.03**
Firm acquires training					0.555	0.00***
Firms acquires design					0.093	0.12
Firm acquires marketing					0.114	0.04**
No. of observations	7,045		7,045		6,922	
LR $chi^2(8)$	395.310		433.800		636.240	
Probability > chi^2	0.000		0.000		0.000	
Pseudo R^2	0.041		0.045		0.067	

*** significant at 1%, ** significant at 5%, * significant at 1%

2.7 The relevance of standards for the protection of IP

This section considers whether standards have relevance for the firm's assessment of the 'effectiveness' of different methods of IP protection. For example, standards may be important in the consideration of the need for secrecy or the extent to which a patent claim is likely to be successful. To assess this in the econometric analysis, we use a binary version of the survey question (posed to innovation active firms only) on the protection of IP, i.e. each unit's assessment of the importance of the different strategies for the protection of IP (=1 if a particular method is regarded as of medium or high effectiveness, 0 otherwise), so again we use logit regression techniques. As the descriptive discussion of the use of the different methods of IP protection above suggests, the type of innovation outcome should affect the probability of observing the rating of the various methods. Looking at patents first in Figure 2.16a, we can see that being a product innovator (with no novelty) does not actually predict in favour of the view that patents are an important element in the firm's competitiveness. However, process innovation predicts quite strongly *against* patents, which is consistent with the idea that disclosure is an important consideration for patents. What does matter is novelty, although novel product innovation impacts more strongly than novel process innovation. Size (where the base line is a small unit of 10–49 employees) is also important, with larger units more likely to regard patents as effective. Firms that value standards as a source of information, as well as those that cooperate, are much more likely to regard patents as important for the competitiveness of their unit.

For types of formal protection other than patents – design rights, copyright and trademarks – product innovation becomes more important as a positive influence on the value attached to these methods. Process innovation is of little consequence either way, except for a small positive influence on the value attached to trademarks. Novelty is of importance but only in so far as it relates to product innovation. The significance of size is also more muted, clicking in as a positive predictor only in firms with more than 100 employees in the case of design rights and trademarks and more than 250 employees in the case of copyright. However, at the individual firm level it is clear that cooperation across firms is strictly complementary to viewing each of the formal methods as being effective, as is the value placed on standards.

Looking at the sector level variables, it can be seen that the size of the stock of relevant standards is an important contributor to the rating of each of the formal methods. With the exception of design rights, R&D is also an important and independent influence. Output has the expected and significant negative sign in each case.

Turning to the informal methods in the second set of results in Figure 2.16b, some interesting differences to those in the first set are apparent. Firstly, firm size plays little role for any of the methods. Secondly, while product innovation is a positive predictor of the effectiveness of all the methods, the impact is relatively modest. However, novel product innovation provides a strong additional impetus for each of the methods. Thirdly, process innovation predicts rather more strongly than product innovation in favour of both lead times and complexity, but is surprisingly insignificant for secrecy. However, this is reversed dramatically when novelty is taken into account, with novel process innovation being a very strong predictor of secrecy. Fourthly, both cooperation and the value placed on standards continue to be important. Finally, at the sectoral level, the impact of the number of standards is positive throughout and more consistent than R&D, which is however a strong predictor of secrecy.

Figure 2.16a – Standards and IP protection
(All innovation active firms, UKIS8 only)
Dependent variable: IP protection method (1 = of medium or high effectiveness, 0 = 'low' or n/a)
Logit estimates

	Patent		Design rights		Copyright		Trademarks	
	Coefficient	**p value**	**Coefficient**	**p value**	**Coefficient**	**p value**	**Coefficient**	**p value**
Firm level characteristics								
Product innovator	0.042	0.754	0.277	0.047**	0.343	0.015**	0.354	0.002***
Process innovator	–0.515	0.000***	–0.101	0.393	–0.187	0.124	–0.238	0.022**
Novel product innovator	0.920	0.000***	0.622	0.000***	0.499	0.000***	0.563	0.000***
Novel process innovator	0.490	0.004***	–0.064	0.722	0.250	0.159	0.357	0.022**
Size (50–99 employees)	0.316	0.041**	0.206	0.219	0.161	0.332	0.220	0.115
Size (100–249 employees)	0.497	0.000***	0.476	0.001***	0.221	0.122	0.292	0.016**
Size (250+ employees)	0.631	0.000***	0.660	0.000***	0.467	0.000***	0.541	0.000***
Firm cooperates in innovation	0.640	0.000***	0.717	0.000***	0.698	0.000***	0.506	0.000***
Firm values standards	0.576	0.000***	0.902	0.000***	0.684	0.000***	0.645	0.000***
Sector level variables								
No. of standards (logarithm)	0.214	0.000***	0.170	0.000***	0.204	0.000***	0.153	0.000***
Business expenditures on R&D (logarithm)	0.126	0.000***	0.008	0.817	0.160	0.000***	0.112	0.001***
Output (logarithm)	–0.315	0.000***	–0.222	0.000***	–0.143	0.004***	–0.111	0.007***
No. of observations	3,191		3,157		3,166		3,180	
LR $chi^2(4)$	425.71		323.71		279.92		330.5	
Probability > chi^2	0		0		0		0	
Pseudo R^2	0.1371		0.1165		0.1032		0.0946	

*** significant at 1%, ** significant at 5%, * significant at 10%

Figure 2.16b – Standards and IP protection
(All innovation active firms, UKIS8 only)
Dependent variable: IP protection method (1= of medium or high effectiveness; 0 = 'low' or n/a)
Logit estimates

	Lead times		Complexity		Secrecy	
	Coefficient	**p value**	**Coefficient**	**p value**	**Coefficient**	**p value**
Firm level characteristics						
Product innovator	0.294	0.002***	0.208	0.029**	0.225	0.040**
Process innovator	0.534	0.000***	0.318	0.000***	0.125	0.198
Novel product innovator	0.396	0.000***	0.728	0.000***	0.644	0.000***
Novel process innovator	0.211	0.154	0.509	0.002***	0.508	0.001***
Size (50–99 employees)	–0.249	0.040**	0.101	0.414	0.046	0.724
Size (100–249 employees)	–0.079	0.452	0.028	0.799	0.118	0.307
Size (250+ employees)	–0.261	0.010**	–0.106	0.305	–0.007	0.951
Firm cooperates in innovation	0.294	0.002***	0.705	0.000***	0.865	0.000***
Firm values standards	0.534	0.000***	0.847	0.000***	0.463	0.000***
Sector level variables						
No. of standards (logarithm)	0.127	0.000***	0.190	0.000***	0.103	0.001***
Business expenditures on R&D (logarithm)	0.036	0.199	0.120	0.000***	0.264	0.000***
Output (logarithm)	–0.294	0.000***	–0.300	0.000***	–0.268	0.000***
No. of observations	3,201		3,221		3,186	
LR $chi^2(4)$	488.54		710.15		543.55	
Probability > chi^2	0		0		0	
Pseudo R^2	0.112		0.1591		0.1398	

*** significant at 1%, ** significant at 5%, * significant at 10%

2.8 The role of IPR strategies in firm performance

Ultimately, economic welfare depends not on innovation per se, but on its contribution to productivity growth. This analysis uses the panel dimension of the two surveys in order to consider the growth of labour productivity in the resultant cross-section (2008–2012) with the objective of discovering whether any particular IP strategy is associated with more productivity growth.

Although the maximum number of firms that appear in both the surveys is approximately 14,000, this is reduced considerably by both the filter of innovation (not all relevant questions are posed to firms which do not report themselves as innovation active) as well as the need to screen for major events in the history of the unit which make turnover and employment in the two periods incommensurate. Although some information on these variables is available, it is rather patchy, and the data used here is taken from a separate database, the Interdepartmental Business Register (IDBR) as supplied by the ONS.

To put structure on the data, the estimation is based on a 'catch-up' or 'convergence' effect in which the growth in productivity of each firm depends upon its 'benchmark' level of performance in the previous period – surviving firms which have a 'low' initial productivity level, grow faster because of such a catch-up effect, which may reflect an underlying process in which poorly performing firms learn from better performing firms or else return to their fundamental productivity level. This effect was modelled in a first stage by estimating a 'benchmark' level of productivity for each business unit for the period 2008–2010 using all the observations from UKIS7. This was done by ordinary least squares (OLS) regression of the logarithm of labour productivity (turnover divided by the number of employees) for 2010 against categorical variables for each of the four size classes and for each of the sectors that a unit is situated. The size of the residual from this equation was then used to sort firms into four quartiles so that the bottom quartile represented firms with the biggest scope for 'catch-up', with firms allocated to the top quartile – the best performing firms – possessing very little or no scope for productivity growth from this source.[11]

In addition to a convergence effect, the model allows that each firm has its 'own' level of time-invariant productivity determined by its individual circumstances – an unobserved so-called 'fixed effect'. Since this is time invariant, however, this effect disappears when we examine productivity growth over the period between the surveys. Placing employment on the right hand side of the equation allows for possible effects of growth (or decline) itself on productivity, as for example, when rapid growth of employment diverts resources away from direct operations. Allowing for other influences, including of course the impact of innovation and IPR strategy, the model therefore can be summed up in the following equation, effectively now a simple cross-section of growth rates:

$$\Delta\, \text{turnover}_i = \alpha + \beta\, \Delta\, \text{employment}_i + \boldsymbol{\gamma}\, \mathbf{INNOV}_i + \boldsymbol{\pi}\, \mathbf{X}_i + \theta\, \mathbf{Z}_i + \delta_1 Q1_i + \delta_2 Q2_i + \delta_3 Q3_i + \varepsilon_i$$

where:

Δ turnover is the change in the logarithm of the turnover of unit i
Δ employment is the change in the logarithm of a unit i's employment (number of employees)
$\mathbf{INNOV}_i$ is a vector representing unit i's innovation activities
$\mathbf{X}_i$ is a vector representing unit i's IP strategy
$\mathbf{Z}_i$ is a vector of other variables influencing the growth of labour productivity at unit i (including sector level variables)
Q1, Q2, Q3 are 'dummy' variables representing whether unit i is (=1) or is not (=0) in the particular quartile of the benchmark productivity estimates
α, β, δ_1, δ_2, δ_3 are constants; $\boldsymbol{\gamma}$, $\boldsymbol{\pi}$ are row vectors of constants
ε_i is a random error term, normally distributed across units

Major changes in the history of the unit with large implications (e.g. acquisition or disposal) were excluded from the sample. The mean change in the logarithm of turnover was around 0.121 (translating into a rate of growth of about 13%), in employment -0.076 (a decline in employment of about 9%), giving a mean increase in labour productivity of 0.196 (growth of about 22%). This seemingly rather high figure is partly explained by the fact that turnover is measured in purely nominal terms, but of course, the impact of the general rise in prices will be picked up by the constant term. Despite omitting obvious causes of large changes in productivity, there was still considerable variance in the data, reflecting the presence of clear 'outliers'.

11 The approach raises the possibility that the *rate* of catch-up might depend upon (for example) the 'standards environment' or individual firm strategies. Initial experiments incorporating such an effect did not suggest that this was a fruitful line of enquiry.

As far as vector **Z** is concerned, we considered a number of potential influences on turnover growth, including those at both sector level and at the level of the individual firm. For the former, experiments with a set of sector dummies suggested that sector level variables were not especially important in explaining productivity growth at the level of the individual unit. Nor did there appear to be any important (systematic) impacts resulting from firm size.

At the level of the firm, it needs to be recalled that the approach allows for time invariant fixed effects (each firm has its own level of productivity around which other factors impinge), so the fact that, for example, a firm collaborates in R&D, which may result in a higher *level* of productivity, would not result in a higher *rate of growth* of productivity. Nevertheless, we would have wished to include a measure of the growth in capital services (such as the capital stock) but this did not prove possible.[12] However, we did find the fact that a firm was an exporter (*exporter*) as being significant, a finding that suggests that a lower exchange rate may have resulted in faster productivity growth for exporting firms, who frequently invoice in foreign currency or who may be experiencing faster demand growth through lower foreign currency prices. We also found that a firm which was newly created in the earlier survey (*new*) was a consistently positive predictor of turnover growth.

Some representative results are shown in Figure 2.17. Set 1 shows the estimated impact of the innovation vector and the catch-up effect, together with the two other variables found to be consistently important – the fact that a firm was 'new' in the earlier survey, and whether or not a firm is an exporter.[13] The catch-up effect modelled appears well determined: each of the three quartiles shows a strong and moreover diminishing impact on turnover growth (while controlling for employment growth). As far as innovation is concerned, the strongest effect comes from *current process innovation*. Lagged process innovation is in fact perversely signed but is statistically insignificant. Both product innovation and lagged product innovation are estimated to have a positive effect on productivity growth but the effect is not well supported statistically.

The fact that product innovation does not immediately appear in these data to support productivity growth should not perhaps be surprising. The idea of product *innovation* in the survey inevitably merges into that of simple product *differentiation*, which may not be able to command a price premium in the market. In dynamic terms, this could mean that product development may simply be a necessary aspect of business competition and survival in the market, and it is of course surviving firms who are represented in the sample. In any case, this does not mean that product innovation is not contributing to productivity growth, but rather that the bulk of the benefit is reaped by consumers and users of the products concerned – what economists understand by a 'spillover' effect.

Various experiments looked at the effect of IP strategy on productivity growth, in order to determine whether strategy had an impact on productivity *over and above* that provided by its incentive effect on innovation in the first place.[14] One approach was to look at each IP strategy individually. Results are shown for what are sometimes believed to be the two main alternatives, patents and secrecy, in the context of a regression which is more 'parsimonious' – including only those variables which seem in the light of earlier study to be important. Both sets 2 and 3 suggest that there may be positive effects from both strategies, with each contributing around 5% points to overall productivity growth amongst those firms which regarded them as important. In the case of patents, however, this is statistically insignificant at the conventional levels of significance.

As part of the cross-checks for this particular set of results, we were guided by the need to consider the noisy quality of the data and in particular, the presence of some rather extreme values. Here we report results from a 'robust regression' technique, which eliminates extreme outliers and reduces the influence of other outliers. Sets 4 and 5 repeat the regressions of sets 2 and 3, and clearly the differences are important. The contribution of several of the variables is reduced, including the estimated impact of employment growth. However, this is not the case for process innovation, which remains well determined in delivering about 5% points to productivity growth, a large proportion of the productivity growth achieved in the period, especially for firms in the top quartile which have no potential for catch up. The IP strategies (at least as measured by the UK Innovation Survey) are now no longer statistically significant.

12 Although we did experiment with a question in the Innovation Survey which related to capacity creation in relation to the 'context' of innovation. This did not prove of especial value.

13 It is well established that being an exporter is well known to be associated with higher levels of productivity. Here, however, we are considering its rate of growth and hence the significance of this factor reflects instead other factors which may have differentially impacted upon exporting firms – most obviously, the exchange rate.

14 Note that since IP strategy is a 'filtered' question in the Innovation Survey, the number of observations is reduced.

Figure 2.17 – Productivity, innovation and IP strategy
Dependent variable = Δ turnover (in logs)

Estimation method:	Set 1 OLS		Set 2 OLS		Set 3 OLS		Set 4 Robust regression		Set 5 Robust regression	
	Coefficient	**p value**	**Coefficient**	**p value**	**Coefficient**	**p value**	**Coefficient**	**p value**	**Coefficient**	**p value**
Δ employment (in logs)	0.376	0.000***	0.369	0.000***	0.367	0.000***	0.281	0.000***	0.280	0.000***
Catch-up effect										
Q1	0.365	0.000***	0.346	0.000***	0.342	0.000***	0.117	0.000***	0.116	0.000***
Q2	0.143	0.000***	0.164	0.000***	0.162	0.000***	0.050	0.000***	0.048	0.000***
Q3	0.089	0.000***	0.095	0.000***	0.094	0.000***	0.019	0.101	0.019	0.103
Innovation										
Process	0.051	0.011**	0.068	0.002***	0.059	0.008***	0.054	0.000***	0.053	0.000***
Process (lagged)	–0.034	0.136								
Product	0.011	0.169								
Product (lagged)	0.026	0.084*								
New (lagged)	0.270	0.000***	0.339	0.000***	0.331	0.000***	0.056	0.013**	0.055	0.014**
Exporter	0.081	0.000***	0.079	0.000***	0.075	0.000***	0.047	0.000***	0.045	0.000***
Exporter (lagged)	–0.007	0.740								
Patent			0.045	0.128			–0.020	0.176		
Secrecy					0.053	0.035**			–0.007	0.563
Constant	–0.032	0.036**	–0.048	0.011**	–0.048	0.011**	0.054	0.000***	0.054	0.000***
Number of observations	5,977		3,529		3,528		3,529		3,528	
Probability > F	0		0		0		0		0	

3. Standards and IP: 2015 Survey

3.1 Introduction

A new survey was undertaken as part of this research to extend the range of empirical evidence on how standards and IP are perceived and practised by economic agents, which focussed on the range of questions that are the subject of the project. The main findings from the survey are presented here.

The survey was conducted through an online instrument, with the link made available to standards active organizations. In all, 395 responses were received, nearly all from members of standards development committees, including those of BSI, CEN, ISO and industry consortia. The sample is not, therefore, statistically representative of the economy. However, it does provide valuable and detailed new information on how standards intensive organizations, mainly businesses, perceive and implement the interaction between their participation in standards development, use of standards in economic activities and formal or informal IP.

3.2 Standards use

We report here on the extent of use of standards in a variety of business and innovation functions, and how this varies according to the size and sector of the operating units concerned. The results are summarized in Figure 3.1.

As well as the main focus of the survey on participation in standards development, the type and extent to which standards are used for a variety of business functions were also covered. While the higher rates of use occur in production and product specification in manufacturing industries, especially engineering, the take up was perhaps surprisingly high, at over 70% of respondents for some uses, in services sectors. Other research, such as the survey undertaken as part of the BRIDGIT Project (see Section 1) has found relatively low standards intensity in services sectors, so these results help to demonstrate the pervasive value and applicability of standards across all sectors.

The extent of use of standards to support activities outside of production operations and product/service specification is also much higher than might have been anticipated. Nearly three-quarters report the application of standards in organization and management, reflecting the widespread use of ISO management standards. This application of standards is marked in services as well as production sectors.

Notably, standards are widely used to support workforce development, which further confirms the link between standards and training found from analysis of the UK Innovation Survey (see Section 2.5). Standards are applied in the development and use of human, as well as physical, capital and are pervasive, not incidental, across the spectrum of industrial sectors. Although production sectors are more likely to use standards, the difference between them and other parts of the economy is small.

Standards are also used in research and innovation by over 70% of responding organizations, paralleling the data from the UK Innovation Survey analysed above. While the share with such use is higher in production sectors, nearly half of services organizations make use of standards in their innovation activities. The application of standards does not show much variation by size of organization.

3.3 Support for research and innovation

Figure 3.1 showed that over 70% of respondents consider that standards are valuable inputs to research and innovation. This is broadly consistent with the results of the UK Innovation Survey, based on a more representative sample, which reports that nearly 50% of innovating firms find that standards are an important source of information for innovation. This new survey adds value to that source with new details on the different ways in which the use of standards has effects on research and innovation activity summarized in Figure 3.2.

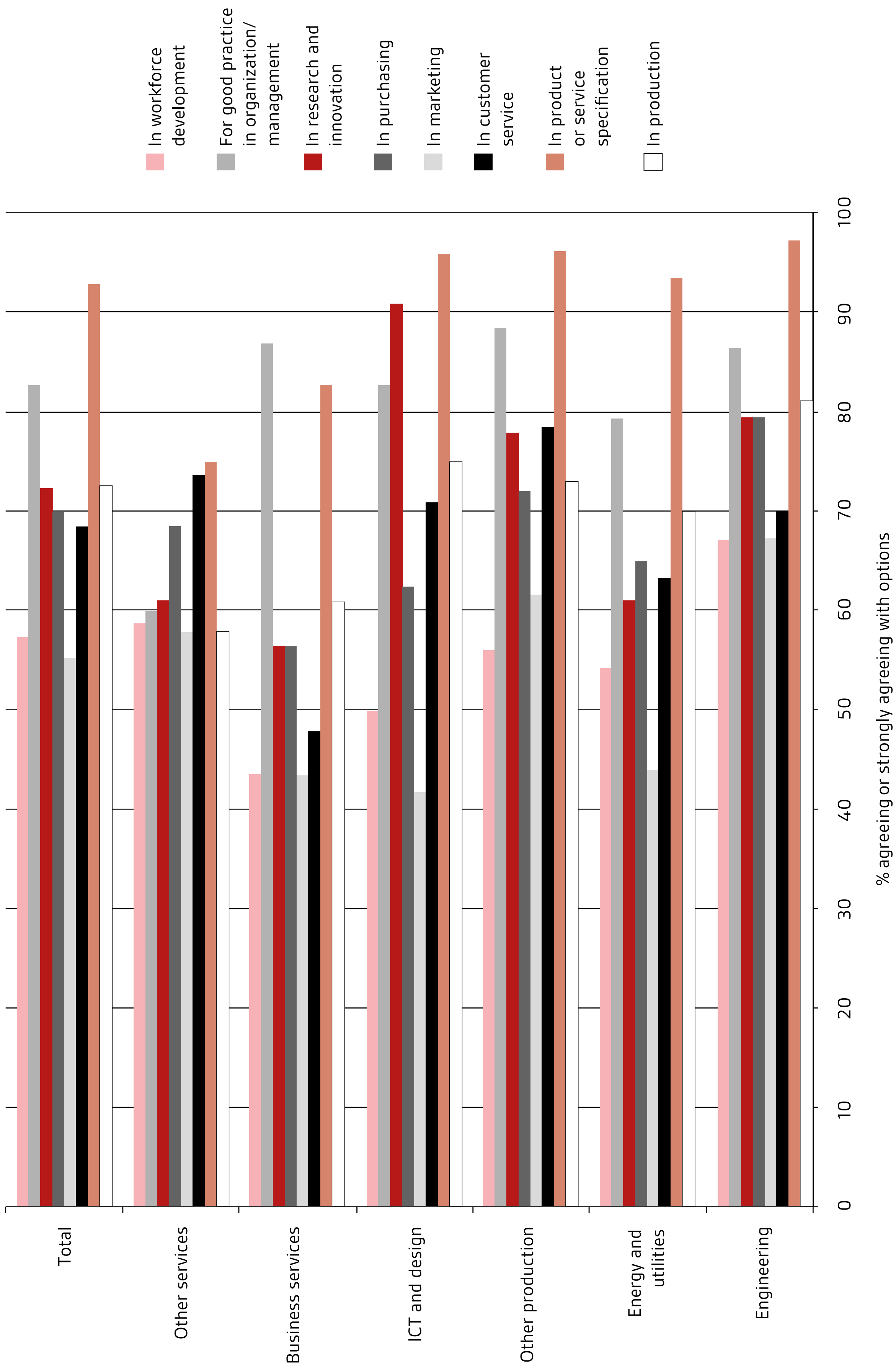
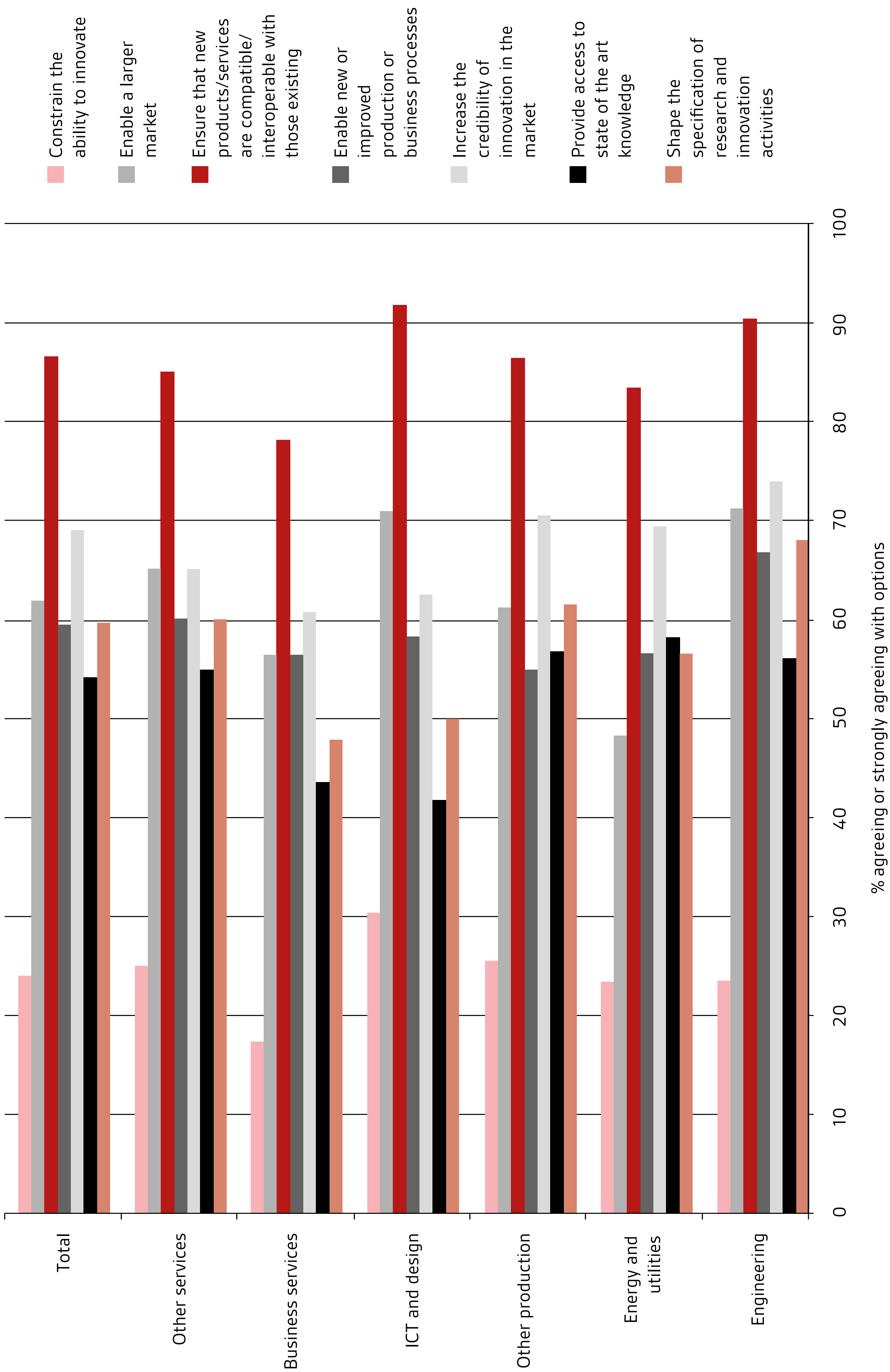


Figure 3.1 – The uses of standards

Figure 3.2 – Roles of standards in research and innovation



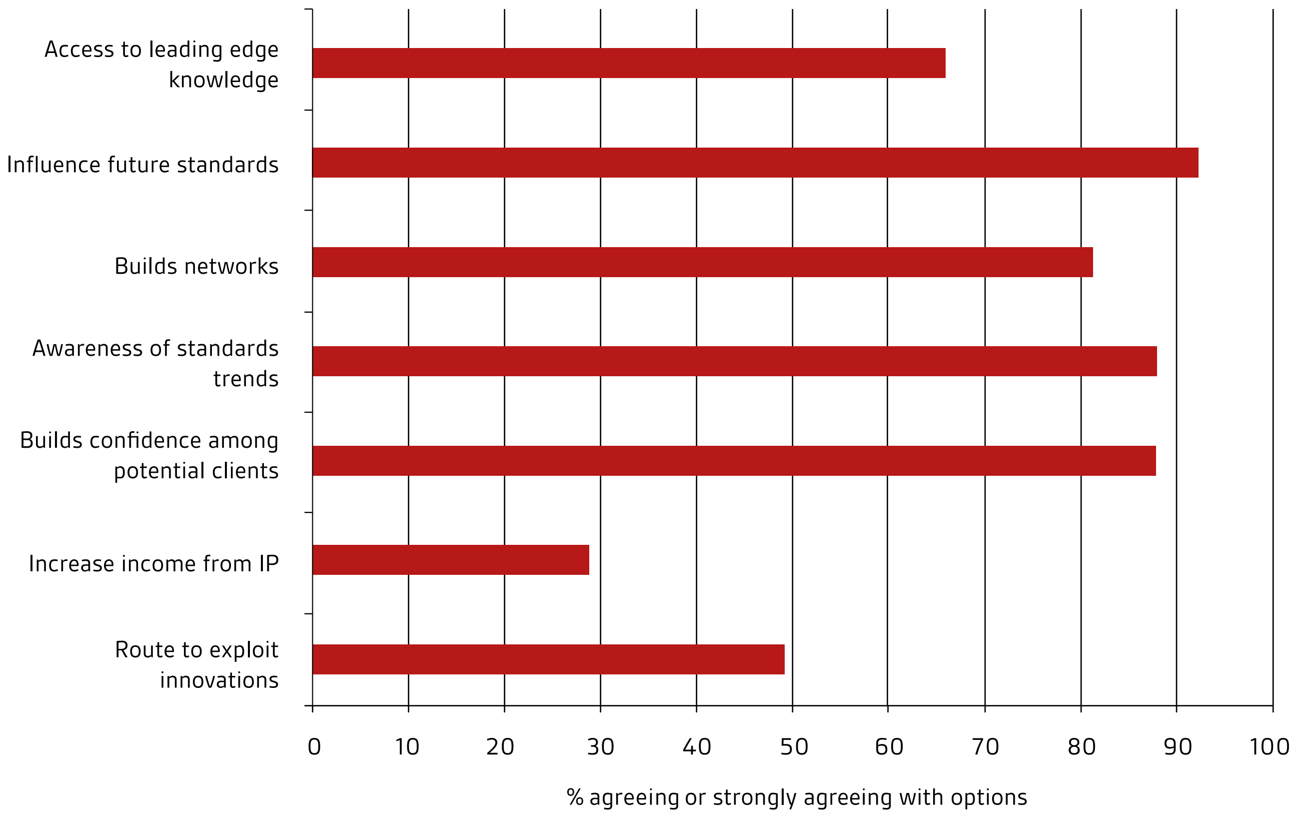
Enabling compatibility and interoperability with existing products is the most frequently noted application, with over 80% citing this role and with higher shares so reporting in production sectors, especially engineering. However, standards are also important in research and innovation for many service sector organizations, with 85% of Other Services respondents citing compatibility and 65% agreeing with the role of raising the market credibility of innovations and in enabling a larger market. Nearly one quarter agree with the idea that standards act as a constraint on the ability to innovate. However, in common with evidence from analyses of data from the UK Innovation Survey (Swann and Lambert, 2010) that even the constraining aspect is correlated with innovation, most of those reporting a constraining effect also report one or more innovation promoting effects. Only 9% of those citing a constraining effect report no positive impacts.

3.4 Benefits of participation

The survey also investigated how participation in the process of standards development generates advantages to business and innovation. This topic has received far less attention in economic research than has the use of standards. However, recent studies from Germany (Wakke and Blind, 2012) have found that business performance is correlated with the extent of a company's participation in standards development activities, with the intensity of involvement measured by the number of seats held on DIN technical committees.

Figure 3.3 shows the percentages of respondents from the BSI Standards and IP Survey who agreed or strongly agreed with the possible benefits of participation in standards development.

Figure 3.3 – Benefits of participation in standards development



These data emphasize the importance of standards in underpinning markets for goods and services and in disseminating knowledge, so participation provides valuable information on the likely future development of product markets and technologies, and the standards that support them. Keeping ahead of developments and the role of standards committees in sustaining networks also seem to provide important motives.

In stark contrast, only a small (if not insignificant) minority regarded participation as a way to increase income from IP. Nearly 50% did see participation as a means of exploiting innovations.

3.5 Protection methods

The survey asked about the extent of use of different types of protection for the IP incorporated in inventions and innovations, including forms of informal or 'strategic' protection – those that are part of business practice but not based on legal property rights, as well as formal IPRs. See Figure 3.4 for the main results.

Patenting is used by nearly 45% overall and is most common amongst engineering based production industries, at over 60%. Trademarks are also widely used in Engineering but also in Business Services, with over 45% reporting. Copyright is used by nearly 40% in general but by nearly 60% of business services respondents. Secrecy is the most widely cited method of protection, at nearly 50% overall but nearly 60% in both engineering and business services.[15] As noted above, though, access to knowledge and networking are important facets of participating in standards development, but sharing is amongst members of the standard development committee and is not usually codified and attributed in the written standard. Lead time and design complexity are both adopted by a relatively small share of respondents' organizations, with Engineering and ICT/Design sectors reporting more use than most.

SMEs are much less likely to apply for patents than larger firms, with 30% applying against 50% to 60% for large organizations, reinforcing the results of much previous research, including the BSI's recent SME study that the costs of maintaining and defending patents are regarded as a major disincentive. SMEs are also less likely to pursue design registration, despite the large share of smaller firms in the design sector. Again, this tends to reflect a perception of high costs of defending IPRs by smaller organizations. For other forms of IP, the shares of users are more similar across the size range. However, it is notable that medium/large respondents are more likely to use all of the forms of IP than either SMEs or the very large.

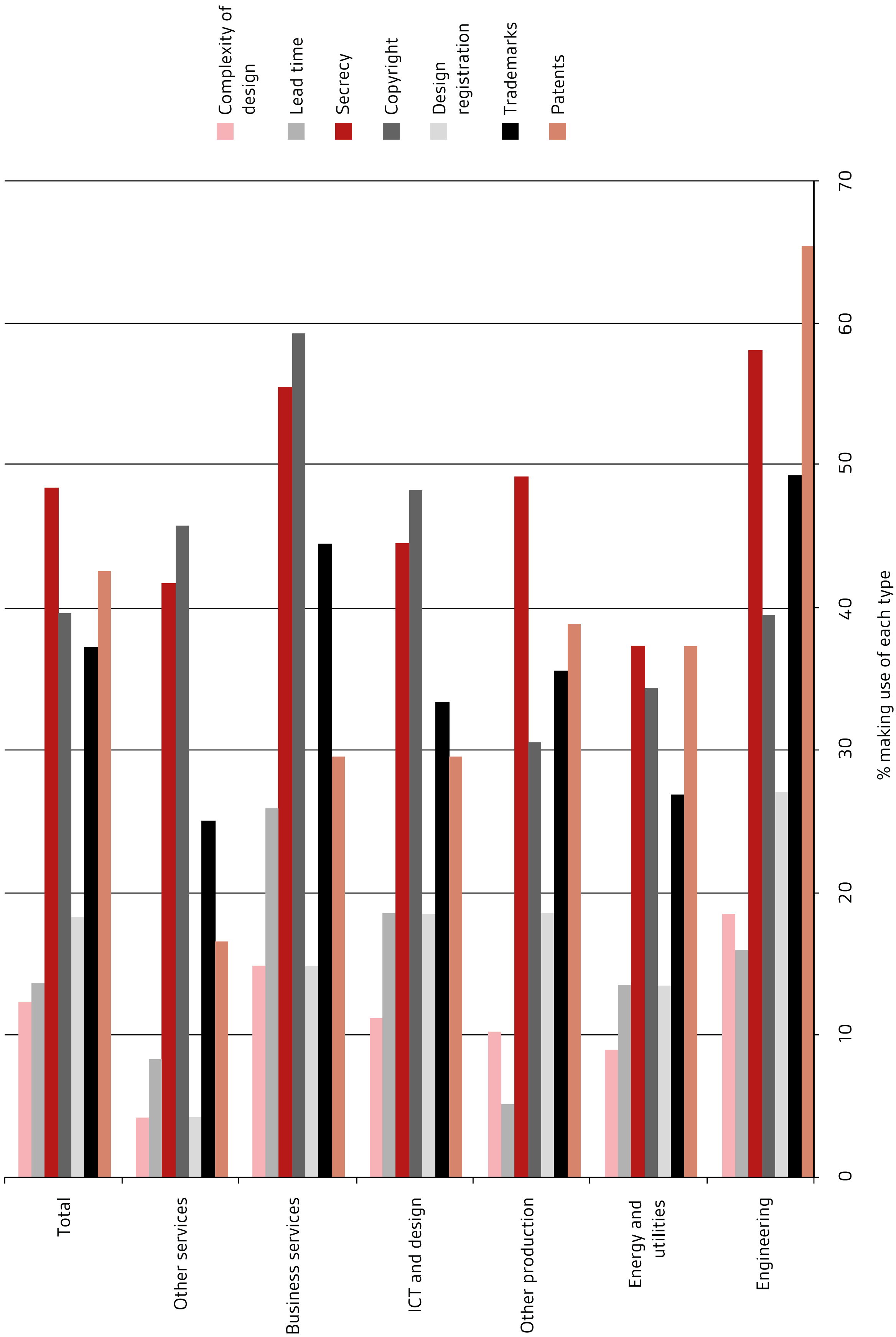
3.6 IP in standards

Much of the literature reviewed in the first section of this report is concerned with the potential tensions between the knowledge sharing aspect of standards development and the knowledge protection rationale for the IP system. That literature is heavily concentrated on how these types of tension can arise in ICTs, especially mobile telecommunications. A major topic for the survey was to discover the extent to which the issue of possible conflict between the objectives of standards development and the rights of IP holders is found in other areas of technology.

The survey therefore asked for experiences of specific issues in the standards making activities of respondents. Some 25% of the sample did not answer this question, with the implication that their standards making activity had not encountered IPRs. The analysis that follows is thus based on those who did provide an answer.

15 These ratings of forms of protection differ from the UK Innovation Survey data considered in Section 2, due to major differences in the statistical sample.

Figure 3.4 – Use of protection methods by sector



Own IP

Regarding the involvement of their own IP in standards development, nearly 80% of respondents reported no issues arising in the process. The most frequently mentioned difficulty was delay in the standards development process, while small shares reported that the standard had circumvented the IP or that infringement had occurred.

Issue	%
None	73
Licensing conditions not accepted	2
Technology was circumvented	6
Infringement of IPR	5
Standard delayed	8
Other	6

Figure 3.5 – Own IP in standards development
Share of those responding to the question

Others' IP

Regarding the IP of other participants in standards development, nearly three quarters (74%) again recorded that no issues had arisen. Some 8% reported non-declaration of patents during the process and difficulties with cross licensing.

Issue	%
None	67
Legal action	5
Excessive licence fees	4
Patent not declared	7
Difficulties with cross licensing	7
Other	10

Figure 3.6 – Other members IP in standards development

External IP

Turning to IP held by those not involved in the development of a standard, the most frequent effect again was some delay, while 7% reported that the standard had been written to avoid the relevant IP.

Issue	%
None	73
Termination	2
IP avoided	7
Delay	11
Other	7

Figure 3.7 – External IP in standards development

It is notable that issues are not reported with greater frequency in ICT, despite the dominance of this sector in the literature on tensions between standards development and IP.

In summary terms, over 70% of respondents to the question noted no issues had arisen from dealing with IPRs in developing standards. The issue that arose most frequently was some delay in completing the standard development process, reported by over 20% of respondents to the question. The incidence of more serious effects, such as infringement of IPR or legal action, is very low. Circumvention of their own IPR was more likely to be reported by organizations who had national or international industry consortia membership, but legal action arising was more probable for those with membership of international SDOs such as ISO/IEC.

3.7 Standards and IP – Complements or substitutes?

One of the key objectives of the project was to discover the extent to which standards and IP act as substitutes or complements, both at a systemic or economy wide level and at a microeconomic level, in the decision making of organizations.

Exploitation routes

In order to approach this question of substitutability or complementarity across the use of IP and participation in standards development, the survey sought views on the relative importance of IP and standards as routes to exploitation of innovations and on the ways in which these are approached in business strategies.

The ways of benefitting are summarized in Figure 3.8. IPR-based approaches are more highly cited than the routes via standards on average. However, services sectors are relatively more likely to see incorporation in standards as ways of exploiting their innovations. The option of BSI's PAS is regarded as viable by over 35%, with those in Other Services sectors especially likely to favour this approach. An above average share of Other Services respondents also value standards incorporation, but this is cited by a below average proportion of Business Services. That sector more generally shows below average enthusiasm for standards development as a pro innovation activity.

The well-established conclusion, summarized in the literature review, and further confirmed in Section 2 that standards and standards development are positively related to innovative activities is refined by the new survey. Standards and IPRs are both valued by innovators at the individual decision level, confirming the results from the system level empirical data discussed above, which finds both the use of standards and IPRs to be significant parts of the innovation system that importantly drives growth and productivity.

Strategies

The survey investigated the extent of strategic engagement with standards development and IP by respondents summarized in Figure 3.9. Some 86% in most sectors see participation in standards development as strategically important, which is unsurprising in a sample drawn from BSI committee members. This share is slightly lower at 78% for Other Services. These data again confirm the high importance of standards and their development in services activities, which are often overlooked in the literature. A smaller, although still substantial, share of respondents find gaining IPRs of strategic importance. Again, the propensity is higher in engineering sectors, but more than one third of services sector respondents also put a strategic value on IPRs.

Overall, less than 30% of respondents report that their organizations have a joint strategy for standards development and IPRs, with Other Services recording a higher share but Business Services relatively low. Nearly 20% of respondents take the view that standards development could be an alternative strategy to pursuing IPRs.

Figure 3.8 – Ways of benefitting from research and innovation

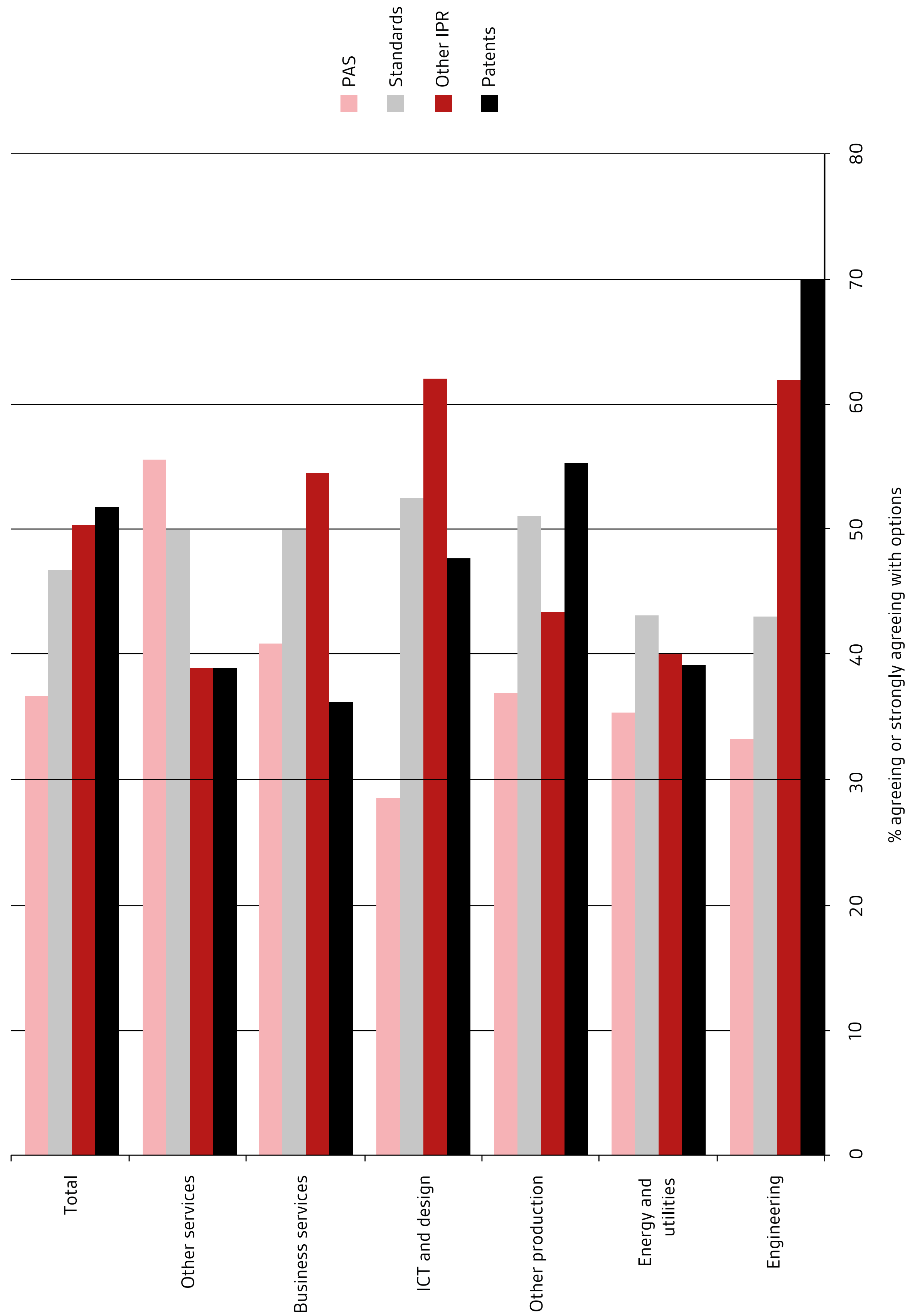
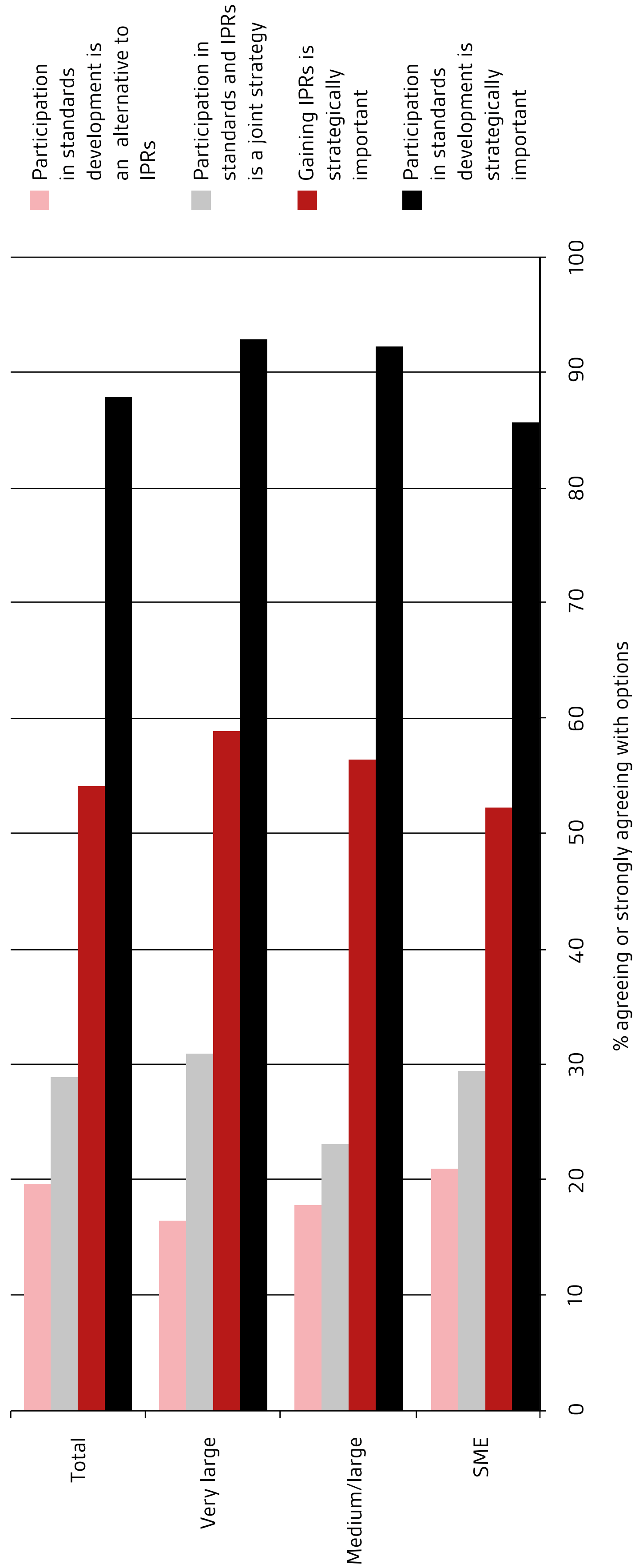


Figure 3.9 – Standards development and IP strategy options
By size of unit



There is thus a relatively low share of standards intensive organizations who have a defined joint strategy for their IP and standards development, although a much higher proportion effectively pursue IP and standards development strategies in parallel. There are some differences in strategic orientation by organization size. A smaller, but still substantial, share of SMEs see standards development or IPRs as strategically important. However, there is no significant variation by these size groups for the shares with a joint strategy or who see standards development as an alternative strategy to gaining IPRs.

Smaller enterprises, those in the 0–49 employee group, face harder choices regarding participation in standards development and seeking and defending formal IP, since both are relatively costly. A slightly higher share of SMEs than larger firms perceive that participation in standards making can be an alternative strategy to seeking some form of protection. Having an influence on the specification of a standard can create market opportunities for smaller firms, which can be more commercially valuable than seeking and defending a property right. However, an IPR can be seen as a more tangible asset that can be used to persuade sources of finance of the viability of an enterprise or as collateral when raising finance.

3.8 Gap analysis

The survey included several questions that sought agreement or disagreement with sets of propositions about the use and value of standards, involvement in standards development and IP. Disagreement was relatively unusual, but a significant proportion of respondents in each case were neutral, in the sense of neither agreeing or disagreeing with the propositions. Figure 3.10 shows a selection of questions that had significant shares of neutral respondents, together with the sectors who had the highest neutral percentages. The majority of these are services sectors, which probably reflects the lower scale of standards development activity and the number of standards directly available for these sectors.

These groups may be regarded as yet to be persuaded about the viability or pay off from taking up some aspects of the standards and IP infrastructure.

Figure 3.10 – Selected topics with high share of neutral responses

	Percentage who neither agree or disagree	**Most neutral sector**
Use of standards to shape the specification of research and innovation activities	24	Business Services
Use of standards constrains the ability to innovate	32	Business Services
Participation in standards development is a route to exploit innovations	37	Business Services
Participation in standards development is a means to increase income from IP	46	Other Production
Non patent IPR as a route to benefit from innovation	30	Other Services
Incorporation in standards as a route to benefit from innovation	32	Other Services
BSI's PAS as a route to benefit from innovation	38	Engineering
Participation in standards development and gaining IPRs is a joint strategy	38	Business Services
Participation in standards development is an alternative to gaining IPRs	31	Engineering

4. Conclusions

The research undertaken for this report has included:

- A review of the literature on standards and IP in the context of a growth and innovation system (see Figure 1.1). This has been supplemented by text boxes which bring together the ideas and views from interviews of interested parties.
- New analysis of recently available data from the regular UK Innovation Survey, which investigates the statistical relationships between standards as a form of knowledge, business use of IP, and other determinants of innovation, such as R&D and staff training.
- A new survey undertaken for the present project on the relative importance of IP and standards, which sought the perceptions of members of standards development committees and how, in their experience as standards makers, the two aspects of the innovation system interact in practice.

This section of the report draws on these three sources to address the specific research questions set for the study.

4.1 Choices

Articulation of the choices that innovators and others have with regard to their IP and relationship to standards and standardization, including sharing (e.g. via standards), protecting (e.g. via patents) and mixed approaches.

The use of standards, participation in standards making and pursuing some form of protection for invention and innovations are strategies available to businesses, but also to specialist institutions such as research and technology organizations (RTOs) and universities. The increasing importance of these institutions in many business contexts has potential implications for the process of standards development, not least because they frequently derive a large share of their income from formal IPR. Evidence from the UK Innovation Survey and from the new survey undertaken for this report indicates that the use of standards to support important business activities, including research and innovation, is very widespread and indeed a large constituency regard standards as providing valuable information which influences business strategy and the propensity to innovate in goods, services or processes. Our analysis of the UK Innovation Survey suggests that innovators of all types – but especially product innovators – place a higher value on standards as a source of information than non-innovators. In acquiring resources to create these innovations, our analysis suggests that those businesses that pursue in-house R&D and invest in training, purchase advanced equipment, including computer hardware and software, are particularly likely to value standards. This is also true for firms that cooperate with other firms and agencies in the pursuit of innovation, suggesting the significance of standards for communication purposes, making collaborative research more productive. This take-up of standards as an input is more extensive than active participation in standards development and the use of formal IPRs such as patents, trademarks or design registration. This is perhaps not surprising as acquiring a patent, for example, requires the demonstration of an inventive step and is therefore both costly and uncertain as to its effects. Here, our analysis of the UK Innovation Survey suggests that only a minority of innovators regard themselves as taking such a step and introducing novel products or processes and are therefore more concerned with forms of IP protection other than patents. Informal methods of IP protection – lead times, complexity of design and secrecy – are especially important for smaller firms. There is also some evidence from the UK Innovation Survey that standards are useful in the evaluation of different strategies for IP protection.

Participation in standards development is also costly in terms of the time commitment involved. However, such participation, as demonstrated by the new survey undertaken for this study, can add value to the use of standards through the sharing of knowledge and the ability to influence the standards that help to shape and grow markets. The survey indicates that learning about and influencing future standards, together with networking with other agents, are more important determinants of participation than direct commercial benefits. The latter are, nevertheless, significant for a substantial percentage of firms.

Innovation strategies based on the use of IPRs, with no use of standards, are not common. Our analysis of the Innovation Survey suggests that decisions about investment in physical, knowledge and human capital are made with the information provided by standards as an important, catalytic contributor.

For those who have IPRs, a mixed approach is more frequent, at least with respect to the use of standards to support efficiency and innovation. The new survey data derive from a group active in standards making, so cannot demonstrate quantitatively the extent of mixed approaches of IPR use and standards making across the economy. However, respondents to the survey are also much more likely than the overall business population to report the use of patents or other formal IPRs, as well as strategic IP protection, such as secrecy. Turning to the wider population of businesses, our analysis of the UK Innovation Survey suggests that standards are especially important in supporting product innovation and for the training that is associated with it. Those taking an inventive or novel step in their innovations are also particularly likely to value standards.

4.2 Impacts

Impacts of those choices at company level and sector-wide, examining technology development, market acceptance, trade implications and issues for SMEs.

Standards, IP and benefits from innovation

Standards can act as a device to consolidate existing best practice in technology or business practices, but they also act as a means of disseminating new elements of technologies and practices in an accessible form. The framework of IPRs, especially the patent system, aims to stimulate the production of new knowledge by providing temporary rights to exclude or require licensing for use by others. So to fulfil the new knowledge dissemination role, the standards development process will inevitably interact with the system of IPRs to access that source of new material.

Standards support research and innovation across the economy. Their impact is no longer confined to production industries but the new survey shows that they now play a significant role, for a high share of businesses, across the range of services sectors.

While ensuring compatibility with existing goods and services is the most widely accepted effect of standards in research and innovation, raising the credibility of innovations, supporting the market and therefore stimulating more innovation are other outcomes valued by a large share of organizations across all sectors of the economy.

Performance and trade

As a networking activity, participation enables sharing of tacit knowledge to support organizations' own research and innovation efforts and to enable the implementation of standards. The reduction in uncertainty from using standards and contributing to standards development provides confidence to invest in capacity, including capital, new technology and training, all commitments for which we find evidence in the UK Innovation Survey. Participants can also gain 'first mover advantages' from their role in helping to determine the specification of future generations of goods, services and processes.

An accumulation of empirical evidence (summarized in the literature review) has demonstrated that the use of standards as part of the knowledge base for research and innovation has substantial economic impacts. Similarly, the link between the research and innovation activities that qualify for IP protection and economic performance indicators, such as growth and productivity, has also been established through economic studies. Empirical research reported in the literature review also finds that innovation strategies based on developing new technologies that gain IPRs and those that emphasize codified knowledge, including standards, are both correlated with productivity and growth.

New analysis for this study of data from the UK Innovation Survey has further established the complementarity of standards and IP as building blocks of growth and innovation. Not least, the codified knowledge base established by standards allows for more informed choice of IP strategy. For example, what is or what is not an inventive step can only be informed by the codified knowledge base established by standards.

Despite the possibility that standards development may have the effect of impeding international trade, much of the important work in standards development is undertaken internationally, and moreover, the literature has demonstrated that the availability of standards, whether generated at a national or international level, enables expansion of international trade, which in turn is recognized as a leading driver of economic growth. Arrangements for mutual recognition across countries of the testable attainment of international measurement standards also promotes open trade while driving up product quality. In general, therefore, standards are instrumental in promoting international specialization.

4.3 Complementary and contradictory aspects of standards and IP

The complementary aspects of standards and patents, as well as where aspects of the standards and patents system are in opposition to one another.

The range of evidence brought together in this report shows that this interaction operates, for the most part, effectively. The majority of SDOs have IPR policies that enable successful negotiation of protocols for handling relevant IPR in the framing and use of standards. This is important, given the likelihood that formal IPR is increasingly going to penetrate the activities of standards committees. From the new evidence gathered by a survey as part of the research for this study, it appears that the share of standards where incidents of serious conflicts arising from the interface between standards development and use and the exercise of IPRs is small. These conflicts include licensing disputes, legal action, infringement, difficulties with cross licensing and the termination of the standard development process. Under 10% of respondents to the survey reported such events. The most frequent negative effect of the interaction was some delay in the standards making process. The reported incidence of conflicts tended to be somewhat higher for members of industry consortia bodies than for formal national and international SDOs, such as BSI or ISO. For example, legal action was reported by 8% of members of international consortia and by 7% of members of European SDOs, such as CEN-CENELEC.

In the case of IPR held by those not participating in the development process, the standard was likely to be formulated to avoid use of that IPR, which is evidence of standards development committees successfully pursuing technology neutrality. The complementarity between standards and IPRs in use as well as in development means that neutrality is often not attainable in practice. However, the relative rarity of serious tensions, such as reported infringement or legal action, is an indication that in most cases, standards developers are able to find a balance between the two, supported by their IP policies, including guidance on the basis for IPR licensing terms. While, therefore, the operation of the interface between standards development and IPRs is not seamless, there is a high degree of compatibility and effective management of the mutual dependencies and potential tensions by SDOs. We note, however, the potential for a few instances of conflict to impact more seriously on the system of standards development process, by, for example, promoting uncertainty amongst participants.

From the sample of organizations covered in the new survey, the IPR and standards development routes to benefitting from innovations have similar degrees of support. In general, therefore, the standards and IP systems are used as complementary resources by UK organizations. This is entirely consistent with the analysis of data from the UK Innovation Survey discussed in Section 2.

There is, though, a relatively low share of organizations – under 20% – who have a defined joint strategy for their IP use and contributions to standards development, although interviews with some of the biggest organizations indicate that they continually review their overall IP strategy. This may reflect specialization of functions within organizations. The institutional framework also has its specializations, with BSI and IPO managing standards development and the IP systems respectively. However, there is some evidence, summarized in the literature review and the empirical analysis above, that a joined up strategic approach can generate additional advantages in operations and performance. There may be opportunities for cross linkages or collaboration between BSI and IPO to support and encourage mutually informed approaches to standards development and IPRs, including, for example, the exchange of knowledge bases on IPRs and standards that are potentially relevant to each other.

A relatively low share of BSI committee members perceive standards development as an alternative to pursuing IPRs – the majority have elements of both. However, in the wider population of businesses, only a minority seek IP protection or participate in standards development. This implies that there may be a substantial constituency for whom BSI might be able to offer routes to market and growth for organizations with new knowledge who are not in practice able to effectively protect it.

Some 35% of respondents see BSI's PAS offering as a viable means of benefitting from their innovations. This indicates that new variations on traditional standards development can stimulate interest and perhaps act as a cross over mechanism, enabling the exploitation of IP, without formal rights. The share favouring the PAS is notably higher amongst services sectors at 50%, where the coverage of traditional standards committees and the use of standards in operations and in innovation is less developed. This interest may indicate scope for further extending the constructive use of standards and attracting participation in development of standards for services.

4.4 Support for SMEs

Support for SMEs in helping them understand parts of the innovation infrastructure, specifically the standards and patents systems.

It is clear from both the literature and our analysis of the UK Innovation Surveys that innovative smaller enterprises face important choices on how to prioritize their use of resources. In relation to IPR and standards development, our survey suggests that these choices are particularly hard for those in the 0–49 employee group, regarding their participation in standards development and seeking, pursuing and defending formal IP, which are both relatively costly options. A slightly higher share of SMEs than their larger counterparts perceive that participation in standards making can be an *alternative* strategy to seeking some form of protection. Having an influence on the specification of a standard can certainly create market opportunities for smaller firms which can be more commercially valuable than seeking and defending a property right. Our interviews suggest that participation in standards development can also significantly reduce uncertainty for an SME, not least because a pooling of knowledge includes that relating to the existing IPR in the field. A significant share of survey respondents accepted that the development of a standard can lead to a larger overall market. There is also extensive agreement with the role of standards committees in enabling knowledge sharing. Small enterprises in the 0–49 employee category are relatively more likely to perceive the advantages of the PAS option.

However, an IPR can be seen as a more readily observable asset that can be used to persuade sources of finance of the viability of an enterprise or as collateral when raising finance.

A theme in the literature review is the different perceptions and potential rewards for smaller firms who are specialized in technology or other knowledge production rather than supplying goods or services to end users. For that group, gaining IPRs and seeing these associated with standards can be an attractive strategic option. Our interviews suggest that they are particularly concerned with clarity in relation to the process of standards development and in better access to data, such as potentially relevant IPRs, to aid their contributions to the process.

4.5 Engaging the neutrals

The main findings of this research concern the largely complementary workings of the IPR and standards making systems. These vital components of the infrastructure already act to:

- promote investment in knowledge by providing enhanced and less risky returns to innovation;
- ensure the effective diffusion of knowledge through the economy so that the benefits of innovation are widespread;
- reduce uncertainty and encourage commitment of resources e.g. to R&D and other forms of innovation related investment.

There is, however, evidence of gaps in the use of these powerful institutions.

A significant proportion of respondents were neutral, in the sense of neither agreeing or disagreeing, with propositions about the value and usefulness of standards development activities and the use of IP. These groups may be regarded as yet to be persuaded about the viability or pay off from taking up some aspects of the standards and IP infrastructure. An implication is that there are gaps in the service offerings of standards and IP institutions, or in the ways that these are presented, so there is potential for extending the engagement of firms and other organizations and encouraging more strategic use of the standards development and IP infrastructure.

The BIS convened Innovation Infrastructure Partners might act to promote the configuration of innovation policy to build on the established strengths and connectivity of the knowledge infrastructure. Initiatives could, for example, include bilateral collaboration between BSI and IPO to consider approaches to better meet the needs of businesses and other economic agents who are currently neutral with respect to the strategic use of standards, their development and the link with IP. Our interviews suggested that promoting greater knowledge of the interrelationship between standards development and IPR may be an important area for policy development, with scope for approaches that reduce the uncertainties surrounding the development of standards.

4.6 Options for further research

There remain some gaps in the knowledge base for SDOs and for governments in understanding and optimizing the economic contribution of standards and their development. This section briefly introduces some options for areas of research that could help to fill these gaps.

Standards as catalysts – Extensions

The research for this study has been based on the idea that standards have important catalytic effects at various points in an innovation system. The report has, of course, been focussed on the standards development/IP catalytic role and has made use of data from the regular UK Innovation Survey and from a new survey of standards committee participants. There is potential for further research on these catalytic roles of standards, only just briefly touched on here, for example, standards as enablers of design, in stimulating investment in both human and fixed capital, of R&D and of managerial and organizational innovation.

Standards in services

The role of standards use and development in services sectors and service provision, including in international trade, has been less well researched than in production activities. The counts of standards relevant to economic sectors in Section 2 indicates far fewer that are directly applicable to services sectors, despite the dominance of services in modern economies. More research into how standards are developed and used in services and their economic impact could help to fill this gap in knowledge.

Trends in patents in standards

While serious issues with IPRs in standards development appear from the survey to occur on a modest scale, some interviewees had the impression that the overlap between the two domains is increasing, especially as standards have more of a new technology role. This could be investigated through a project to work closely with the BSI knowledge base team to design and apply effective search strategies to identify patent entailed standards and whether these are an increasing share. The technologies involved could be recorded, as part of the story of increasing engagement as reported in interviews is convergence with ICTs.

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