# 1. Introduction

Firm level strategies which are founded upon innovation depend for their ultimate impact on many of the wider aspects of sectoral, national and global innovation systems within which they are formulated. Beyond the protection of intellectual property, these wider aspects include (for example) institutionalized processes of standardization within standard setting organizations (SSOs). While there are now many studies which explore microeconomic aspects of such processes, including their interaction with intellectual property protection, these have been limited in the main to the exploration of issues arising in a small number of sectors, and we still lack evidence regarding the impact of standardization on wider systems of innovation by considering aggregations of related standards. Further investigation along these lines is important because of the potential for SSO standards development to generate aspects of ‘systems failure’ in which monopolistic elements become entrenched and creative competition and entry (and hence possibly innovation) inhibited. While a number of studies have been conducted at the macroeconomic or national level and which clearly point to positive contributions running from standards to innovation and productivity, these have been unable to shed much light on the patterns and mechanisms involved. In this contribution we seek evidence from a combination of the United Kingdom Innovation Survey (UKIS) with sectoral level data on the stock of standards available, to determine how far standardization influences innovation based strategy. Our findings suggest that this source of knowledge has discernible impacts on firms’ innovation strategies, especially in relation to the creation of the in-house capabilities needed to deliver the strategy, and where the extensive margin of such investments among firms has considerable relevance for economic policy. We corroborate the inferences made in this part of the paper with data (also from UKIS) on the value that firms place on standards as a source of information.

The paper is organized as follows. The next section considers briefly how standardization can be seen from an innovation system perspective. Section 3 discusses the sectoral dimension of institutionalized standardization activity and its implications for knowledge flows which are integral to the empirical analysis, which is then further motivated in Section 4 by a consideration of the implications of variation in the extent of codified knowledge provided by standards. Section 5 then outlines the empirical methodology and data used. Section 6 discusses the results. Section 7 offers a summary and conclusion.

**2. Standardization in an Innovation System**

Standardization takes many forms and fulfills several well established economic functions within innovation systems, but quite generally requires the adoption of a common specification for a product or process. That occurring within an organization has of course been integral to many firm level strategies aimed at creating value.[[1]](#footnote-2) Our main interest here however is in those standardization processes which require coordination and collaboration across firms and which thereby involve the disclosure of intellectual property, some of which is then incorporated within a codified knowledge base which may both structure and inform business strategy. Such processes thereby form a close relationship to other types of collaboration involving knowledge exchange, including research consortia and patent pools, both cases in which there is considerable debate about the impact, not only upon innovation but also upon competition[[2]](#footnote-3). Given the strong sectoral element to the importance of standards stocks that is known to exist and discussed further below, our contribution to this question is to consider the impact on strategy of the resultant distribution in knowledge bases. However, in distinction to many earlier studies, we consider differences not just in the type of innovation (e.g. product, process or organizational) but explore differences in the purpose of the innovation which may be genuinely entrepreneurial, but may also be more defensive, as a rational response for example, to global competition and entry or to domestic regulation.

While decentralized choices (i.e. ‘markets’) may provide one form of the coordination required to create a standard, possibly through the dominance, or at least leadership, of individual firms, there is now a long literature which suggests that often they do not – one reason being the difficulty of excluding other firms from using a standard, potentially rendering the resource commitments in developing the standard unprofitable in more fragmented market structures, where no individual firm or small group of firms has sufficient market power to create a so-called *de facto* standard. But where the ‘prize’ of setting a dominant standard is large enough, there may be sufficient to generate a ‘standards war’ with a variety of possible outcomes (Shapiro and Varian 1999).

An alternative path to standardization, in which a committee, following the formal rules of an SSO, achieves consensus among its members, has also proved an important component of innovation systems, especially where network effects are present and the mutual objective of substantial increases in the size of the market outweighs simple competitive considerations. By far the most frequently analyzed examples of such a path have been in the development of ICT, where there are very many committees dedicated to the creation of common ‘technology platforms’, i.e. an aggregation of standards which achieve inter-operability between different elements within the platform and within which firms agree to compete (see for example Besen and Farrell 1994, Tassey 2017).

Individual standards developed by SSOs promote ‘order’ within and between markets, and while it may be argued that this is opposed to innovation which implies disruption to the status quo, it is now clear that both economic theory and the empirical evidence have advanced sufficiently to recognise that the reality is considerably more nuanced. In terms of theoretical developments for example, evolutionary theories predict that the creation of order in product markets stimulates process innovation (e.g. Mueller and Tilton (1969), Gort and Klepper (1982)), while much of the game theoretic literature has been concerned with the compatibility and inter-operability provided through standardization and which by extending the market and/or clearly defining the market encourages forward commitments to R&D and other sunk cost investments related to innovation (Farrell and Saloner 1985). Empirical studies have also tended (at least on balance) to indicate positive impacts of standardization activity on innovation; for example there is now evidence from several countries linking standardization activity to aggregate productivity growth, initially for Germany (Blind et al 1999 and Blind et al 2011), but with broadly similar results for the UK, (Temple et al, 2005, chapter 2), Australia (Standards Australia 2007), Canada (Standards Council of Canada 2007) and France (AFNOR 2009). Moreover key surveys of the literature examining the relationship between standards and innovation point to many different mechanisms at work, only some of which have been explored empirically (see for example discussions in Swann 2010, Blind 2009, Swann and Lambert 2017). These surveys point to the importance of standardization activity as ‘catalytic’ in character, in stimulating the complementarities between different agents and institutions within an innovation system.

At the level of innovation systems, we can extend the idea that individual standards promote order to consider whether and how the aggregation of standards promote order and stability within the system, as recently suggested by Hawkins (2017), who argues that standardization needs to be afforded a structural position rather than simply an enabling mechanism within a system, thereby addressing a postulated bias in existing analysis towards the potentially destabilizing influence of innovation linked to innovative entry and entrepreneurship. Although SSO activity takes many specific forms, we may develop this idea further by considering the following more or less stable characteristics constituted by such activity, conditioning the process of knowledge accumulation through standards more generally and hence, we argue, firm level decentralised strategic responses to evolving technological opportunities.

(1) The standards created are ‘open’ in character, which can be defined in various overlapping ways (West 2007), but following Simcoe (2006) by the fact that any firm is able to *use* them “on reasonably equal terms” thereby making a distinction from openness in terms of access to the creation of standards, which may be restricted in various ways but in any event almost always by the costs involved in participation. Although these costs may well be lower for larger firms, Blind and Manglesdorff (2013) using evidence from the electrical engineering and machinery sectors, show that small and medium sized firms often participate indirectly through the formation of alliances. How effective such mechanisms are in ensuring that standards promote innovation without unduly restricting competition, is of course central to the policy evaluation of any innovation system.

(2) This openness in use extends beyond a specification of a product or process but to a larger body of commercially relevant knowledge providing information and guidance on all aspects of that product or process. To take one example, the ISO standard for a particular aluminium welding technology, details the requirements for the specification and qualification of welding procedures and consists of:

— Part 1: Vocabulary

— Part 2: Design of weld joints

— Part 3: Qualification of welding operators

— Part 4: Specification and qualification of welding procedures

— Part 5: Quality and inspection requirements.

Standards documents also usually include cross references to related standards and to any relevant Intellectual Property Rights, providing users with a network of information sources and wider contexts.

(3) Standards and the codified information they contain also create order by their relationship to each other, with sets of standards frequently helping define technological trajectories and hence forming part of the framework within which firms compete. The order created impacts upon sunk cost forward commitments, not just in R&D, but also in terms of other innovation related expenditures and cumulative further learning. This makes the stock and flow of standards an important contributor to the commercialization of innovation and the stabilizing influence of ‘industrialization’ (see the diagram in Hawkins 2017).

(4) SSOs are typically comprised of technical committees in which members pool various types of intellectual property, often of a proprietary nature. The mutual disclosure of intellectual property within technical committees has created a considerable literature on the economic consequences of intellectual property deemed as essential for adherence to the standard, possibly protected by IPR, as in the case of so-called ‘standard essential patents’ (SEPs). In theory, this can lead to several pathological outcomes. These include the potential for opportunism where essential IP is only revealed when standardizing firms have already committed to certain paths of development, and the licence fee may be able to extract some of the rents from using the standard for innovation due to costs associated with switching to an alternative. However, rule bound SSO processes as well as repeated interactions may be able to lessen this threat in the form of *ex ante* commitments such as proposed by for example by Swanson and Baumol (2005), Lerner and Tirole (2015). In practice, the types of commitment proposed therein are difficult to implement and SSO procedures generally involve less clear-cut FRAND commitments[[3]](#footnote-4). For a recent survey here see Comino et al 2018. A further potential problem is that of royalty ‘stacking’ where royalty payments on SEPs which are vertically related are detrimental both to producer and user surpluses (Cournot 1838/1897, Shapiro 2001), because one monopolists supplying to another fails to take into account the impact on each other’s profits in charging the monopoly price.

(5) The process of pooling intellectual property within an SSO also constitutes a significant learning mechanism in its own right, and there is significant potential for knowledge spillovers to be internalized among participants and for rents to be obtained through repeated interaction with other firms and the formation of a network. Inter alia, firms may learn ways of incorporating standardization into their business strategies.

These characteristics of standards development operate through each of the dimensions of an innovation system as identified by Malerba (2005) – i.e. as a knowledge base acting over a particular ‘technological domain’ with specific collective learning processes, as a forum for ‘actors and networks’, and of course as an ‘institution’ acting, as we have seen, as a constraint on business behavior (North 1990), but importantly, one which is capable of co-evolution with other institutions, for example those represented by intellectual property rights. However the resultant codified knowledge bases are not uniformly distributed across national or global systems of innovation, but have a strong sectoral dimension, embracing specific product groups and user-producer interfaces with implications for the knowledge base of these sectors. Our approach in the empirical part of this paper is to use this sectoral dimension, to which we now turn, before examining the implications for innovation.

**3. The Sectoral Dimension of Standards Development and Use**

The empirical analysis in this paper is partly based on the contention that the knowledge made available as both codified and open through standards publication varies considerably across sectors, partly driven by and in co-evolution with the historical evolution of technological opportunities, as well as by various differences in the configuration of supply and demand.

On the demand side, with reference to both existing and potential or expected demand, the benefits from standardization stem from the opportunities made possible through technological change, with powerful motivations arising in specific competitive contexts. These include the potential for significant networking effects, where the common objective of a larger market dominates concerns about intellectual property disclosure. This has proved particularly important in ICT where patenting has not prevented standardization through ‘technology platforms’ where powerful positions for particular firms or coalitions may nevertheless be generated, especially where the need to use particular patents can be incorporated in the standard.

From the supply side, since participation is costly in terms of resource commitments, but the availability of an open standard as we have defined it, is not, makes standards themselves something strongly resembling a public good, although of course implementation is never costless. Participation may however, as noted above, be motivated by the benefits of being part of a network and/or by being able to generate rents through the contribution of proprietary technology. Here the complexity of the technology may be an important determining factor. Moreover, there is almost certainly a role for cumulative causation, with established SSOs in a sector generating a learning path and the skill sets which encourage participation, partly by reducing the costs of developing new standards and partly by providing a proven path for rent-seeking behaviour. Indeed, historically it is possible to distinguish several waves of standardization through SSOs, as identified for example by Steinmueller (2017) who describes the strong link between the development of mass production in what is sometimes termed the ‘Second Industrial Revolution’ and the creation of what he terms ‘reference standards’ dealing for example, with units of measurement of mass, length, or time or providing ways of assessing the properties of materials, activities closely aligned with engineering and instrumentation. While much of this activity was of course carried out ‘in-house’, with dominant integrated manufacturing firms providing purely proprietary standards for suppliers and users, oligopolistic structures were also able to generate rents from collaborative efforts, and which allowed for the pooling of intellectual property on the basis of ‘mutually assured destruction’ in the event of litigation (U.S. Federal Trade Commission [2003, ch. 2, pp. 30–31] as modelled in Schmalansee (2009)), who notes the potential for repeated interaction to resolve possible prisoner’s dilemmas. Later waves of standardization owed much to the regulation of these powerful positions in both the US and Europe, notably in computing and telecommunications, which opened up technological opportunities based upon ‘modularity’ in input-output interfaces in complex systems (Baldwin and Clark 2004). This arguably opened opportunities for business strategies to attempt to manage the process of the standardization needed and achieve a degree of industrial leadership through efforts to maintain and promote particular design configurations. Intellectual property rights have undoubtedly played a large part and even been integral to this process and have spawned a considerable literature. Further, the complexity of systems has made possible the contribution to standardization of firms which are dedicated to R&D and rely more heavily on royalty payments. The impact of the changing composition of participation in standards development has been both theoretically modelled (of interest because of the potential for opportunistic behavior or royalty stacking mentioned above) but there is little empirical evidence indicating the significance of royalty payments as a significant barrier to standards use or as a motivator for participation (Lambert and Temple 2015).

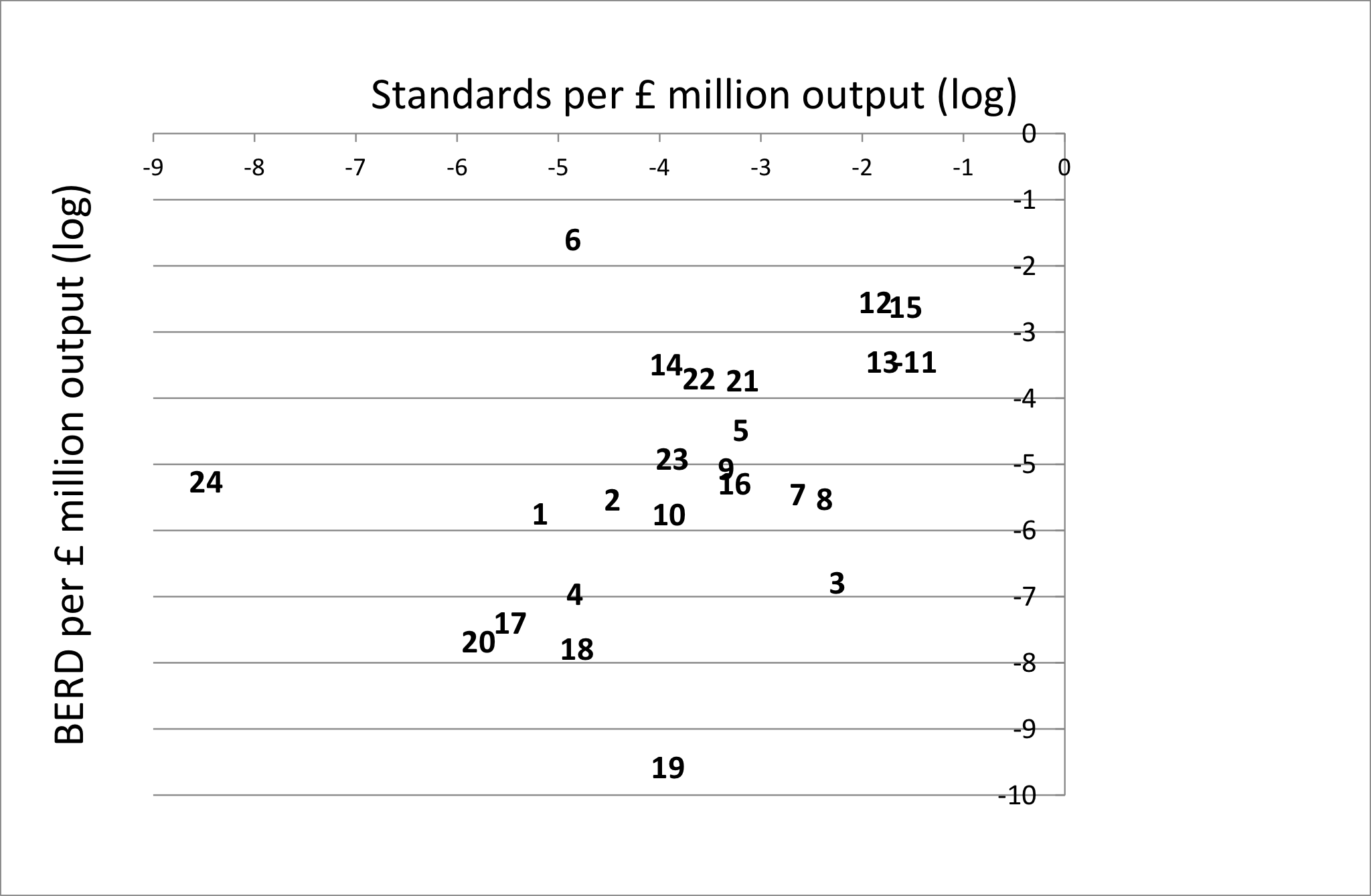
These waves of standardization have left their mark on the sectoral distribution of knowledge in standards. Figure 1 shows a comparison between aggregate business expenditure on R&D across 24 UK and the stock of relevant standards available to producers[[4]](#footnote-5) (both normalized by sectoral outputs). While the two are clearly positively correlated, certain manufacturing sectors notably SICs 12 (electrical equipment), 15 (other transport – including aerospace), 13 (machinery and equipment), 11 (computing and electronic products) stand out as generating, simultaneously considerable amounts of both R&D and codified information in the form of standards, while 21 (telecommunications) and 22 (computing and IT services) stand out in the same way in services.

Given these sectoral differences in access to open standards, there are of course important questions as to how this has effects in a national system of innovation, at the core of which are business strategies aimed at innovation. We have argued, that standardization is a collaborative activity in which firms have proprietary stakes in the intellectual property disclosed in the process. So a fundamental question concerns whether an environment rich in this type of knowledge has discernible impacts not only on the likelihood that a firm will adopt a strategy focused on innovation, but also upon the pattern of its related investments. Other things being equal, the knowledge being pooled will be that which does least harm to each firm’s competitive position, and a conception of standardization as providing public goods may be an accurate one[[5]](#footnote-6). However, as we have seen, this outcome

may be modified or indeed overturned by the ability of firms to leverage the value of their IP through standardization and making an innovation based strategy for competing firms more expensive or difficult to achieve. Consequently a major part of the empirical analysis of this paper focuses on the extensive margin of innovation related investments, i.e. on the extent to which individual firms are able to commit to such investments. However before passing onto the empirical analysis, we consider it important to consider in more detail the relationship between the standards environment, its information content, and business strategies aimed at innovation.

FIGURE 1:

Sectoral Distribution of R&D and Stocks of Standards (UK 2012)



**4. Business Strategies and the Information Content of Standards**

How far is the sectoral dimension to committee based SSO activity associated with discernible differences in business strategies, and if so which elements? As we use the concept here, business strategies are founded upon rational decision-making in which strategies are formulated with clear objectives in mind, made in the light of a firm’s understanding of its own capabilities and of the particular competitive environment in which it is situated (see for example Kay, 1993). Adding an assumption that firms are aiming to increase their value in the long-run, the approach suggests that a business strategy has three main elements:

* first, an objective which increases value added for the firm (*a value proposition*);
* second the means for *delivering* that path;
* and third, a means for *capturing* the value created and the conditions for its *sustainability* into the longer term

We consider each in turn, noting the potential impact of sectoral variations in the stock of codified knowledge made available through standards.

Innovation is of course only one possible route for increasing value, which may entail for example, engaging in strategic and/or entry deterring behaviour. However in terms of the framework adopted here a more fundamental starting point is the objective of the strategy – typically involving an increase in the value added obtained from its operations. In fact however, many studies of innovation based strategy have begun with a consideration of the *form* taken by innovation, e.g. in terms of product, process or organizational innovation (see for example Battisti and Stoneman (2008) in the case of the UK) or whether they are ‘simple’ or ‘complex’ embracing more than one type of innovation simultaneously (see for example Tavassoli and Karlsson (2016). There is no strong reason to suppose that a strong knowledge base in the form of standards favours either product or process innovation, but plausibly it may encourage incremental product innovation rather than novel product innovation, where in the absence of standards, the supplier-user interface may suffer from information asymmetries. The ‘order’ created in product markets may be an important stimulus to more radical *process* innovation, as suggested by life cycle theorists. While it is usual to associate innovation with pro-active profit oriented strategies in the Schumpeterian tradition, it is also possible to distinguish these from what might be termed ‘defensive’ innovations – those undertaken in response to a changing environment. Examples of the latter include responses to increasing international competition, or in achieving a response to changes in a regulatory regime in which case standards may offer a lower cost way of meeting the changing business requirements, although of course regulatory capture by participants in SSOs is a possibility, which would raise the relative costs of non-participants. Although receiving little attention in the innovation literature, the distinction between these two motivations has intermittently been applied in the case of the UK (Lamfalussy 1959, 1963, Eltis 1996) and has arisen more generally in the debate about the impact of globalization and competition from developing economies and especially China on the labour markets of developed economies where the nature of the competition induces reactive defensive innovation (e.g. Wood 1994, van Reenen 2011).

In our view, the form taken by innovation should properly be considered as part of the process of delivering the value proposition. In addition, achieving value through innovation requires mechanisms for reconfiguring internal capabilities to deliver the strategic source of value. Here, much policy interest focuses on R&D and increasingly on effective forms of collaboration. As far as R&D is concerned, the first question is whether a strong standards knowledge base reduces associated fixed costs and hence works on the extensive margin of R&D, and secondly whether it enables collaborative behaviour by reducing transactions costs. Strong codified knowledge bases should assist collaboration(s), whether with the science base – or with competitors or suppliers.

However delivery may require other inputs outside of R&D stemming from a more general reconfiguration of internal capabilities and the acquisition or generation of innovation related (complementary) inputs. Here, there is now a considerable volume of evidence that this may require further innovation in managerial techniques or other organizational methods for successful delivery (for the UK, Battisti and Stoneman (2010), or more generally Frenz and Lambert 2012, Tavasolli and Karlsson 2016). Our own earlier work, based on a survey of firms on their use of standards suggested that, beyond product specifications, they are widely used not only in research and innovation, but also for workforce development and training (Lambert and Temple, 2015).

Innovation by itself is seldom adequate for the *capture* of value by individual firms and firm level business strategies must consider and incorporate the *management* of intellectual property into that strategy. In the ‘profiting from innovation’ (PFI) framework for example, strategies are shaped by an ‘appropriability regime’ (Teece 1986) – i.e. the protection of an innovation allowed by formal intellectual property rights regime (patents, trademarks etc.) and by the extent to which there are ‘natural’ barriers to imitation – e.g. in terms of the complexity of the product and the tacitness of the technology. Without such natural barriers or when IPR are strong, firms need to consider their asset position in relation to the innovation – in particular are there strengths in assets which are complementary to the innovation and where competitor firms are in a better position to supply so-called ‘bottleneck’ inputs? Arguably, the existence of standards enables the acquisition of these complementary inputs at more competitive prices by reducing information asymmetries and the potential for bottlenecks.

The discussion suggests the importance for empirical analysis to consider explicitly the stated aim(s) of innovation strategies and to distinguish between those which are pro-active and more defensive aims. Arguably, a facilitation of the latter is an important aspect of the ‘order’ provided by standards within an innovation system.

Further the discussion makes it clear that there is no clear-cut set of hypotheses regarding the relationship between the strength of the standards environment and the pattern of delivery. A strong standards environment should however enable the accumulation of knowledge which directly serves the ‘core’ element in an innovation strategy which delivers competitive advantage – often associated with R&D and workforce skills - while reducing the potential for complementary inputs, e.g. in marketing, to act as bottlenecks. We now consider the empirical approach and the data employed.

**5. Data and Empirical Methodology**

Our main source of data for the empirical analysis comes from the ninth version of the UK Innovation Survey covering the period 2012-2014. The surveys provide considerable evidence regarding both innovation outcomes (product versus process innovation and the degree of novelty involved) as well as innovation related commitments to R&D, innovation related training, etc. Among other information sought in the Survey is one directly relevant to the purpose of a strategy, termed the ‘context for innovation’. It is to our knowledge rather rarely used in survey use, but as discussed above clarity as to purpose is essential for an articulated innovation based strategy. The survey is also well constructed to provide information regarding methods for delivering the aims of the strategy, covering not only product, process or organizational innovation, whether offering novelty but also covering various inputs related to the innovation. The latter include not only R&D (either internally or externally sourced) but also other means of knowledge acquisition (including cooperation). The data are particularly well suited to an examination of the extensive margins of these innovation related commitments of resources.

In order to measure broad sectoral differences in both technological opportunities and appropriability conditions (as suggested by the PFI framework), the survey data have been supplemented by data for 24 sectors, covering aggregate business spending on R&D in 2012, and a summary measure of appropriability. The latter is a measure of the extent to which firms feel that there exist effective means of value capture. This was generated from the previous version (2010-2012) of the survey, which (unlike the 2012-14 survey) asked a question regarding the “effectiveness” of various methods “for maintaining or increasing the competitiveness of product and process introduced during 2010 to 2012?” These methods embraced both formal means of protection (patents, trademarks, design rights, copyright, trademarks) and informal (lead time advantages, complexity and secrecy). These were then amalgamated into a single measures of appropriability based on sectoral averages of individual row means. Matched data from sectors to the underlying survey was available for 11,787 business units (henceforth ‘firms’).

Although the surveys contain limited direct evidence regarding the role of standards (but see below), we were able to combine the survey with a specially constructed set of standards data. These allowed us to examine the impact of the system wide ‘standards environment’ on innovation strategies. In order to obtain useful measures of this environment facing firms when formulating strategies, we used the PERINORM[[6]](#footnote-7) standards database to generate data for the sectors in both manufacturing and services. The analysis employed two measures of the availability of codified information – first a simple count of the relevant standards available to producer firms in each sector as well as a plausible measure of the currency of those standards – the year after which half these stocks of standards were published (the median year of the stock)[[7]](#footnote-8).

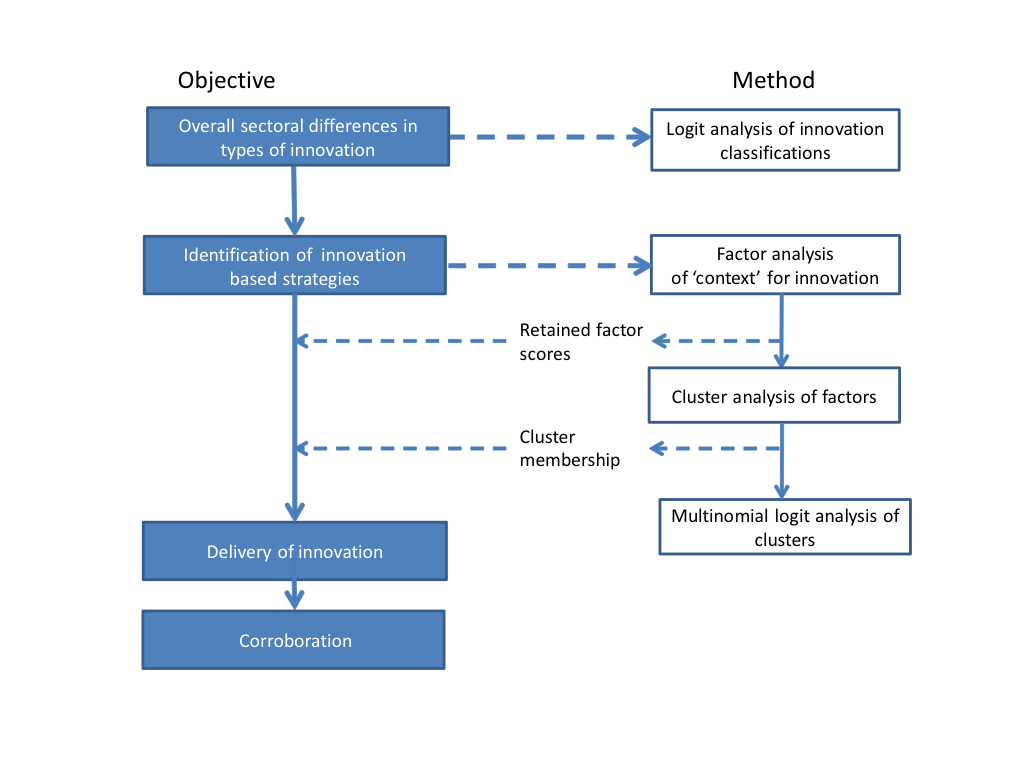
A schemata for the methodology adopted is shown in Figure 2. The framework of the survey filters those units who are regarded as being ‘active’ in the field of innovation; inter alia this

may include firms who are searching for an innovation but are not actually innovators or who report an innovation, but have no clear strategy founded upon innovation. In our view the binary concept of innovation underpinning the Survey is too broad to identify a strategy in which innovation is the lead element. Our approach necessitates first of all therefore the identification of a coherent innovation based strategy. As argued above, this requires that innovation has the clear objective of value creation. In order to meet this challenge, we use a factor analysis of the survey question regarding the ‘context’ for innovation, which distinguishes between the importance of 11 mechanisms for value creation[[8]](#footnote-9), e.g. ‘entering new markets’, ‘improving the quality of goods and services’ or ‘improving health and safety’ (for the full list see table 1, while further details can be found in the data appendix). The purpose of the factor analysis is not only to reduce the dimensionality of these data but also in the first instance to provide a means of identifying firms which, because of the intensity of their belief that innovation would lead to increased value, could genuinely be described as possessing an innovation based strategy. Furthermore, there is potential for further factors to provide a classification scheme for such strategies, which is developed using cluster analysis. A subsidiary multinomial analysis of the clusters identified, in order to determine the extent of any sectoral influences on the mix of strategies, was also undertaken.

Both the factor scores and cluster membership were then used in the subsequent analysis of the strategy delivery mechanisms. For delivery we consider the sectoral patterns in terms of (i) the type of innovation (ii) the extensive margins of innovation related inputs, (iii) cooperation with external partners. For each of these, the Innovation Survey is particularly well suited[[9]](#footnote-10).

Figure 2

Methodology for Empirical Analysis



Although direct reference to standards in the survey is limited, it does however contain one question of direct relevance to our assessment of standards in innovation strategy. This is Question 16, again with sample restricted to firms recorded as active in some aspect of innovation asks respondents to rate “how important to this business's innovation activities was information from” [one of] a variety of sources?” One of the twelve sources is that of “technical, industry or service standards.” While first of all internal sources of information and then those generated by customers, suppliers and competitors are typically considered the most important, previous surveys have found that standards both rival the last named and are more important than other sources[[10]](#footnote-11). Inevitably, the pattern of responses is going to reflect the decisions made by individual firms as well as the extent of standards availability which suggests that we can employ the pattern of responses *indirectly* to test inferences regarding the sectoral patterns revealed in the preceding analysis. So for example, if access to a stronger knowledge base in the form of standards is associated with more product innovation, then we would expect, *ceteris paribus,* a product innovator to rate this information rather higher than a process innovator. In our view, this approach provides an important source of confirmatory evidence for our analysis.

1. A purely ‘internal’ standardizing strategy was of course central to the eventual superior productivity of the factory system which eventually culminated in the development of the Model T at the Ford Motor Company (see for example Hounshell, 1984) ; a recent formal economic model distinguishing ‘standardizing firms’ from ‘innovators’ can be found in Acemoglu et al (2012).

   [↑](#footnote-ref-2)
2. For example, the activities of SSOs are considered by the OECD Competition Committee. OECD (2010) states that “By bringing together different players in an industry, the standard setting process provides an opportunity for collusion, deception and strategy about which regulators must be vigilant and proactive”, noting *inter alia* the potential for standardization processes to be subject to ‘patent ambushes’.

   [↑](#footnote-ref-3)
3. A commitment to license on ‘fair, reasonable and non-discriminatory terms’. [↑](#footnote-ref-4)
4. The measure is described in more detail below while the sectors by SIC code can be found in the appendix [↑](#footnote-ref-5)
5. Paradigmatic may be the knowledge generated by what is known as the measurement infrastructure discussed in King et al (2017) and where the knowledge used in standardization may considerably reduce the fixed cost element in R&D projects, and help firms avoid duplicative elements. [↑](#footnote-ref-6)
6. 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). [↑](#footnote-ref-7)
7. The use of ‘counts of standards’ in empirical research now has a long record beginning with Swann et al (1996), in the context of trade competitiveness. Swann also introduced the median age of the relevant stock in Temple et al (2005). See also Jungmittag et al (1999), CEBR (2015), Spencer and Temple (2016). [↑](#footnote-ref-8)
8. The actual survey has twelve mechanisms but our data aggregates the need to meet health and environmental regulation. [↑](#footnote-ref-9)
9. Unfortunately, this version of the survey was not of direct use for an examination of the informational role that standards may play in helping firms to manage their intellectual property. [↑](#footnote-ref-10)
10. Lambert and Temple (2015) find for example that looking at the two previous waves of the survey, 44.7% of respondents found technical industry or service standards to be of ‘medium’ or ‘high’ importance. [↑](#footnote-ref-11)