

Appropriation strategies and open innovation in SMEs

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Abstract

Drawing upon data from the 5th UK innovation survey, our goal is to shed light on how management choices on the nature of appropriation relate to management choices on the degree of openness within SMEs. To this end, our findings indicate a threshold effect of both informal and formal appropriation mechanisms on the likelihood of engaging in both coupled and inbound open innovation. That is, an emphasis on appropriation appears to be important in shifting firms from a closed to an open strategy. There is, however, little evidence that either approach to appropriation increases the extent of open innovation. In this, only informal IP protection mechanisms associate with an increasing extent of inbound open innovation. The implications of our findings are discussed.

1. Introduction

Whilst one might wonder about the extent to which it represents old wine on new bottles (Trott and Hartmann 2009; Oakey 2013), there is little doubt that the concept of ‘open innovation’ (Chesborough, 2003a,b) has enjoyed growing popularity over the last decade. In short, open innovation holds that businesses must increasingly utilise both internal and external sources of innovation – rather than rely solely on internal research and development efforts. Moreover, firms must recognise that both internal and external paths to the market exist (in the latter case, for example, through technology licensing). This, we were told, is “a new logic of open innovation that embraces external ideas and knowledge in conjunction with internal R&D. This change offers novel ways to create value – *along with new opportunities to claim portions of that value*” (Chesborough, 2003b, p. 41, emphasis added).

The ability to capture value from ones innovation is called ‘appropriability’ – and is typically concerned with monetising intellectual property rights. However, to the extent that openness entails disclosure this implies a tension with appropriability. Moreover, a key issue is that both Open Innovation and appropriation present particular challenges to smaller firms. As Gassmann and colleagues (2010, p. 219) observe, “SMEs are the largest number of companies in an economy, but they are under-researched in the open innovation literature” (see also Wynarczyk *et al.*, 2013). Whilst most of the literature regarding open innovation has been concerned with large firms, recent empirical evidence suggests that open strategies are increasingly widespread in SMEs (e.g. van de Vrande *et al.*, 2009) and associate with improved innovation performance (Parida *et al.*, 2012). Given internal resource constraints to innovation in small firms (Rothwell 1991), the potential offered by ‘openness’ ought not to be too surprising. Similarly, recent studies have shown the IP strategies of smaller firms to be

different from their larger peers, at least in part because of the lack of resources to defend more formal protection mechanisms (e.g. Leiponen and Byma, 2009). Rather, SMEs are likely to rely on ‘looser’ forms of IP protection, such as secrecy, complexity and speed.

This, then, raises a paradox: Open Innovation strategies seem particularly well suited to the pursuit of innovation in resource constrained small and medium-sized firms; with open innovation enabling firms to overcome the ‘liability of smallness’ (Gassmann *et al.*, 2010). However, ‘openness’ entails disclosure and resource constraints limit the ability of SMEs to establish and enforce protection. This apparent paradox is the focus of the current study. Specifically, we draw upon data from the 5th UK Innovation Survey, which allows us to construct measures for both the inbound open innovation and coupled open innovation strategies. These measures have considerable recent precedent in the empirical literature on open innovation (e.g. Laursen and Salter, 2006; Leiponen and Helfat 2010; Classen *et al.*, 2012; Love *et al.*, 2014). The survey also provides data on the use of a variety of both formal and informal mechanisms for the protection of intellectual property, narrowly, and innovations, broadly (as well as on a variety of variables which one might anticipate moderating the relationship between the organisation of innovation and the pursuit of particular appropriation strategies). Our goal is to better understand how management choices on the nature of appropriation relate to management choices on the degree of openness.

The paper is structured as follows: section 2 provides a brief elaboration of the concept of open innovation, as it appears in the literature, and the dimensions of openness which are the focus of the analyses presented in this paper. In addition, this section reflects upon the apparent tensions between openness and appropriability and presents three linked hypotheses, which our subsequent analyses test. Section 3 describes our data. Section 4 outlines our

choice of econometric method and details the results of our estimations. Finally, section 5 offers a concluding discussion with initial reflections on business and public policy.

2. Open Innovation

Open innovation as a concept is most obviously associated with the work of Henry Chesbrough. Accordingly, Chesbrough's initial text (2003a) is where we turn for an overview. To this end Chesbrough observes that "valuable ideas can come from inside or out of the company and can go to the market from inside or outside the company as well. This approach [i.e. "open innovation"] places external ideas and external paths to market on the same level of importance as that reserved for internal ideas and paths in the Closed Innovation model" (Chesbrough, 2003a). To students of innovation studies, from a wide variety of disciplinary backgrounds, this may seem rather 'old hat'. Interactive and network models of innovation have achieved something of a normative status over the last 30 years. And, whilst there has been the occasional recent related defence of the linear model (Balconi *et al.*, 2010), Chesbrough's 'closed' model has much of the appearance of a straw man. Nevertheless, the open innovation concept has use as a focusing device and, in according outflows the same importance as inflows, adds something to standard empirical accounts of innovation networking (e.g. Bougrain and Haudeville, 2002; Nieto and Santamaria, 2007).

Importantly, as Chesbrough (2003a,b) stressed, openness is not a binary phenomenon. Yet, much of the empirical work has sought to contrast open and closed strategies (Barge-Gil, 2010). Such a stark distinction offers simple clarity, but it does little to capture the essential 'more or less' character of open innovation. Recognising Chesbrough's (2003b) continuum "from essentially closed to completely open" (p. 37) is a crucial precursor to "understanding

the mechanisms, inside and outside of the organisation, when and how to fully profit from [open innovation]” (Enkel, Gassmann, and Chesbrough 2009, p. 312). As outlined below, the approach taken here follows recent empirical work (e.g. Laursen and Salter 2006; Garriga, von Krogh, and Spaeth 2013) in adopting measures of open innovation that are grounded in a recognition that firms may be more and less open, not simply open and closed.

2.1 Modes of openness

Much of the work on innovation systems and innovation networks has stressed the importance of external sources of inspiration, ideas, knowledge and resources for innovation by firms (or regions, or nations) (Pittaway et al. 2004). The perspective adopted is that of the firm (or region, or nation); and SMEs figure large in many expositions, with networks viewed as a means to ameliorate resource constraints while preserving behavioural advantages. The emphasis is on external search and subsequent absorption. Improving ‘absorptive capacity’ (Cohen and Levinthal, 1990) is the frequent managerial exhortation (e.g. Spithoven, Clarysse, and Knockaert 2011) or policy advice (Giuliani 2005). This is Chesbrough’s (2003) “inbound innovation”, and it is likely to be considerably more commonplace than “outbound innovation” (Huizingh 2011). That is, if firms ‘acquire’ and ‘source’ from many places, but ‘sell’ and ‘reveal’ to only a few (Dahlander and Gann, 2010), then an asymmetry is likely to be apparent from the firm’s perspective. Moreover, to the extent that outbound innovation entails that the firm’s intellectual property (the bases of its innovation) be commercialised by ‘others’ (through the sale of licences or spinoff activity, for example), for smaller firms, in particular, this mode of open innovation is likely to be relatively infrequent. Given Arrow’s

classic “information paradox”¹, firms are likely to require both identifiable and legally protectable ‘rights’ to their intellectual property and the wherewithal to protect those rights.

One immediate consequence is that micro data generated directly from firms is likely to better represent inbound innovation than outbound innovation. This is true of the Community Innovation Survey (CIS) data used here and is manifest in the focus of open innovation studies that draw from it (e.g. Laursen and Salter, 2006). Certainly, in SMEs that dominate business populations (and survey samples), a tendency towards inbound innovation over outbound innovation may be an inevitable consequence of resource constraints (Van de Vrande et al., 2009). The sorts of knowledge sourcing activities that are commonly measured as inbound open innovation (see Leiponen and Helfat 2010; Garriga, von Krogh, and Spaeth 2013) may often require little procedural formality and limited resource commitments.

Given a predominant focus on inbound open innovation, a popular approach adopted in the empirical literature follows Laursen and Salter (2006) in distinguishing between broad and deep forms of open innovation (see also Tether and Tajar, 2008 and Garriga, von Krogh, and Spaeth, 2013). Here, an open innovation strategy is conceived of as a search strategy. Openness breadth is typically measured as a simple count of the number of sources of information and knowledge used for innovation; whilst depth is measured as either the intensity of use of the various sources of information and knowledge or as a simple count of the number of innovation-related cooperative partners. This approach raises a couple of concerns: In the first instance, as simple counts of sources or partners, both are essentially concerned with breadth. Certainly, intensity of use or cooperation may imply greater reciprocity and resource commitment, but they do not fundamentally measure depth. For

¹ The paradox runs like this: In deciding whether to buy or not, the potential purchaser of the information describing an innovation or, more commonly, a technology, needs to know about the technology in sufficient detail so as to understand its capabilities. However, once the purchaser has this detailed knowledge, he/she has

instance, Leiponen and Helfat (2010) study the impact of breadth in knowledge sourcing on the innovativeness of a sample of Finnish firms, and measure breadth as a count of the number of sources used intensively. Similarly, Love, Roper, and Vahter (2014) explore the relationship between past openness to current openness and measure breadth as simple count of innovation partners. Indeed, in their more recent work, Laursen and Salter (2014) appear to recognise the limitations of their prior measures of breadth and depth; distinguishing instead between ‘external search breadth’ and ‘collaborative breadth’. The former is measured to capture some element of intensity, whilst the latter is measured, as before, as a simple count of cooperative partners.

Of course, the measures themselves are not problematic (besides the inconsistent use of measures and terminology). Rather, the problem is with what they purport to measure. Here our concern is with the conception of cooperation or partnering as inbound open innovation. To this end, there is a nice parallel in network theory’s distinction between flow and bond models of networks (Borgatti and Halgin 2011). The flow model denotes the transfer of tangible and intangible resources (e.g. information) between actors in a network. In contrast, the bond model represents the alignment of interests and coordination of action. As Glückler (2013) summarizes: “As an economic outcome, innovation can either be explained through flows of information or through the coordinated creation of collective novelty” (p. 884).

To the extent that cooperation entails complementary partners working towards the development and/or commercialisation of new technologies, it is essentially concerned with co-creation (Enkel *et al.*, 2009). Cooperation necessarily entails reciprocity; that is, ‘give and take’. To that end, its conflation with inbound open innovation seems misplaced and is likely to muddle the empirical landscape. Here we prefer the approach adopted by Gassmann and

Enkel (2004), which is consistent with recent network theorizing. These authors distinguish three core open innovation archetypes: outside-in, inside-out and coupled (Gassmann *et al.*, 2010). The first two are, respectively, the familiar inbound and outbound open innovation processes. The coupling process, however, aligns with the bond model of networking and acknowledges the likelihood that, in some instance, open innovation is a more intensively collaborative process.

Unfortunately, the available data limit us to exploring only two of these three ‘types’: outside-in (or inbound) open innovation and coupled open innovation. Regardless, inbound and coupled models of open innovation represent quite different logics of organising innovation. These differing logics are likely to be manifest in, *inter alia*, differences in resource commitments, managerial commitment, reciprocity and the importance of trust. We anticipate that these, in turn, will be reflected in different attitudes to appropriation and in the use of different protection mechanism. That is, different forms of open innovation, entailing different degrees of exposure, will be influenced by how firms perceive the problem of appropriability.

2.2 Openness and appropriation

As Geroski (1995, p. 91) observes “the feature of inventive and innovative activity that most clearly sets it apart from other strategic investments made by firms is the problem of appropriability”. Both the creation of value and the appropriation of value are central to competitive advantage (Lawson *et al.*, 2012). Yet, to the extent that openness entails disclosure (or exposure), this implies a tension with appropriation. Almirall and Casadesus-Masanell (2010) characterise this tension in terms of a trade-off between divergence and

discovery. Divergence relates to the idea that the goals of network actors are unlikely to be perfectly aligned, whilst discovery rests on the notion that openness may stimulate innovation and improve value creation by combining multiple complementary perspectives. Divergence and discovery work in opposite directions, such that there is a trade-off between the cost of losing control of the technology and the benefits of aggregating knowledge from other actors to enhance innovation. As Almirall and Casadesus-Masanell (2010) suggest, opening up “often hampers the strength of property rights and impairs the developers ability to capture value” (p. 27). This friction may retard open innovation if it discourages information search or collaboration (West 2006). In their study of European firms, Enkel and colleagues (2009), for instance, note “loss of knowledge” and “loss of control” as amongst the principal risks associated with open innovation activities from the perspective of firms. In the case of technology-based small firms, Oakey (2013) argues that concerns over confidentiality and the degradation of internally-generated IPs provide “good reason” for firms to be ‘closed’.

What is clear, is that firms’ varying use of appropriation mechanisms and their inconsistent ability to protect their technologies from imitation has long been considered an important determinant of variety in innovation modes (e.g. Pavitt 1984). For instance, in his classic essay, Teece (1986) observed that the nature of appropriability regimes influenced the organization of innovation most suitable for “profiting from innovation”. In ‘loose’ regimes integration is suggested, whilst ‘tight’ regimes with secure legal protection allow firms to pursue partnering strategies in search of specialisation economies. In short, firms’ ability to pursue open innovation strategies will be tied, at least in part, to their intellectual property strategies.

Reflecting on Teece's (1986) classic work, Pisano (2006, p. 1124) notes that:

“In order to help innovators specialize (safely), markets for know-how must work effectively. Networks of innovation thus depend partly on intellectual property regimes. Strong intellectual property regimes would support broader and more diffuse networks of innovation”.

Certainly, there is some supporting empirical evidence for this view. For instance, using data from the 1st Dutch Community Innovation Survey (CIS), Brouwer and Kleinknecht (1999) observed that both the propensity to patent and patenting intensity correlated with participation in collaborative R&D. From this, it is argued that patents, as a formal and well-defined appropriation mechanism, play an important role in clarifying ownership of the intellectual output of collaborative innovation and limit the scope for disagreement (Arundel 2001). It may also signal their quality to potential partners (Laursen and Salter 2014). In his study of 154 industrial firms, Lichtenthaler (2010) similarly concludes that “a firm’s intellectual property portfolio constitutes an important driver of open innovation” (p. 387). “At first glance” (West 2006, p. 32), it would seem, stronger IP regimes are likely to associate with more Open Innovation.

Yet, patents are not the only appropriation mechanism available to firms and appropriation strategies may take various forms, employing a variety of isolating mechanisms – ranging from patents and copyright to secrecy and speed-to-market. In recent work, Laursen and Salter (2014) use UK Innovation Survey data to construct a measure of ‘appropriation strategy’ which acknowledges this broader array of protection mechanisms. In this they simply sum responses on the perceived importance of all appropriation mechanisms listed (a total of six). The implication is that higher scores on this measure equate with stronger appropriation strategies. Their findings suggest a concave relationship between the ‘strength’

of appropriation strategy and openness. Openness is measured in the same fashion as in the current manuscript and the concavity is observed to be stronger for coupled openness than simpler inbound openness. However, in both cases, the point of inflection is high and the general conclusion is that stronger appropriation is associated with greater openness.

However, just as the concept of open innovation is not uniform, it seems rather crude to treat the various appropriation mechanisms as simply additive. Indeed, Laursen and Salter (2014) recognise this limitation, noting that future research may advance their discussion by exploring the relationship between choices amongst protection mechanisms and modes of openness. Greater sensitivity in the treatment of different protection mechanisms may go some way to resolving the apparent contradictions in the literature; with, openness and appropriation seen as both conflicting and complementary. Contrast, for example, Chesborough's (2003) strong managerial injunction to open up the firm and move away from an excessive focus on protecting ideas and Oakey's (2013) suggestion that for technology-based firms "internal development of new products...must remain confidential", with consistent empirical evidence that the employment of (certain types) of protection mechanisms associates with openness (e.g. Laursen and Salter 2014).

To this end, it may be useful to distinguish between 'types' of protection mechanism. Our data lists six mechanisms: patents, trademarks, registration of design, secrecy, lead-time and complexity. Whilst some of these are inevitably mutually exclusive (e.g. patents, which require disclosure, are inevitably incompatible with an appropriation strategy grounded in secrecy) (Hurmelinna-Laukkanen and Puumalainen 2007), evidence suggests broad complementarity across innovation protection mechanisms (Thomä and Bizer 2013). In this vein, it is common to distinguish two broad types of mechanisms: On the one hand, are those

mechanisms founded on legal protection (e.g. patents, trademarks, registration of design). These may be characterised as *institutional* forms of protection and be contrasted with more the *strategic* forms of protection afforded by secrecy, complexity and speed (Arbussa and Coenders 2007).

In other terms, this is the familiar distinction between formal and informal IP protection (e.g. Amara, Landry, and Traoré 2008; Thomä and Bizer 2013). Formal mechanisms are those which have a legal basis (patents, design registration, trademarks) and informal mechanisms are extra-legal (secrecy, complexity, speed-to-markets). Empirical evidence has shown informal mechanisms to be more widely used than formal mechanisms. Aggregating data from the 3rd, 4th and 5th waves of the UK Innovation Survey, Hall et al. (2011) show that only 22% of firms use any formal IP protections (with only 16% using patents), whilst almost 34% used at least one informal mechanism (around 32% used secrecy). These differences are starker still amongst small firms (Leiponen and Byma 2009). This is perhaps unremarkable. The strength of the protection afforded by patents, for example, rests on the availability of resources to credibly threaten litigation in the event of infringement. Smaller firms rarely have the necessary resources (West 2006). Moreover, as Thomä and Bizer (2013) argue, cost and complexity issues are likely to see smaller firms more reliant upon informal methods of protecting their intellectual assets rather than formal methods.

Our interest, however, is not in the relative frequency of the use of formal and informal protection mechanisms (although our data are consistent with prior evidence that informal mechanisms are predominant). Rather, it is in their relationship with our two forms of openness – inbound and coupled open innovation. Following the arguments above, one might associate formal protection mechanisms most clearly with Teece's tight IP regimes and

anticipate a positive relationship with coupled openness. Vested in collaboration, coupled openness requires partners to observe an agreed structure for the relationship. As a partnership, it implies reciprocal knowledge flows which are likely to entail more ‘revealing’ (Henkel, Schöberl, and Alexy 2013) than in the inbound open innovation model. Importantly, in contrast to the use of informal protection mechanisms, a firm’s use of formal protection mechanisms is likely to be highly visible to external actors (Hall et al. 2011). In this way it sends ‘quality’ signals to potential partners; signalling the possession of valuable technology and the capability to develop valuable technology (Laursen and Salter 2014). It is also likely to signal a familiarity with the formal IPR system, which may lessen concerns over IP conflicts. This leads us to hypothesise that:

H1: The use of formal innovation protection mechanisms is positively associated with a coupled open innovation strategy.

With respect to the relationship between the use of informal protection mechanisms and coupled open innovation, we are somewhat ambivalent. On the one hand, one might anticipate that the extent of disclosure required would render informal methods insufficient in protecting the firm’s prior art. In contrast, however, Leiponen and Byma (2009) find that small firms that engage in horizontal innovation-related cooperation show a preference for protecting innovations through speed-to-market rather than patents. Given resource consideration which may preclude formal methods for all but a peculiar subset of SMEs, an emphasis on informal protection methods may imply confidence in a firm’s complementary assets. This, in turn, may support a belief in the firm’s ability to appropriate a larger share of value from a coupled open innovation process. However, Leiponen and Byma (2009) find no relationship between the use of informal protection mechanisms and vertical cooperation. In

their sample, it would appear, only cooperation with rivals requires a particular emphasis on appropriation. On balance, we do not anticipate any relationship between a coupled innovation process and the use of informal protection mechanisms.

In the case of inbound open innovation, where the extent of disclosure is limited, the use of informal mechanisms may be sufficient. Here the information and knowledge flows are predominantly one way. The limited revealing required on the part of the focal firm is likely to be adequately protected by secrecy, complexity or lead-time advantages. Moreover, confidence in the efficacy of these methods is likely to provide a platform for searching outside the firm, trusting that external actors will have limited incentive or ability to imitate. This leads us to hypothesise that:

H2: The use of informal innovation protection mechanisms is positively associated with an inbound open innovation strategy.

We also anticipate the relationship between an inbound open innovation strategy and the use of formal appropriation mechanisms to be positive. Partly this reflects observed complementarities in the use of various protection mechanisms (Thomä and Bizer 2013). However, it may also reflect the ‘quality’ signalled by formal mechanisms, with higher quality firms better able to recognise valuable external sources of knowledge and information. In addition, the use of formal mechanisms has been shown to be higher in competitive environments, rich in technology opportunity and where codified knowledge plays a greater role (Hall et al. 2011). These features are likely to both induce and admit greater external search in the form of inbound open innovation. This leads us to hypothesise that:

H3: The use of formal innovation protection mechanisms is positively associated with an inbound open innovation strategy.

In summary, our interest is in the association between the relative emphases on formal and informal innovation protection mechanisms and two forms of open innovation: inbound open innovation and coupled open innovation. Despite recent contributions (e.g. Laursen and Salter 2014; Mina, Bascavusoglu-Moreau, and Hughes 2014) relatively little is known about how SMEs approaches to appropriation relate to their open innovation practices. Given the varying strengths of the relationships implied in inbound and coupled modes of openness, we anticipate variations in the quantity and quality of resource and knowledge flows and, importantly, the extent to which the firm (and its partners) are ‘exposed’. Varying exposure (or disclosure) places varying pressure on intellectual property and its protection. This ‘paradox’ of openness (Laursen and Salter 2014), in relation to appropriation, is likely to be particularly acute for smaller firms. Such firms possess limited resources to enforce formal, institutional, protection mechanisms and, given smaller innovation portfolios, are likely to be more selective in the protection mechanisms they employ (Thomä and Bizer 2013). Yet, it is exactly these resource constraints, that may see them garner the greatest relative returns from openness (Van de Vrande et al. 2009; Parida *et al.*, 2012).

3. Data and measures

3.1 Data

To test our hypotheses we employ data from the 2007 UK Innovation Survey (UK IS 2007), which covers the period from 2004 to 2006². The UK Innovation Surveys are part of the wider European Community Innovation Survey project. The Community Innovation Surveys derive their motivation and guidance from the OECD's Oslo Manual (OECD, 2005) and are a 'subject' (rather than 'object') oriented approach to collecting information on innovation activities (Arundel and Smith 2013). The European innovation surveys have been extensively used as the basis for empirical studies of innovation.

The 2007 survey is the fifth UK Innovation Survey and was sent to 28,000 UK establishments (here, we call them 'firms', which may be the source of confusion in the case of multiplant enterprises, but is less likely to be a concern in the SMEs that are our particular interest) with 10 or more employees. Whilst the sample incorporated a census of firms employing more than 250 workers, the SME component of the sample was stratified to ensure adequate regional and industrial coverage. The survey was funded by the Department of Business, Innovation and Skills (BIS), and it was administered by the Office for National Statistics (ONS). Survey questionnaires were distributed in a single wave on March 31st 2007. A 53% response rate was achieved. The survey includes both service and manufacturing firms. As noted, our interest is in SMEs. In line with EU convention, we take that to mean firms employing fewer than 250 workers (and, in this case, more than 9). This particular focus results in a study sample of 5781 firms.

3.2 Measures

² The 2007 UK Innovation Survey is available at the following webpage: <http://www.berr.gov.uk/files/file44938.pdf>. The UK Innovation Survey was funded by the Department for Innovation, Universities and Skills (DIUS). The survey was conducted on behalf of DIUS by the Office for National Statistics (ONS), with assistance from the Northern Ireland Department of Enterprise, Trade and Investment (DETI). The data is Crown Copyright. We would like to thank the Virtual Microdata Laboratory: Office for National Statistics for allowing us access to the 2007 UK IS. The original data creators, depositors and copyright holders, and the funders of the 2007 UK Community Innovation Survey, and the UK Data Archive, and the VML bear no responsibility for our analysis and interpretation of the data and results.

Our dependent variables measure the extent of inbound open innovation activities and coupled open innovation activities, respectively. In doing so, they fall in line with a recent body of empirical work on open innovation that draws on Community Innovation Survey data (or similarly constructed data) (see for example, Laursen and Salter 2006; Aija Leiponen and Helfat 2010; Love *et al.*, 2014). Specifically, we construct measures for inbound open innovation and coupled open innovation.

Our measure of inbound openness of innovation employs a survey question which asked respondents about the use and importance of a variety of information sources for the firm's innovation activities. In total 11 potential information sources (see appendix for a list of the sources) were listed and firms were directed to indicate if each source was of 'high', 'medium' or 'low' importance, or were 'not used'. To create our variable, we gave each 'high' response a value of 1; all other responses were given a value of 0. These scores were summed. In this way, our measure of inbound open innovation is a count of the number of "high" use sources of information for innovation. This has the benefit of measuring both the extent of inbound openness and capturing, to some degree, the intensity of use. That is, firms may be more or less open, not simply open or closed.

Our measure of coupled open innovation follows a similar logic. Firms were asked whether they had cooperated with a variety of potential innovation partners over the period covered by the survey. In total 7 partner 'types' were listed (see appendix). Whilst firms were also given scope to indicate the location of partners, this information is not used here. Rather, where firms indicated cooperation with a given partner 'type', located at one or more spatial scale, this was coded as 1; whilst no cooperative relation with that type of partner was coded as 0.

The 7 types were then simply summed to arrive at our measure of coupled open innovation. This measure does not necessarily capture the total number of cooperative partners (since firms may have cooperated with more than 1 supplier, customer, and so on). However, it does afford an indication of the breadth of cooperation and, albeit imperfectly, the extent of coupled open innovation. Although framed in terms of the breadth or depth of inbound open innovation, this measure enjoys recent empirical precedent (cf. Laursen and Salter 2006; Love, Roper, and Vahter 2014).

Our independent variables measure the use of an array of formal and informal innovation protection mechanisms. In total, 6 means of protecting innovation were listed and, given the mixed sectoral composition of our sample, all 6 are used in constructing our variables. Firms were asked to indicate whether they had used each mechanism for the protection of innovations during the period covered by the survey³. From these responses we construct two variables which simply sum the use of the various mechanisms: formal (registration of design, trademarks, patents) and informal (secrecy, complexity of design, and lead-time advantage on competitors) to create indices of the use of formal and informal appropriation strategies. Our formal methods are public and have a legal basis. Our informal methods are strategic, extra-legal and imperfectly observable outside of the firm.

In addition to the dependent and independent variables, the survey collects data on a variety of firm level characteristics that past research has shown to influence openness. Following the oft repeated aphorism that “firms must have resources to get resources” (Eisenhardt and Schoonhoven, 1996, p.137), we include firm size⁴ in 2006 to capture broad resource stocks.

³ They were also asked to indicate the importance of each (“low”, “medium” and “high”). But, here, we only use the information on use.

⁴ In the models, we take the natural log of firm size reasoning that the effect of one additional employee diminishes over the size distribution.

We also include measures of innovation-specific training and the conduct of internal R&D (both binary variable indicating incidence) to proxy resource qualities. These variables are intended to control for our expectations that access to resource, and resource sophistication may associate with both the extent of openness and the extent of appropriation strategies. Recognising that openness may vary across industries (Aslesen and Freel, 2012), we include a series of dummy variables for industry using SIC at the 2-digit level. Finally, we include controls for market location. In part this is in recognition of the variety in systems and enforcement across IP jurisdictions, but also reflects the notion that a more local market focus may make it easier to develop high trust relationships which lessen the need for protection (Thomä and Bizer 2013).

Finally, as outlined below, we ultimately estimate zero-inflated negative binomial (ZINB) models in recognition of the high number of ‘zero’ responses in the dependent variables (some 57.14% of sample firms used no sources of information “intensively” and 45.01% reported no cooperative partners). ZINB estimations assume that the zero outcomes and the non-zero outcomes are a result of two different processes. Here, the former is concerned with modelling the likelihood of being ‘open’ at all (inbound and coupled) – i.e. a binary outcome modelled with a logit. The group of ‘closed’ firms is likely to be a mix of non-innovators and ‘closed’ innovators. To the extent that innovation outputs are an imperfect proxy for innovation intent, the relative distribution of these is difficult to estimate⁵. The latter is concerned with modelling the extent of openness – i.e. a count outcome modelled with a negative binomial model. Whilst our primary concern is with extent, recognising the two processes is important in generating robust estimates. A similar approach to modelling

⁵ The UK Innovation Survey does include a measure of “innovation active” firms – 73% of SMEs in the 2007 Survey. However, this measure is technology innovation oriented and excludes broader forms of innovation such as marketing or organisational innovation which are likely to be important to SMEs.

openness was followed by Xia and Roper (2008) and Drechsler and Natter (2012)⁶. Unfortunately, Xia and Roper (2008) do not report the components of their logit (the ‘zero’ openness model). Drechsler and Natter (2012) note that “[t]he underlying reasons for these large fraction of zeros might be unobserved heterogeneity across the firms and/or a process with separate mechanisms for generating zeros (closed innovation) and non-zeros (high levels of openness)” (p. 442). They don’t speculate on the “separate mechanisms” and include the same variables in both the binary and count components of their ZINB; rationalising that a similar vector of variables will explain both ‘openness’ (as a binary phenomenon) and its extent. We take a similar approach here.

[Insert table 1 here]

Table 1 reports mean statistics and a correlation matrix for our independent and control variables. The correlation matrix offers some indication of the extent to which multicollinearity may be a problem in our subsequent analyses. As can be seen, none of the reported values are high enough to raise concern over the model specifications. In addition to the correlation matrices, variance inflation factor (VIF) scores were calculated for each of the sets of independent variables in each of the models reported in this paper. Again, none of the VIF scores were sufficiently high to cause concern. Another concern in studies of this type (i.e. single respondent surveys) concerns bias arising from common methods variance (CMV). Whilst the innovation survey was designed to minimise the potential for CMV by varying the response type (mixing Likert scale questions, yes/no answers, percentages and absolute numbers), we formally tested for CMV using Harmon’s one-factor test (for recent

⁶ We are grateful to an anonymous review for pointing us in the direction of these two papers.

examples in the open innovation literature see Leiponen and Helfat, 2010 and Love *et al.*, 2014). We included all independent and control variables (excepting industry dummies) in the exploratory factor analysis. This identified a number of factors, with the first factor accounting for less than the majority of the variance. Accordingly, we are confident that bias arising from CMV is not a major concern in our study. Both the VIF scores and the CMV test results are available from the authors on request.

4. Methods and Results

As noted, given the count nature of our dependent variables, count regression methods are suggested. Whilst Poisson models have a number of attractions, over-dispersion in the dependent variables renders them unreliable for both inbound and coupled innovation models.

Following this we estimated zero inflated negative binomial models for inbound and coupled open innovation. In all instances, the likelihood ratio test that $\alpha=0$ is significantly different from zero. This suggests that the data is over-dispersed and that a zero-inflated negative binomial model is more appropriate than a zero-inflated Poisson model. Furthermore, the Vuong test results in both models suggest that the zero-inflated negative binomial model is a better technique to use compared to the standard negative binomial model.

4.1 Coupled Open Innovation Regression Results

Table 2 presents the results of the model testing the relationships between the extent of firms' coupled open innovation strategies and firms' respective use of formal and informal appropriation mechanisms. Column 1 contains the results of the logit model intended to explain the 'zero' outcome (i.e. being closed); whilst column 2 contains the results of the negative binomial model concerned with the degree, or extent, of coupled open innovation. As indicated, in modelling our relationships, we control for a variety of factors which have previously been hypothesised to influence openness. In large part, these 'controls' act as anticipated. In both the logit and the negative binomial models, resources 'matter'. Both the volume of resources (proxied by the number of employees) and the quality of resources (investment in innovation-specific training and investment in R&D) are positively associated with coupled open innovation and with higher rates of coupled open innovation. Clearly, the role of internal resource and capability in allowing the pursuit of cooperative models of innovation ought not to be underestimated when delivering open innovation imperatives to small firms (Fritsch and Lukas, 2001; Tether, 2002).

However, contrary to expectations, the geography of markets does not appear to have any influence on the extent of coupled open innovation. Although, it does appear that engagement in 'distant' (i.e. non-EU) markets associates with a greater likelihood of having at least one cooperative partner.

Turning to our variables of interest: We hypothesised (H1) that the use of formal IP protection mechanisms would associate with a coupled open innovation. However, our data provides only partial support. The use of formal mechanisms does not appear to be related to the extent of engagement in coupled open innovation. The rationalisation underpinning our hypothesis rested partly on empirical precedent related to patents (Brouwer and Kleinknecht,

1999), but largely on the anticipated dual effects of the greater ‘revealing’ associated with partnerships (Henkel, Schöberl, and Alexy 2013) and the ‘quality’ signals that visible IP sends to potential partners (Laursen and Salter, 2014). However, in our SMEs, these influences don’t appear to dominate beyond a threshold effect (see below). This may reflect potential countervailing forces. For instance, given evidence that smaller firms tend to be highly selective in their use of protection mechanisms (Thomä and Bizer 2013), it may be that an excessive emphasis on appropriability signalled by the use of multiple formal protection mechanisms is sometimes “interpreted as signalling that collaboration with the focal firm will be difficult, and that conflicts over control and ownership of knowledge might ensue” (Laursen and Salter, 2014, p. 870). On the other hand, it may also reflect anxiety over exposure for firms with limited resource to prosecute infringement.

In contrast to formal protection mechanisms, we were ambivalent about the likely association between coupled open innovation and the use of informal protection mechanisms. For instance, we speculated that the extent of disclosure likely to attend coupled open innovation would render the protection afforded by informal mechanisms insufficient. However, past empirical work had suggested a positive relationship between the use of informal IP protection and cooperation with competitors (Leiponen and Byma, 2009). Our SME data reflects this ambivalence. Again, there is no evidence that a focus on IP protection associates with greater openness.

Strikingly, IP protection (both formal and informal) is significantly associated with the zero outcomes. In other words, the extent of IP protection reduces the likelihood of being closed to coupled open innovation. Whilst IP protection does not associate with the extent of openness, it appears to have the flavour of a ‘ticket to the game’. A similar finding is noted by

Drechsler and Natter (2012) on the basis of German Innovation Survey data. Their concern was also with a cooperation-based openness measure, although their sample included large firms. From their results, they conclude that “an effective appropriability regime is important to move from closeness to openness in innovation” (p. 443). There is, however, no evidence in our data that it subsequently associates with increasing levels of openness.

4.2 Inbound open innovation estimation results

Turning to hypotheses 2 and 3, table 3 follows a similar logic to table 2, with respect to our model of inbound open innovation. As before, column 1 contains the output from the logit model to explain ‘zero’ outcomes, and column 2 contains the negative binomial model of the extent of inbound open innovation.

Again, taking our control variables in the first instance: As before, having resources appears to be associated with both the likelihood of being open and with the extent of openness. That is, resource quantities and qualities associate with the likelihood of using at least one information source intensively and using more sources. Inbound open innovation (here, conceived of as external search) may be thought of as a ‘soft’ form of openness (Laursen and Salter, 2014). It frequently involves sourcing knowledge from external actors without the requirement for formal, often legally binding, agreements. In this sense, it may be thought to require less resource. As Van de Vrande and colleagues (2009) observe, the most common open innovation practices in smaller firms include customer involvement and external networking. These are typically “informal, unstructured practices which do not necessarily require substantial investments” (p. 434). Accordingly, one may think of these forms of open innovation as accessible for all firms. However, firms must still “have resources to get

resources”: capable employees and internal innovation efforts (both common measures of absorptive capacity) are strongly associated with external search activities.

As was the case for coupled open innovation, the geography of markets does not appear to influence the extent of openness. However, again, the data suggest that it associates with the likelihood of being open or not. In this case, being active in any international markets increases the probability of a non-zero result.

Turning to our appropriation variables: the results are broadly the same as those for coupled open innovation; but differ in one important respect. Again, use of IP protection mechanisms appears to act as a ticket to the game. Increasing use of both informal and formal mechanisms are negatively associated with ‘closedness’ – providing partial support for both H2 and H3. Further support for H2 is provided by the observation that the use of informal protection mechanisms positively associates with the extent of inbound innovation. The use of one additional informal protection mechanism (secrecy, complexity or speed-to-market) is associated with, on average, a 9% higher rate of inbound open innovation. It is clear that the use of strategic methods of protecting intellectual property is strongly related to external search in our sample of SMEs. As Van de Vrande et al. (2009) observe, due to limited resources, smaller firms will be confronted with the boundaries of their firm sooner rather than later. This, in turn, requires them to draw extensively on their networks to find innovation resources. Confidence in their abilities to protect the own IP may encourage broader and more intensive search. Similarly, higher managerial quality (Laursen and Salter 2014), signalled by a clearly articulated appropriation strategy, may also enable greater inbound open innovation.

However, there is no evidence of a relationship between formal IP protection and the extent of inbound open innovation. Formal IP protection is not statistically significant related to the number of sources of information used (above 1). Taken together with the earlier observations on coupled open innovation, it is tempting to see our results as an extension of West's (2006) observation that it is easier to see the relationship between IP protection and openness when it is outbound rather than inbound. However, an important caveat would be to note the threshold effect, echoing Drechsler and Natter (2012), that a focus on IP helps firms shift from closed to open; although it may not induce greater openness thereafter. In the case of inbound and coupled open innovation, formal IP may indicate more complex or sophisticated innovations, which are less well suited to extensive openness (Almirall and Casadesus-Masanell 2010).

In summary, in a similar vein to Thomä and Bizer (2013) our results suggest that the extent of innovation cooperation and networking in small firms is strongly related to the kind of appropriation strategies chosen. SMEs emphasising informal, strategic methods of protection record higher rates of both coupled and inbound-open innovation. In contrast, the use of formal protection mechanisms has limited association with the extent of either inbound or coupled openness. Crucially, however, a focus on both formal and informal IP protection predicts the likelihood of being open at all.

5. Concluding remarks

Both value creation and value capture are important elements of successful innovation (Lawson *et al.*, 2012). Openness can stimulate value creation by allowing firms to tap into a

larger and more diverse pool of complementary knowledge and related resources (Almirall and Casadesus-Masanell 2010). This is likely to be particularly important for smaller innovators, who confront the boundaries of their expertise rather sooner than their larger counterparts. Opening up innovation processes may enable SMEs to overcome their ‘liability of smallness’, and there is growing evidence that smaller firms are engaging in open innovation practices at an increasing rate (Gassmann *et al.*, 2010; Van de Vrande *et al.* 2009). Indeed, recent work has suggested that “SMEs are more dependent on OI than large companies” (Spithoven, *et al.*, 2013, p. 555).

Yet, openness entails various extents of revealing. And revealing may limit value capture. In this vein, there is evidence that firms identify “loss of knowledge” as a key open innovation concern (Enkel *et al.*, 2009). Indeed, Laursen and Salter (2014) identify this as “the paradox of openness” and West (2006) suggests that the apparent friction may retard open innovation processes if it discourages information search or cumulative innovation.

To date, there is limited empirical evidence on the relationship between SMEs open innovation strategies and their appropriation strategies. Whilst recent work has looked at the relationship between openness and appropriation strategies in a sample of small and large firms (Laursen and Salter 2014), the link between different choices of appropriation mechanisms and openness in SMEs is underexplored. The current study attempted to begin filling this gap.

Drawing upon data from the 5th UK Innovation Survey, we find that there is little evidence of a relationship between the extent of openness and the use of formal protection mechanisms. Formal protection mechanisms offer legal exclusion rights and are frequently argued to

benefit (and even be necessary in) outbound and coupled open innovation modes (Henkel *et al.*, 2013). For our SMEs, and for inbound and coupled open innovation, there is simply no evidence that this is the case. This may reflect a number of factors. For instance, legal exclusion rights are meaningful only to the extent that the firm is both willing and able to prosecute infringement. Smaller firms rarely have the resources necessary to credibly threaten litigation (West, 2006). In this way, owning extensive patent portfolios, for instance, is unlikely to either deter or encourage open innovation. Of course, other factors may also be at play. For instance, while networks and collaboration allow smaller firms to mitigate resource and knowledge constraints, a declared focus on formal IPRs may signal potentially complex negotiations or reluctant reciprocity to potential partners. It may also be that possession of valuable IP leads some firms to be more inward looking (Lichtenthaler 2010). If technology rather than market advantages are central to competitive advantage, such firms may be reluctant to rely on technology that can only be developed with external assistance.

This is not to say that there is no relationship between appropriation strategies and open innovation. Rather, our data suggests that both forms of IP protection significantly distinguish between open and closed firms. Moreover, the use of informal mechanisms to protect a firm's intellectual property is strongly associated with the extent of inbound open innovation in small firms. Even in small firms, managers can make their firms more open by engaging in innovation-related cooperation or by drawing broadly from a network of actors. Those that are able to identify a clear strategy for protecting their intellectual property seem better placed to engage in open innovation. This may reflect either managerial quality or a more specific confidence in the firm's ability to appropriate value – and the relative valence of these explanations remains an open empirical question. Regardless, appropriating the benefits from an innovation require significant managerial effort (Laursen and Salter, 2014) and the

varying extent of that effort appears to associate strongly with varying modes of innovation (Thomä and Bizer 2013).

It is also likely that the role of IP strategy may differ depending upon the ‘degree’ or ‘ambition’ of the firms’ innovation activities. To that end, an earlier version of the paper (results not reported here, but available from the authors on request) estimated the models for novel innovators and incremental innovators separately. Here, ‘novel’ innovations (in either products or processes) are those that were new to the industry; whilst ‘incremental’ innovations were new to the firm only. Our tentative results suggest little difference in the role of IP strategies for inbound open innovation, with only an emphasis on informal protection mechanisms associating with a higher degree of openness in both novel and incremental innovators. However, in the case of coupled open innovation, there is some evidence that attention to both forms of IP associates with the degree of openness in incremental innovators. In this way, providing support for hypothesis 1. In contrast, there is no evidence of an association between formal IP and degree of openness in novel innovators. Rationalising this finding is difficult. One may speculate that *prior* formal IP in incremental innovators signals their quality as potential collaborators and provides a ‘ticket to the game’; whilst, in novel innovators, concerns about the centrality to of IP to the *current* innovation acts against the presumed benefits of collaboration. Given our apprehension over interpretability, we do not fully report the results here, but believe that they hint at an important avenue for further research.

In closing, we recognise important limitations to our work. In the first instance, the data we draw upon is cross-sectional. Accordingly, we have consciously avoided strong causal statements; although, to some extent, our argument has the flavour of appropriation strategies

influencing innovation strategies. Whilst one may speculate, the casual mechanisms at play are likely to require richer data to fully elucidate. Technically, our models contain a potential endogeneity grounded in reverse causality: one may plausibly argue that experience with open innovation will shape firms' attitudes to appropriation. We recognise this possibility and, indeed, believe that it is likely to be the case. However, echoing Laursen and Salter (2014), we believe that any relationship between appropriation efforts and openness is likely to be circular rather than linear. In this way, having access to panel data, whilst attractive, is unlikely to be conclusive. Rather, in contrast to calls for more large scale data analysis and fewer case studies, we believe that detailed case studies of SMEs in different technology settings are likely to be required.

In addition, it may be that the relationship between appropriation and open innovation differs according to partner type or information source⁷. We have treated partners and sources as simply additive. Our goal was to explore the relationship between IP strategies and broad measures of open innovation common in the empirical literature. However, future work may be well served trying to disentangle the relationship between smaller firms espoused IP strategies and, for instance, cooperation with particular partners – extending the work of (Cassiman and Veugelers 2002).

The issue of firm size is also not straightforward. Data considerations have constrained us to look at SMEs as a group. The focus on SMEs is consistent with recent empirical work in field specific journals (e.g. Spithoven *et al.*, 2013; Parida *et al.*, 2012; Verbano *et al.*, 2015), however, it seems likely that as resources diminish (with diminishing firm size) the tension

⁷ We are grateful to an anonymous reviewer for raising this point.

between openness and appropriability will become more acute. Studies focusing on exclusively the smallest firms may yield additional insights.

As an aside, the data in the reported correlation matrix indicate a potential complementarity between inbound and coupled open innovation (a Pearson's r of 0.46). Whilst these appear to be independent constructs, explaining around 21% of the variance in each other, they may be frequently pursued together. The extent of this complementarity is beyond the scope of the current analysis, but may present opportunities for future research⁸. For instance, one may speculate that the extent of complementarity is related to the nature of the innovation pursued; with more novel innovation projects drawing upon both inbound and coupled innovation, whilst less novel projects more frequently rely on inbound open innovation alone. Unfortunately, we are constrained to examine them separately here.

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⁸ We are grateful to an anonymous reviewer for raising this issue.

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Table 1. Mean scores and correlation matrix

	Mean	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Coupled Innovation	0.542	1.00								
2. Inbound Innovation	0.558	0.46 ^a	1.00							
3. Log (of employment)	3.611	0.18 ^a	0.20 ^a	1.00						
4. Innovation-specific training	0.342	0.33 ^a	0.37 ^a	0.19 ^a	1.00					
5. Internal R&D	0.294	0.36 ^a	0.45 ^a	0.13 ^a	0.41 ^a	1.00				
6. Formal IP (0-3)	1.056	0.30 ^a	0.39 ^a	0.23 ^a	0.35 ^a	0.40 ^a	1.00			
7. Informal IP (0-3)	1.630	0.35 ^a	0.41 ^a	0.24 ^a	0.41 ^a	0.38 ^a	0.41 ^a	1.00		
8. International market – Europe	0.328	0.20 ^a	0.20 ^a	0.15 ^a	0.19 ^a	0.17 ^a	0.30 ^a	0.37 ^a	1.00 ^a	
9. International market – non-EU	0.223	0.23 ^a	0.22 ^a	0.14 ^a	0.15 ^a	0.30 ^a	0.32 ^a	0.35 ^a	0.64 ^a	1.00

N=5781

Table 2: ZINB regression models of the extent of coupled open innovation

	‘Closed’ innovation (i.e. zero outcome)		Degree of openness (i.e. >0 outcome)	
	coefficient	standard errors	irr	standard errors
Log (employees)	-0.168 ^a	0.041	1.054 ^a	0.017
Training	-1.337 ^a	0.118	1.198 ^b	0.081
Internal R&D	-1.766 ^a	0.121	1.050 ^a	0.026
Formal Innovation protection (0 to 3)	-0.160 ^b	0.066	1.022	0.047
Informal Innovation protection (0 to 3)	-0.681 ^a	0.060	1.018	0.055
International market – European	0.036	0.186	0.964	0.244
International market – non- European	-0.546 ^a	0.182	0.915	0.388
Constant	4.903 ^a	0.219	1.621 ^a	0.283
Ln alpha	-2.304 ^a	0.250		
alpha	0.125	0.032		
Vuong test	13.44 ^a			
Log likelihood	-2418.92			
Likelihood Ratio	94.52 ^a			
N	5781			

38 industry dummy variables were included in the model with construction (SIC45 as the reference).

^a p<0.1, ^b p<0.5

Table 3: ZINB regression models of the extent of inbound open innovation

	'Closed' innovation (i.e. zero outcome)		Degree of openness (i.e. >0 outcome)	
	coefficient	standard errors	irr	standard errors
Log (employees)	-0.080 ^a	0.024	1.028 ^a	0.003
Training	-0.679 ^a	0.077	1.336 ^a	0.057
Internal R&D	-1.181 ^a	0.088	1.234 ^a	0.042
Formal Innovation protection (0 to 3)	-0.229 ^a	0.033	1.027	0.022
Informal Innovation protection (0 to 3)	-0.250 ^a	0.039	1.091 ^a	0.023
International market – Europe	-0.251 ^b	0.103	0.811	0.234
International market – non- European	-0.300 ^a	0.101	1.001	0.238
Constant	3.779 ^a	0.132	1.860 ^a	0.226
Ln alpha	-7.102 ^a	0.706		
Alpha	0.071	0.024		
Vuong test	9.88 ^a			
Log likelihood	-4138.027			
Likelihood Ratio	169.68 ^a			
N	5781			

38 industry dummy variables were included in the model with construction (SIC45 as the reference).

^a p<0.1, ^b p<0.5

Appendix

Potential sources of information

- Within your enterprise or enterprise group
- Suppliers
- Clients or customers
- Competitors

- Consultants, commercial labs, private R&D institutes
- Universities or other HEI
- Government or other public research institutes
- Conferences, trade fairs, exhibitions
- Scientific journals
- Professional and industry associations
- Technical, industry or service standards

Potential collaborative partners

- Clients of customers

- Suppliers
- Competitors
- Within your enterprise or enterprise group
- Consultants, commercial labs, private R&D institutes
- Universities or other HEI
- Government or other public research institutes