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Innovation collaboration and appropriability by knowledge-intensive business services firms

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ABSTRACT

We uncover a "paradox of formal appropriability mechanisms" in the case of knowledge-intensive business services (KIBS) firms. Despite evidence that KIBS firms do not typically consider formal appropriability mechanisms, such as patents, to be central mechanisms for capturing value from innovation, we show that they are nevertheless important for their innovation collaboration. Drawing on an original survey of publicly-traded UK and US KIBS firms, we find a significant positive association between the importance of innovation collaboration and the importance of formal appropriability mechanisms. We interrogate the evidence for clients, as they are the most important partners for innovation collaboration. We find that the importance of innovation collaboration with clients goes hand-in-hand with the importance of formal appropriability mechanisms, although a negative relation appears when firms assign very high importance to formal appropriability mechanisms. Thus, modest levels of emphasis on formal appropriability mechanisms may prevent conflicts over ownership of jointly developed knowledge assets and knowledge leakages, while also avoiding the possibly negative effects of overly strict controls by legal departments on innovation collaboration. As well as exploring formal appropriability mechanisms, we also investigate the relationship between contractual and strategic appropriability mechanisms and innovation collaboration for KIBS firms.

1. Introduction

Collaboration for innovation has long been the norm for services firms (Arundel et al., 2007; Chesbrough, 2011), and especially for knowledge-intensive business services (KIBS) firms, which rely heavily on technical or professional knowledge to solve the problems of their clients (Miles, 2005). Since KIBS firms create knowledge assets regularly and jointly with external partners, they may find value capture even more challenging than firms in other sectors. Continuous search and transfer of knowledge in collaboration with external partners (and especially clients) can expose KIBS firms to regular conflicts in establishing and enforcing ownership over co-produced knowledge assets or preventing leakages of knowledge.

Evolutionary economics highlights the role of search in enabling firms to develop new combinations of knowledge and pursue new technological paths (Nelson and Winter, 1982; Metcalfe, 1994). An important part of search includes access to external knowledge through collaboration with other organisations (Rothwell et al., 1974; von Hippel, 1976). But there are dangers in sharing knowledge with external partners: there is scope for unintentional knowledge leakages and, indeed, imitation by competitors (Cassiman and Veugelers, 2002). Research on firms in manufacturing sectors shows that appropriability mechanisms may be employed to avoid these unwanted spillovers. Nevertheless, excessive emphasis on appropriability mechanisms may discourage potential innovation collaborators, reducing incentives for, the scope of, or effectiveness of innovation collaboration (Laursen and Salter, 2014; Liebeskind, 1997). In the particular case of services firms, however, an additional challenge concerns conflicts of ownership over knowledge assets which are regularly and jointly created with clients. To date, however, few studies of firms' choice of structures (including governance modes and appropriability mechanisms) to source external knowledge and prevent unwanted spillovers of knowledge have addressed service firms.

We draw on an original survey of 153 publicly-traded KIBS firms in the UK and the USA. Our paper advances our understanding of the relation between appropriability mechanisms and collabora-

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tion for innovation by KIBS firms in two main ways. First, we argue that although KIBS firms do not typically consider formal appropriability mechanisms (such as patents, copyrights and trademarks) to be central mechanisms for capturing value from innovation, they are however important for their innovation collaboration. We find a significant positive association between the importance of innovation collaboration and the importance of formal appropriability mechanisms in general. This significant positive association between the importance of innovation collaboration and that of formal appropriability mechanisms holds in particular consistently for collaboration for innovation with suppliers, competitors, consultants, commercial labs, or private R&D institutes, universities and government or public research institutes. This is because formal appropriability mechanisms may facilitate collaboration for innovation by serving as signals of innovation capabilities, or by providing a framework for what knowledge is shared and what remains private (Audretsch et al., 2012; Hagedoorn and Zober, 2015).

Second, we build on earlier work showing the existence of a concave relation between innovation collaboration and importance of appropriability strategies for manufacturing firms (Laursen and Salter, 2014), and extend this for KIBS firms. In particular, we find a significant inverted U-shaped association between the importance of firms' innovation collaboration with clients and that of formal appropriability mechanisms. The importance of innovation collaboration with clients goes hand-in-hand with the importance of formal appropriability mechanisms, although a negative relation appears when firms assign very high importance to formal appropriability mechanisms. Thus, modest levels of emphasis on formal appropriability mechanisms may prevent conflicts over ownership of jointly developed knowledge assets and knowledge leakages, while also avoiding the possibly negative effects of overly strict controls by legal departments on innovation collaboration. As well as exploring formal appropriability mechanisms, we also investigate the relationship between contractual and strategic appropriability mechanisms and innovation collaboration for KIBS firms.

We provide next the theoretical framework of the study. After that, we describe the data and the methods. We then present the findings. Implications and conclusions follow. Finally, we discuss the limitations of our research.

2. Theoretical framework: collaboration and appropriability by KIBS firms

First, we explore the peculiarities of innovation and collaboration with external organisations by KIBS firms. Second, we explore appropriability and collaboration for innovation by KIBS firms.

2.1. Innovation and collaboration by KIBS firms

There are two main difficulties in conceptualising innovation by KIBS firms. First, innovation by KIBS firms is hard to analyse, categorise, and measure, as it often involves simultaneously new services, new ways of producing and delivering services, new forms of client interaction, and new forms of quality control and assurance (den Hertog, 2000). A second complicating factor is that there is great heterogeneity among KIBS firms regarding the way they undertake innovation (Miozzo and Soete, 2001; Evangelista, 2000). KIBS firms can vary from "system integrator" firms, which develop complex engineering or IT "solutions" that meet the needs of large client organisations (Davies, 2004; Miozzo and Grimshaw, 2011), to professional services firms such as R&D, design or management consultancy, that help their client organisations to change in the course of implementing new or improved technologies or operations (Hansen et al., 1999; Miozzo et al., 2012).

Despite this heterogeneity, however, a defining feature of KIBS firms is that they are involved in the continuous creation and transfer of knowledge in collaboration with other organisations, especially with client organisations (Doloreaux and Shearmur, 2012; Gallouj and Weinstein, 1997; Jones et al., 1998). Also, all KIBS firms are unusually high in terms of the share of graduate and professional employment compared to firms in other sectors of the economy. These graduates are trained in different knowledge areas – some specialise in scientific and technical knowledge, others more in administrative, managerial or socio-legal issues (European Commission, 2004). This means that KIBS firms must adopt measures to retain these valuable high-skilled professional employees, and prevent them from being poached by competitors.

With the exception of firms in a few science- and technology-based sectors, KIBS firms do not typically have R&D departments. Instead, innovations tend to be developed in the course of specific projects for clients, and therefore are not always easy to distinguish from the customisation of the usual service. Scholars refer to the notion of "co-production" of knowledge with clients to denote the way that routine work for specific clients relies on clients' transfer of (partly tacit) knowledge, and how this is intertwined with learning and innovation on one or both sides of the relationship (Bettencourt et al., 2002).

Drawing on surveys such as the European Innobarometer and the Community Innovation Survey, researchers have emphasised the importance of innovation collaboration with clients for services firms. Among their findings is that service firms are less likely than manufacturing firms to collaborate for innovation with universities or suppliers, but more likely to collaborate with clients (Arundel et al., 2007). Also, service firms are less likely than manufacturing firms to source new technologies through in-house R&D, through the acquisition of advanced machinery and equipment, or through collaborations with universities and research institutes. Instead, innovating services firms are more likely to source new technologies through collaborations with clients and suppliers, or through the acquisition of external intellectual property (Tether, 2005). In general, evidence from the surveys indicates that innovation in services firms does not seem to follow dramatically different paths from those displayed by manufacturing firms, but differences appear to be more of degree than of kind.

A recent stream of research on open innovation in services (Chesbrough, 2011) has stimulated renewed interest on collaboration for innovation by services firms. Mina et al. (2014), using a survey to study the open innovation practices of UK business services firms, find that they are in fact more open seekers of external knowledge than manufacturing firms. Innovation collaboration by business service firms tends to increase with R&D intensity and with human capital intensity. While both clients, on the one hand, and universities and other research organisations, on the other, are important as a source of external knowledge for business services, they find, contrary to the Arundel et al. (2007) study, that universities and public research organisations are relatively more important. This may be understood in the light of Love et al.'s (2011) exploration of openness in different stages of UK business services firms' innovation processes: collaboration with clients is important at the early stage, collaboration with research organisations at the intermediate stage, and collaboration with professional associations at the exploitation stage of innovation.

Like firms in manufacturing sectors, KIBS firms seek to reduce involuntary leakages or transfers of knowledge in the process of innovation collaboration. But, in the case of KIBS firms, since joint knowledge creation, especially with clients, is the norm, regular conflict over ownership of the jointly-developed knowledge assets may be more likely. The services provider is likely to want to replicate the solution, process, or design in projects with other clients; the client might want to use it in its own other activities, and may

want to prevent it from being offered to its competitors (Leiponen, 2008). For example, a study of IT services found evidence of cases where IT services providers also provided services to firms in direct competition with their existing clients; this led to client firms fearing knowledge leakages and the replication of IT systems that had delivered them a competitive edge (Miozzo and Grimshaw, 2005). The study stressed the need for frequent discussion, negotiation and re-negotiation to reconcile objectives and interests between the client and KIBS firm, and to institutionalise processes for managing such conflicts over intellectual property rights.

In particular, the insight that innovations are developed in the course of specific projects with clients provides a rationale to single out in our analysis collaboration with clients from collaboration with other external organisations. We suggest that working with clients may require KIBS firms to pay extra attention to their appropriability strategy in the face of conflicting objectives. KIBS firms may not only be concerned about knowledge leakages in innovation collaboration with external organisations, but also experience conflicts in establishing ownership over jointly-created knowledge assets with clients. KIBS firms and their clients may have different objectives, with KIBS firms wanting to replicate the innovations developed jointly with a particular client with other clients, and clients being concerned about KIBS firms' offering the jointly-developed innovation to their competitors.

2.2. Collaboration and appropriability by KIBS firms

While the relationship between external innovation collaboration and appropriability strategy has received considerable attention in the context of manufacturing firms, this has been less explored for KIBS firms. There are two polar positions in the literature examining the relation between appropriablity strategy and innovation collaboration for manufacturing firms. On the one hand, one group argues that appropriability mechanisms can help heterogeneous partners collaborate for innovation and that, in strong appropriability regimes (where imitation is difficult either because of strong formal appropriability mechanisms or difficult-to-imitate technology), firms are more willing to collaborate for innovation (Pisano and Teece, 2007; Graham and Mowery, 2006). On the other hand, there are those who argue that innovation collaboration may be facilitated when firms deliberately reduce their use of some of their intellectual property rights (Chesbrough 2003; von Hippel and von Krogh, 2006). In support of the latter position, both Henkel et al. (2014) and Alexy et al. (2009) note that revealing freely or "selectively" core technologies can draw more users into firms' product ecosystems.

Firms typically protect rents due to innovation by using a range of appropriability mechanisms, including patents, copyrights, trademarks, design rights, confidentiality agreements, secrecy, employment contracts, lead-time advantages, complexity of product/process, and complementary assets. Although patents have been the main focus of attention on debates on innovation incentives, these tend to be the least emphasised appropriability mechanisms in most manufacturing sectors, with firms emphasising more heavily secrecy and lead-time advantages (Cohen et al., 2000; Hall et al., 2014; Leiponen and Byma, 2009).[1]

Formal appropriability mechanisms, including patents, may facilitate innovation collaboration by providing a framework for what knowledge is shared and what remains private. Hagedoorn and Zober (2015) report on a survey of firms active in innovation collaboration: 90% of firms regarded patents, 86% trade secrets, 71% trademarks, and 64% design rights as the most important instruments for protecting the innovative capabilities of firms from their innovation partners. Appropriability mechanisms can also facilitate the flow of the tacit component of knowledge—for example, when clauses of assistance and/or exchange of employees are included in licensing contracts (Foray, 2004).

Appropriability mechanisms can also signal innovative capabilities to potential partners. Having control over particular and valuable knowledge assets helps partners to identify each other, and can alert potential users as to the availability of the technology. For example, some firms are known to screen patent databases to identify potential partners for collaboration (Alexy et al., 2009; Audretsch et al., 2012). Also, possessing technical and commercial information in the form of trade secrets is considered an important signal of innovation capabilities (Hagedoorn and Zober, 2015). This signalling dimension of appropriability mechanisms is all the more important because firms operate with incomplete information regarding other firms' activities and innovative capabilities, and the value of their innovations.

Nevertheless, even when particular appropriability mechanisms contribute to external innovation collaboration, placing high levels of emphasis on them can be harmful for collaboration. Using panel data from three successive waves of a large-scale survey of UK manufacturing firms, Laursen and Salter (2014) find a concave relation between firms' breadth of external search and collaboration for innovation, and the strength of the firms' appropriability strategies. The authors explain the negative consequences of placing heavy emphasis on formal appropriability and innovation collaboration on the basis of strict controls by legal departments of collaborative relationships, complex organisational processes in place for getting approval for joint projects, conflicts over ownership of intellectual property, and complex inter-organisational negotiations damaging trust. Similarly, heavy emphasis on secrecy has been shown to cause discontent among employees, inhibit learning, and restrict opportunities for innovation collaboration (Liebeskind, 1997). Indeed, imposing restrictive secrecy rules cause loss of trust, and excessive use of security rules and monitoring procedures incurs labour and material costs.

There is some evidence that formal appropriability mechanisms are even less important for capturing value for services firms than for manufacturing firms (Hipp, 2008; Miles et al., 2000). Not only is the product of service innovation in many cases not suitable for patenting, but also KIBS firms' innovations may require less upfront investment (for many KIBS – but not all – there is no need for large R&D labs, engineering teams, costly equipment, and expensive clinical trials). Service innovation can be difficult to copy, for example, because of reliance on the input of highly-skilled and experienced professionals (Samuelson, 2010).

While much innovative output from services firms can not be effectively protected by patents, since the 1990s, patents have been applicable to some aspects of computer software in most economies (Hall and MacGarvie, 2006). There have been historical swings in the patentability of business methods (including auction methods, e-commerce techniques, and banking and financial services methods), with a more restrictive approach to their patentability since the late 1990s (Andersen and Howells, 2000). The copyright system has long been applied to published works: its application to innovative activity is much more recent and ill-defined, though copyright offices in most countries have accepted registration of computer programs since the mid-1960s. The less important role of patents in capturing value from innovation for

[1] The importance of patents, however, has been increasing compared to earlier surveys (see Levin et al., 1987). Firms often patent for reasons other than profiting from a patented innovation through its commercialisation or licensing. In addition to preventing copying, the most important reasons to patent include preventing competitors from patenting related inventions ("patent blocking"), forcing competitors into negotiations, and preventing lawsuits (Cohen et al., 2000). The broad role of patents was already envisaged in a historical study of the chemical industry, where Arora (1997) shows that how patents are used (or not used) affects opportunities for entry, industry structure and the rate of technological change itself.

services compared to manufacturing firms is currently challenged by Mina et al. (2014), who find that the use of patents is as important for business services as for manufacturing firms, and is more important than strategic appropriability mechanisms.

Thus, a further issue is that services firms, including KIBS, are argued to use mechanisms other than formal appropriability mechanisms to protect their knowledge. There is some evidence that they attempt to capture value from innovation mainly through contracts, secrecy, and a variety of strategic mechanisms, including lead-time advantages, making intangible products more tangible (e.g. embedding software in microchips), creating lock-in effects (such as offering bounded value-for-money services, loyalty cards, and, in the case of software and IT services, providing easy interoperability), and building entry barriers (such as the institutionalisation of professional qualifications and accreditation systems) (Greenwood et al., 2005; Hurmelinna-Laukkanen and Ritala, 2010; Miles et al., 2000).

Contracts with clients and other organisations are not only an important mechanism to capture value from innovation but also to head off conflicts in innovation collaboration by KIBS firms, or at least of limiting how far they escalate. The case of the collaboration between the IT services provider EDS (now part of HP) and the aero-engine firm Rolls Royce in a "business transformation programme", might be instructive. EDS provided a range of innovative IT services to Rolls Royce, including IT support for product development, manufacturing processes, supply-chain management, and repair and overhaul. To facilitate knowledge transfer and avoid conflicts over jointly-developed knowledge assets, the firms signed a complex contract with shared costs and profits (Miozzo and Grimshaw, 2005). Other studies also underline the importance of complex contracts between knowledge-intensive services suppliers and their clients in joint innovation collaboration (Massini and Miozzo, 2012; Miozzo and Grimshaw, 2011).

Similarly, Leiponen (2008) explores the role of exclusive arrangements, preventing knowledge-intensive services suppliers from servicing the clients' competitors. She shows that large and powerful clients prefer tighter control over jointly-created knowledge, although they might benefit more from providing greater incentives for fast knowledge creation by knowledge-intensive services suppliers rather than from tight control.

Thus, in order to enrich our understanding of how the choices of KIBS firms to collaborate for innovation with external partners are related to their appropriability strategies, this paper presents the results of exploratory research. We explore the relation between the importance of innovation collaboration and that of different types of appropriability mechanisms. Building on existing work (Greenwood et al., 2005; Hurmelinna-Laukkanen and Ritala, 2010; Miles et al., 2000), we consider different types of appropriability mechanisms that are relevant to KIBS firms: formal, contractual and strategic. We also build on previous work on innovation collaboration and appropriability carried out for manufacturing firms (Laursen and Salter, 2014). Nevertheless, we expect that some features that are "heightened" in KIBS firms, such as the emphasis on highly-skilled and experienced professionals, and the importance of the interaction with clients for innovation, may affect the relation between the choice among (and levels of emphasis on) different appropriability mechanisms and that of innovation collaboration with external partners.

3. Data and methods

We draw on an original survey administered through telephone interviews between September and December 2012. The sampling frame is the UK and US publicly-traded knowledge-intensive service firms listed in Datastream.[2] The UK and USA have relatively similar business and innovation systems, and legal frameworks for intellectual property protection; knowledge-intensive business services account for a large percentage of GDP in both countries. The initial list comprises 406 UK and 1892 US firms. The respondents were in senior managerial positions, including CEO, CFO, head of marketing, head of communications, head of business development, and technical project manager. The survey resulted in 223 responses (92 UK and 131 US firms).[3] The overall response rate is 10.3%, which is comparable to several previous studies (e.g. Mina et al., 2014). However, the response rates are significantly different in the UK and the US (23% and 7% respectively). Appendix Table A1 shows details of the assessment of the survey's non-response bias using the characteristic comparison method (Lawton and Parasuraman, 1980), which compares respondents and non-respondents by country, firm size (number of employees) and industrial sector (2-digit SIC code): UK firms and large firms are over-represented in the final sample.

The biases in favour of UK firms and large firms require the use of appropriate weight adjustment techniques (e.g., Love et al., 2011). We assign underrepresented groups of respondents higher weights compared with overrepresented groups in our regression, based on the inverse response propensity as assessed using logistic regression modelling (David et al., 1983; Kalton and Flores-Cervantes, 2003).[4] Indeed, we regress whether each of the 406 UK and 1892 US firms responded to our survey (yes = 1 and no = 0) on variables capturing auxiliary firm information about firm size (the number of employees) and country of origin (US or UK). The reciprocal of each firm's propensity to respond to the survey is then used to weight observations on each sample firm.[5]

The unit of analysis in the regressions is the portfolio of either product or process innovations that were introduced by our sample firms between 2009 and 2011 (see the description of the dependent variables below). During the survey period, a firm may introduce both product and process innovations. In such a case, for the firm, two units of innovations (i.e. product innovations and process innovations) are used for the analysis. We adopt a two-stage cluster sampling design. The primary sampling units are firms, and the secondary sampling units are their portfolios of product or process innovations.[6] Because some firms introduced

[2] These include firms operating in the following sectors: telecommunications, financial intermediation and auxiliary activities, research and development, legal services, accounting, book-keeping and auditing, tax consultancy, market research and public opinion polling, business and management consultancy, management activities of holding companies, architectural and engineering activities and related technical consultancy, and technical testing and analysis. The first two of this list have substantial consumer markets, and thus are usually excluded from business services though labelled knowledge-intensive services; since they are essential for business activities, they are often described as belonging to the category of "business-related services".

[3] We use Cochran's sample size formula (Cochran, 1977) to determine the adequacy of our sample size. As our key variables are constructed from a five-point scale (as illustrated later in the section about variables) and we set an alpha level of 0.1 and the acceptable level of error at 5%, the required sample size is around 68. Therefore, our achieved sample size is adequate for regression analysis.

[4] Eisen et al. (2012) provide a detailed empirical example of the application of inverse response propensity weights to adjust non-response bias for survey analysis.

[5] The advantage of using this weighting method for the adjustment of non-response bias (compared to post-stratification weighting for instance) is that any continuous variable that are associated with non-responses (such as the number of employees) can also be adjusted without assigning them to somewhat arbitrary categories.

[6] The sample is self-weighted in that all the sampling frame firms were contacted and for each firm that responded, its portfolios of product or process innovations were surveyed. Therefore, weights are given only to adjust for non-response bias (because of the sampling design, the sample does not have to be weighted). As there is no information available at the innovation level about the survey population, non-response bias is adjusted at firm level.

both product and process innovations over the same period, we use the Huber-White cluster-robust standard error estimator (Rogers, 1993; White, 1980; Williams, 2000) in order to adjust for intra-firm correlation and ensure consistent inference. Furthermore, using a robust heteroscedasticity-consistent (rather than the standard OLS) estimator, we account for the presence of heteroscedasticity of unknown form (White, 1980).

The relationship between the importance of innovation collaboration and that of appropriability mechanisms is analysed using multiple regression analysis (adjusted by country and firm size). The analysis was carried out using STATA 10. The final sample in the analysis comprises 233 product and process innovations, clustered into 153 innovating firms (i.e., the analysis is conducted using firms which introduced at least one innovation during the period 2009–2011). There are two reasons for this research design. First, for each portfolio of product or process innovations, we asked each respondent to give scores regarding the significance of the various types of appropriability mechanisms to protect the specific group of innovations. This enables us to distinguish whether product and process innovations are protected differently.[7] Second, if a firm had introduced no innovations during the survey period, there would be no reason to ask how the firm protected its innovation.

3.1. Dependent variables

Following the questions used in the Community Innovation Survey, we asked firm representatives whether the firm cooperated with each of the following partners for innovation: (1) clients or customers, (2) suppliers, (3) competitors, (4) consultants, commercial labs, or private R&D institutes, (5) universities, and (6) government or public research institutes. We also asked them to score from 1 to 5 how important the partner is for the firm's creation of innovation (when the firm did not collaborate with a particular type of partner, a score of zero is awarded). We chose to single out clients because of the important role attached to innovation collaboration with clients in the existing literature (Bettencourt et al., 2002; den Hertog, 2000; Arundel et al., 2007). This means that scores for the importance of collaboration for innovation for clients – integers ranging from 0 to 5 – are used as dependent variables for a set of regressions. Furthermore, we follow the approach of Amara et al. (2008) and created an extra variable '*importance of innovation collaboration with all other partners*', using the average of the scores of perceived importance of suppliers, competitors, consultants, commercial labs, or private R&D institutes, universities and government or public research institutes (i.e. partner types 2–6) for innovation ($\alpha = 0.55$),[8] as an additional dependent variable for the assessment of the relationship between firms' appropriability strategies and the importance of innovation collaboration with other partners regardless of whether firms collaborate with clients or not. This index therefore measures the aggregate level of importance of innovation collaboration with suppliers, competitors, consultants, commercial labs, or private R&D institutes, universities and government or public research institutes, without differentiating by partner type. The values of the composite index that captures the average importance of collaboration with these external partners can range from 0 to 5, and are not necessarily integers.

3.2. Explanatory variables

For each portfolio of product or process innovations, we asked respondents to give a score from 1 to 5 indicating how significant each of several mechanisms has been in protecting this specific portfolio from copying or imitation by competitors or for otherwise capturing value from their firm's innovations. The mechanisms are: (1) patents (excluding business method patents), (2) business method patents, (3) copyrights, (4) trademarks, (5) design rights, (6) confidentiality agreements, (7) employment contracts, (8) secrecy, (9) lead-time advantages, (10) complexity of the service or service process, and (11) complementary service development and delivery capabilities (this list follows the Community Innovation Survey, but includes additional appropriability mechanisms). Responses were factor analysed, using principal component analysis as the extraction method, Varimax as the rotation method, and retaining factors that explain more than 70% of the variance as factor selection criteria. Three types of significant appropriability orientations were identified as a result (Kaiser-Meyer-Olkin measure of sampling adequacy = 0.864) (Table 1), and factor scores for each orientation are calculated by regression methods. The three orientations towards appropriability mechanisms are labelled '*formal*', '*contractual*' and '*strategic*'. A *formal* orientation emphasises the significance of patents, copyrights, trademarks and design rights to capture value from innovation by firms. A *contractual* orientation highlights the significance of confidentiality agreements, employment contracts, and secrecy to capture value from innovation.[9] A *strategic* orientation stresses the importance of lead-time advantages, complexity of the service or service process, and complementary service development and delivery capabilities to capture value from innovation. Appendix Table A2 provides further information on data validity. Also, in light of previous research that identifies a concave relation between the importance of innovation collaboration and that of different levels of emphasis on appropriability mechanisms (Laursen and Salter, 2014), we introduce squared terms of the three types of appropriability orientations.

3.3. Control variables

We include a number of control variables suggested as relevant by the literature. First, a firm's R&D investments may affect its capacity to absorb external knowledge (e.g. Cohen and Levinthal, 1990), thus we construct the index '*R&D investments*'based on a survey question following the Community Innovation Survey. The question asked respondents whether they spent, for the year 2011, more than 1% of their turnover in support of innovation on each of the following activities: (1) conducting R&D internally (yes = 1 and no = 0), (2) acquisition of machinery, equipment and software (yes = 1 and no = 0), (3) training for innovative activities (yes = 1 and no = 0), and (4) all forms of design (yes = 1 and no = 0). We use the average of the standardised item scores ($\alpha = 0.66$). Second, as product or process innovation influences a firm's collaboration with different types of partners (Fitjar and Rodríguez-Pose, 2013), we include in the model whether the innovation is a product innovation or not (product innovation = 1 and process innovation = 0). Additionally, we control for other variables, including whether the firm is located in the USA (USA = 1 and UK = 0), firm size (log of the number of employees) and the type of sector in which the firm

[7] Many innovation surveys ask about product and process innovations, but then do not request information specific to these.

[8] A Cronbach's α value of 0.5 is acceptable for short item scales (Bowling, 2002).

[9] Secrecy is typically classified as a strategic appropriability mechanism, but the factor analysis groups it together with confidentiality agreements and employment contracts; so we call this group for simplicity 'contractual appropriability mechanisms'. Nevertheless, there are indeed some "contractual" aspects of secrecy. Although there are trade secrets laws which legally forbid employees of a firm to provide outsiders with documents connected to the business of the firm, unlike formal appropriability mechanisms such as patents, trade secrets laws do not protect against competitors using "fair" means to replicate the knowledge, protection does not extend to non-codified knowledge, and infringement is difficult to prosecute unless the employee has entered into an explicit contract of trade secrets with the firm, and the firm has made efforts to safeguard the secrecy of the piece of knowledge concerned (Liebeskind, 1997).

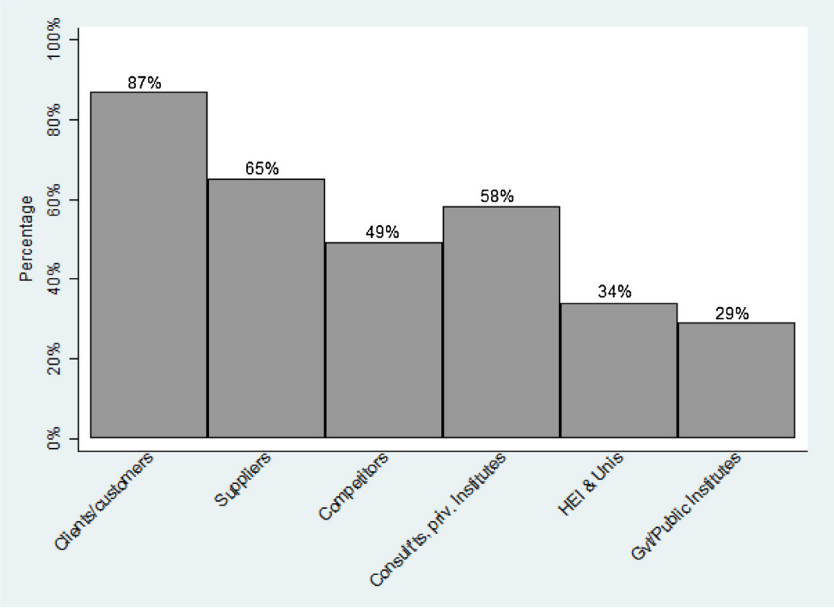

Fig. 1. Partners with which firms cooperate for innovation (%) (N = 153; weighted results).
Note: The survey question asked each firm that had introduced innovations whether the firm cooperated with each of the various partners for innovation.

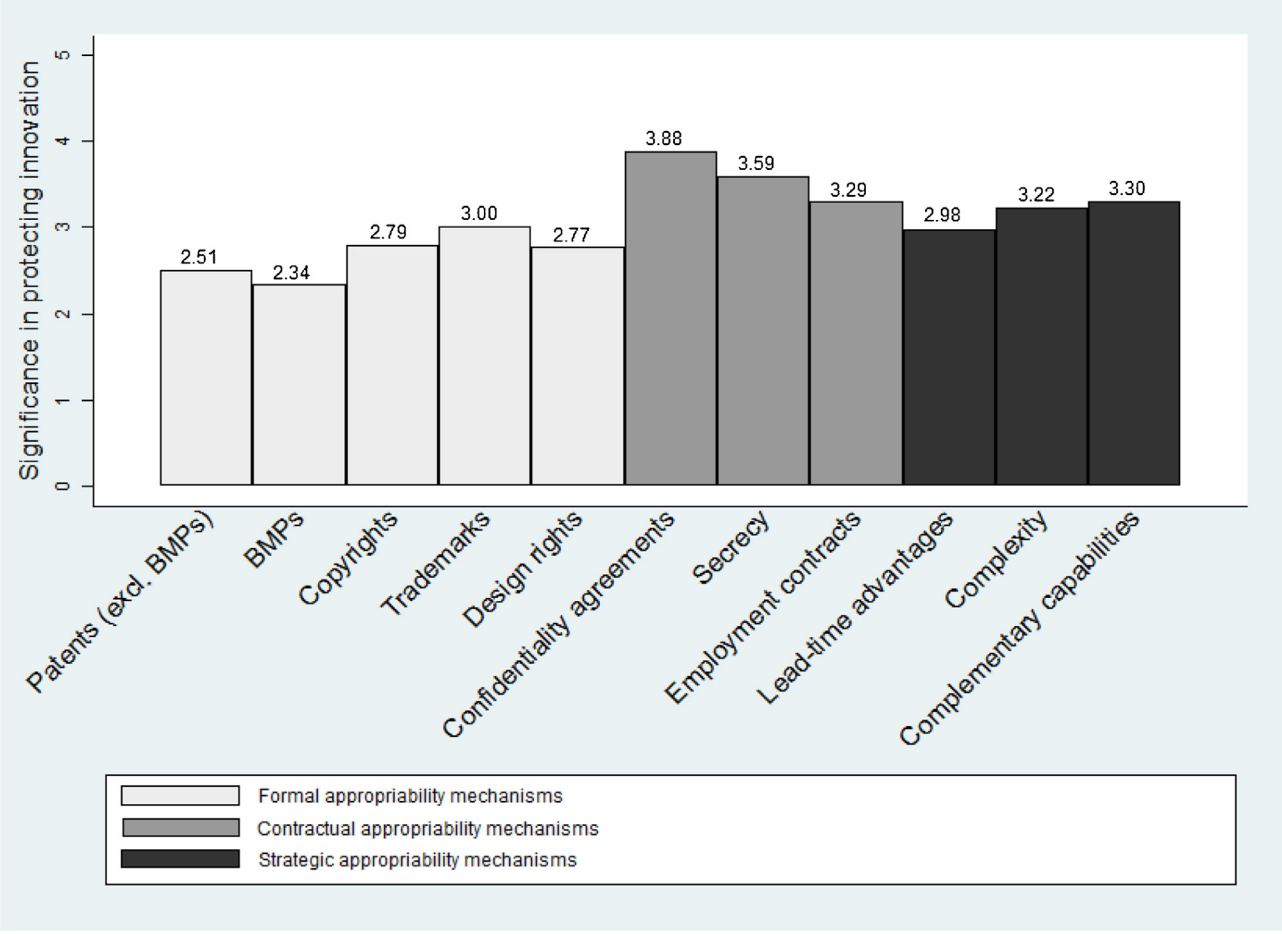

Fig. 2. Mean scores of significance of appropriability mechanisms (N = 233; weighted results).
Note: The survey question asked each firm that had introduced innovations, for each portfolio of (product or process) innovations, to score from 1 to 5 how significant each of several mechanisms has been in protecting this specific group of innovation from copying or imitation by competitors or for otherwise capturing value from their firms' innovation.

Table 1
Factor analysis results.

Items	Rotated factor loadings		
	Formal appropriability mechanisms	Contractual appropriability mechanisms	Strategic appropriability mechanisms
Patents	**0.80**	0.00	0.36
Business method patents	**0.83**	0.02	0.31
Copyrights	**0.82**	0.36	0.04
Trademarks	**0.77**	0.48	0.00
Design rights	**0.74**	0.38	0.14
Confidentiality agreements	0.23	**0.80**	0.27
Secrecy	0.23	**0.72**	0.34
Employment contracts	0.21	**0.76**	0.29
Lead-time advantages	0.23	0.28	**0.74**
Complexity of service product/process/design	0.14	0.18	**0.83**
Complementary service development and delivery capabilities	0.20	0.43	**0.73**

operates (seven industry dummies using the firms' primary 2-digit SIC code).

The objective of this paper is to explore the association between the importance of innovation collaboration with external partners and that of different appropriability mechanisms. The nature of this study is exploratory; we intend to uncover associations, rather than to establish casual relationships between the nominally dependent and independent variables. Hence, we do not imply that firms decide on what appropriability mechanisms to use and then whether to seek (certain) external partners for innovation. Nor do we claim the reverse: that firms decide first about their choice of collaboration strategy and then decide about their appropriability strategy. Both are possible in principle, and firm strategies almost inevitably evolve over time. The relation between the two sets of variables is likely to be determined by a number of factors, including the nature of the service, the types of innovations introduced, the capabilities of the firm, the type of knowledge required for innovation, and the type of sector. In particular, results may be influenced by the self-selection of appropriability and collaboration strategies by "high-quality" firms (Laursen and Salter, 2014). Consequently, further steps were taken to enhance the robustness of the analysis. We adopted two indicators of firm "quality". One indicator of quality is the number of innovations introduced by the sample firms. We thus asked respondents to state the number of products and process innovations their firms introduced between 2009 and 2011. A second indicator is the growth rate of the firms' total assets (in thousand US dollars) over the three-year period (2009–2011) up to the year of the survey (e.g., Weinzimmer et al., 1998). Firm growth rate is calculated from the difference in total assets between 2011 and 2009, divided by the value of total assets in 2009 and multiplied by 100.

4. Findings

4.1. Descriptive statistics

Strikingly, the survey shows that the sample firms collaborate extensively for innovation. Cooperation with clients/customers is the most important type of collaboration in the innovation process, with 87% of firms cooperating with this type of partner (Fig. 1). Suppliers of materials, equipment or software are the second most important partners in the innovation process, with 65% of firms cooperating with this type of partner. This is followed by cooperation with consultants, commercial labs, or private R&D institutes (58% of firms), competitors (49%), universities or other higher education institutions (34%), and government or public research institutes (29%).

Regarding the relative significance of each appropriability mechanism, confidentiality agreements, secrecy, employment contracts, complementary capabilities and complexity in service design are perceived to be amongst the most important means of capturing value from innovation (Fig. 2). According to our respondents, formal appropriability mechanisms are less important than contractual or strategic appropriability mechanisms. In fact, patents were the least important of all the methods considered for capturing value from innovation.

4.2. Regression analysis

Tables 2 and 3 present the descriptive statistics and correlation coefficients among the variables. Table 4 presents the regression results using cluster-robust estimators (which take into account intra-firm correlation) for both the full specification, and a reduced version without the squared terms, in order to assess whether the estimated effects behave consistently in the two specifications. The inclusion of the squared terms improves the fit of our model to the data in the regressions of collaboration with clients, as reflected in the F-test for the change in R-squared between the reduced and the full specification.

To assess the risk of multicollinearity in the regression analysis, we calculated the variance inflation factors (VIFs) among the predictor variables for the two full specification models. The maximum estimated VIF across our explanatory variables for both models was 4.87 and the mean value was 1.86, which are well below the recommended ceiling of 10 (Wooldridge, 2000).

Following Shugart et al. (2005), we use graphical representations of the predicted results with 90% confidence intervals to interpret regression results from the nonlinear models. The approach is useful for the interpretation of specific effects in cases in which coefficients of relevant variables from the regression results are not all statistically significant in nonlinear models.

Four key findings emerge from the regression results. First, despite previous evidence from existing literature and our survey that *formal* appropriability mechanisms are less relevant for capturing value from innovation by KIBS firms than contractual or strategic mechanisms, we find a significant positive association between the importance of innovation collaboration and the importance of formal appropriability mechanisms in general. This significant positive association between the importance of innovation collaboration and that of formal appropriability mechanisms holds in particular consistently for collaboration for innovation with all other partners (i.e. suppliers, competitors, consultants, commercial labs, or private R&D institutes, universities, and government or public research institutes) (see Table 4 and Figs. 3 and 4).

Second, there is however a maximum limit, or a turning point, to the positive association between the importance of innovation with clients and the importance of formal appropriability mechanisms. We find a significant inverted U-shaped relation between the importance of firms' innovation collaboration with clients and that of formal appropriability mechanisms (column 2 in Table 4). As

Table 2
Descriptive statistics for variables (weighted results).

Variables	Type of variables	Description	Mean	Std. Dev.
Firm level				
Importance of innovation collaboration				
Importance of innovation collaboration with clients	Scores; continuous	Scores from 1 to 5 how important clients are for the firm's creation of innovation (when the firm did not collaborate with clients, a score of zero is awarded).	3.67	1.68
Importance of innovation collaboration with all other partners	Index: 5 items (Cronbach's alpha value = 0.55)	Scores from 1 to 5 how important the following partners are for the firm's creation of innovation (when the firm did not collaborate with clients, a score of zero is awarded) 1) suppliers 2) competitors 3) consultants, commercial labs, or private R&D institutes 4) universities 5) government or public research institutes.	1.56	1.00
R&D investments	Index: 4 items (Cronbach's alpha value = 0.66)	Whether respondents spent, for the year 2011, more than 1% of their turnover in support of innovation on each of the following activities 1) conducting R&D internally (yes = 1 and no = 0) 2) acquisition of machinery, equipment and software (yes = 1 and no = 0) 3) training for innovative activities (yes = 1 and no = 0) 4) all forms of design (yes = 1 and no = 0).	0.17	0.66
Number of employees (log)	Continuous	log of the number of employees	5.68	2.16
Firm growth rate	Continuous (%)	The difference in total assets between 2011 and 2009, divided by the value of total assets in 2009 and multiplied by 100	77.78	382.84
US firm	Categorical	Whether the firm is located in the USA (yes = 1 and no = 0)	0.82	0.38
Groups of innovation level				
Orientation to formal appropriability mechanisms	Index: factor scores from regression methods	Factor analysis results; see Table 1	0.11	0.98
Orientation to contractual appropriability mechanisms	Index: factor scores from regression methods	Factor analysis results; see Table 1	−0.03	0.98
Orientation to strategic appropriability mechanisms	Index: factor scores from regression methods	Factor analysis results; see Table 1	−0.05	0.98
Product innovation	Categorical	Whether the innovation is a product innovation (yes = 1 and no = 0)	0.59	0.49
Number of innovations	Continuous	The number of product or process innovations introduced between 2009 and 2011	6.78	24.64
N = 233				

Table 3
Correlation Table (weighted results).

	1	2	3	4	5	6	7	8	9	10	11
1. Importance of innovation collaboration with clients	1.00										
2. Importance of innovation collaboration with other partners	0.26***	1.00									
3. Orientation to formal appropriability mechanisms	0.22***	0.25***	1.00								
4. Orientation to contractual appropriability mechanisms	0.19***	0.12**	0.00	1.00							
5. Orientation to strategic appropriability mechanisms	0.01	0.09	0.00	0.00	1.00						
6. R&D investments	0.12*	0.25***	0.17***	0.01	0.28***	1.00					
7. Product innovation	0.04	0.04	0.07	0.09	0.04	0.03	1.00				
8. Number of innovations	0.07	0.08	−0.13	0.12	−0.11	−0.06	0.02	1.00			
9. Number of employees (log)	0.14**	0.25***	0.13*	0.22***	0.01	−0.05	−0.00	0.16	1.00		
10. Firm growth rate	0.08	0.07	0.17	−0.00	0.08*	0.14	−0.03	−0.01	−0.22*	1.00	
11. US firm	0.09	0.17***	0.29***	−0.04	−0.03	0.12*	−0.03	−0.14*	−0.15**	0.08	1.00

* significant at the 10% level.
** significant at the 5% level.
*** significant at the 1% level.

can be seen from Fig. 4, the turning point of the curve occurs when a firm's orientation to formal appropriability mechanism is about 0.64, which is above the mean level of the variable of 0.11 (Table 2). This suggests that initially the importance of innovation collaboration with clients goes hand-in-hand with the importance of formal appropriability mechanisms, but a negative relation appears when firms assign very high importance to formal appropriability mechanisms.

Table 4
Regression analysis (weighted results).

	Dependent variable			
	Importance of innovation collaboration with clients		Importance of innovation collaboration with all other partners	
	Coef. (Robust Std. Err.)		Coef. (Robust Std. Err.)	
	(1)	(2)	(3)	(4)
Formal	0.37*	0.50**	0.27**	0.26**
	(0.21)	(0.21)	(0.11)	(0.11)
Formal squared		−0.39**		−0.04
		(0.17)		(0.10)
Contractual	0.17	0.21	0.02	0.01
	(0.16)	(0.15)	(0.08)	(0.08)
Contractual squared		−0.15		−0.10*
		(0.13)		(0.05)
Strategic	−0.08	−0.03	0.03	0.00
	(0.19)	(0.16)	(0.08)	(0.09)
Strategic squared		0.19*		0.04
		(0.10)		(0.06)
R&D investments	0.25	0.28	0.34**	0.35**
	(0.26)	(0.24)	(0.13)	(0.14)
Product innovation	0.08	0.05	0.04	0.01
	(0.13)	(0.14)	(0.09)	(0.09)
Number of innovations	0.00	0.00*	0.00**	0.00**
	(0.00)	(0.00)	(0.00)	(0.00)
Number of employees (log)	0.07	0.08	0.08	0.08
	(0.07)	(0.07)	(0.05)	(0.05)
Firm growth rate	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
USA	−0.04	−0.11	0.07	0.07
	(0.39)	(0.39)	(0.19)	(0.19)
Industry dummies	Yes	Yes	Yes	Yes
Constant	2.89***	3.10***	0.91**	1.00**
	(0.94)	(0.90)	(0.42)	(0.43)
R squared	0.16	0.21	0.20	0.21
F-test for model	2.90***	3.06***	4.59***	3.92***
F-test for R squared change		2.87**		1.28
N observations	233	233	233	233

Note: (1) Main effects model with 'importance of innovation collaboration with clients' as the dependent variable.
(2) Full specification model with 'importance of innovation collaboration with clients' as the dependent variable.
(3) Main effects model with 'importance of innovation collaboration with all other partners' as the dependent variable.
(4) Full specification model with 'importance of innovation collaboration with all other partners' as the dependent variable.
* significant at the 10% level.
** significant at the 5% level.
*** significant at the 1% level.

Third, regression results suggest a significant inverted U-shaped relation between the importance of innovation collaboration with all other partners and the importance of *contractual* appropriability mechanisms (column 4 in Table 4). Fig. 5 depicts this relationship: the importance of innovation collaboration peaks around the mean importance of contractual appropriability mechanisms. Our results suggest that the importance of innovation collaboration rises initially with the importance of contractual appropriability mechanisms, but declines when firms' emphasis on contractual appropriability mechanisms exceeds the mean value. Thus, high levels of emphasis on contractual appropriability mechanisms are associated with a decreasing importance of innovation collaboration with partner organisations other than clients. We treat this finding with caution, however. Although we obtain a significant negative coefficient for the importance of contractual appropriability mechanisms squared, the inclusion of the squared terms does not improve significantly the overall fit of our model to the data in the regression of collaboration with all other partners (see F-test for the change in R-squared).

Fourth, we find a significant positive coefficient for the squared term of the importance of *strategic* appropriability mechanisms in the regression model where the dependent variable is the importance of collaboration with clients (column 2 in Table 4). Thus, innovation collaboration with clients is more important when firms place either low or high levels of emphasis on strategic appropriability mechanisms. This U-shaped relation is depicted in Fig. 6. Again, however, this result should be treated with caution due to the wide 90% confidence intervals at low and high levels of emphasis on strategic appropriability mechanisms.

Finally, our results show that there is a significant positive association between higher R&D investments and the importance of innovation collaboration with other external partners (suppliers, competitors, consultants, commercial labs, or private R&D institutes, universities and government or public research institutes). This finding is in line with the existing literature (e.g., Laursen and Salter, 2014; Mina et al., 2014), and therefore increases our confidence in the survey results.

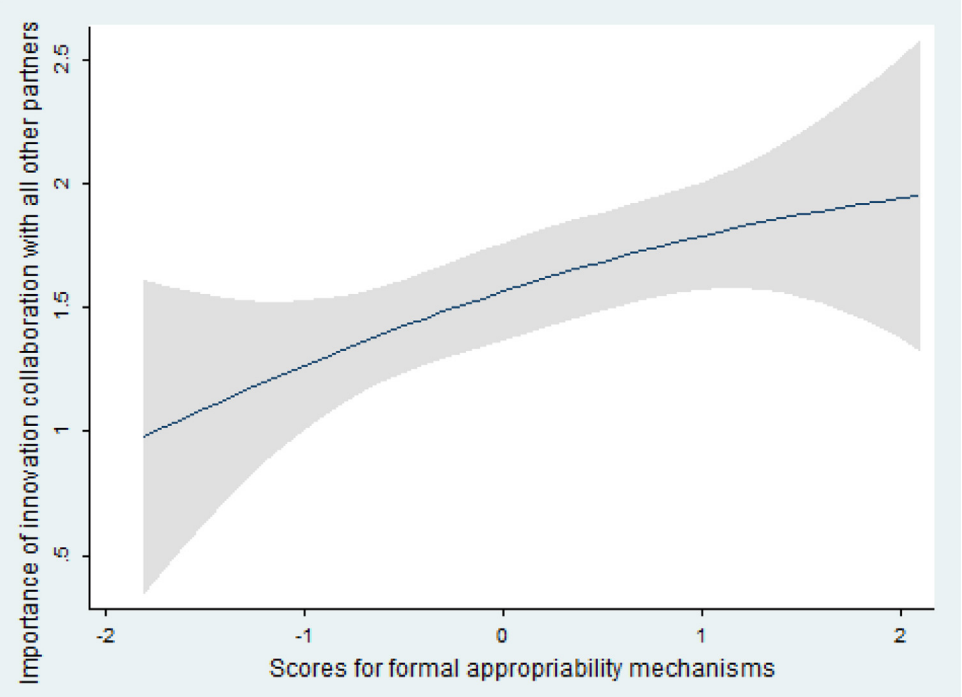

Fig. 3. Association between predicted importance of innovation collaboration with all other partners and emphasis on formal appropriability mechanisms.
Note: (1) Grey area indicates 90% confidence intervals. (2) The group 'all other partners' includes suppliers, competitors, consultants, commercial labs, or private R&D institutes, universities, and government or public research institutes.

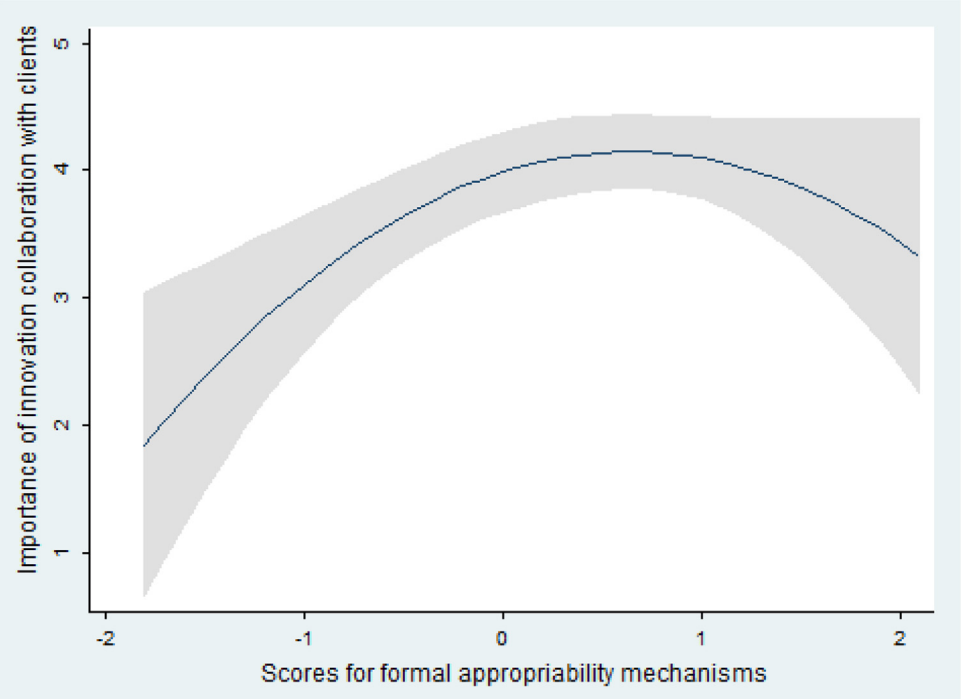

Fig. 4. Association between predicted importance of innovation collaboration with clients and emphasis on formal appropriability mechanisms.
Note: Grey area indicates 90% confidence intervals.

5. Discussion and conclusions

Our study contributes to the understanding of the relation between collaboration for innovation and appropriability strategy for knowledge-intensive business services firms in several ways. First, our findings uncover a "paradox of formal appropriability mechanisms" in the case of KIBS firms. On the one hand, both the existing literature and our own sample firms show that KIBS firms do not regard *formal* appropriability mechanisms as the most effective methods for protecting their innovations from copying or imitation by competitors, or for otherwise capturing value from their innovation (Andersen and Howells, 2000; Hipp, 2008; Samuelson, 2010). On the other hand, however, our research reveals a positive association between the importance of formal

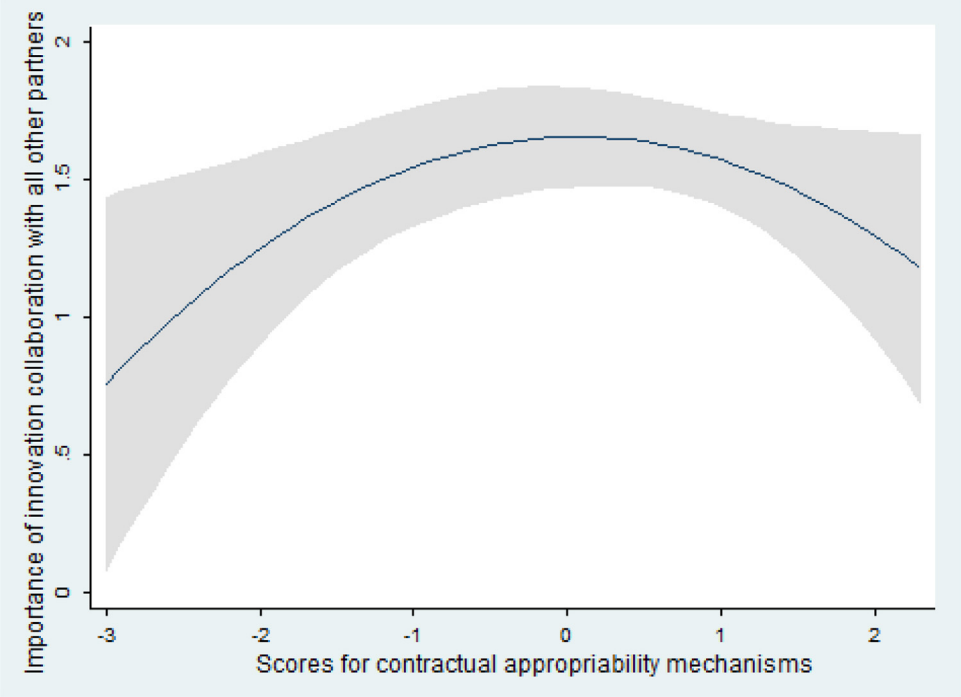

Fig. 5. Association between predicted importance of innovation collaboration with all other partners and emphasis on contractual appropriability mechanisms.
Note: (1) Grey area indicates 90% confidence intervals. (2) The group 'all other partners' includes suppliers, competitors, consultants, commercial labs, or private R&D institutes, universities, and government or public research institutes.

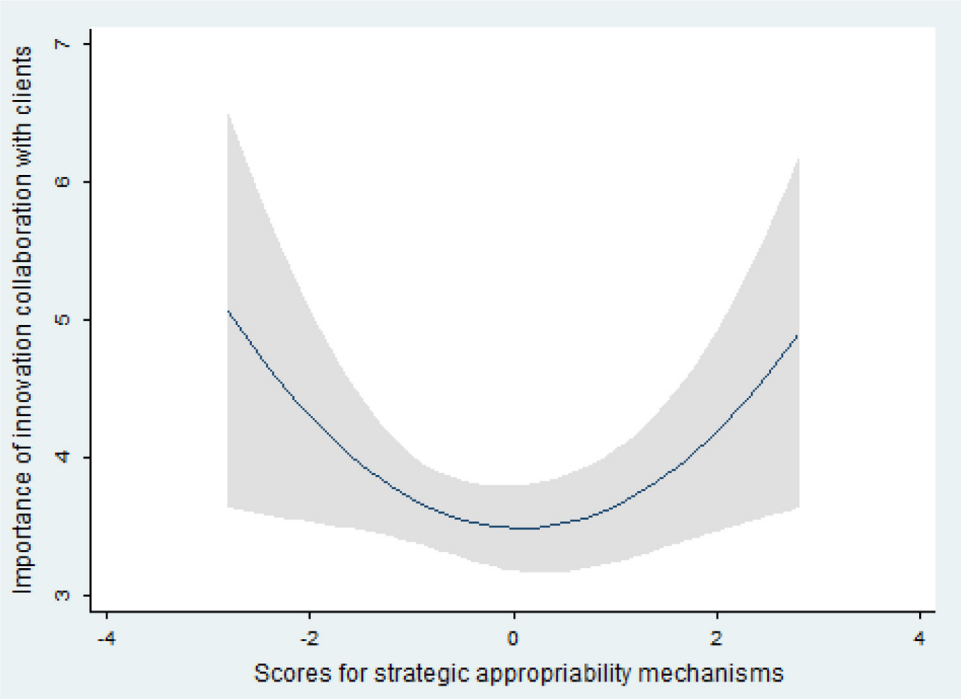

Fig. 6. Association between predicted importance of innovation collaboration with clients and emphasis on strategic appropriability mechanisms.
Note: Grey area indicates 90% confidence intervals.

appropriability mechanisms and that of innovation collaboration by KIBS firms. This suggests that for KIBS firms, for which joint knowledge creation and transfer, especially with clients, is the norm (Bettencourt et al., 2002; den Hertog, 2000), the use of formal appropriability mechanisms can facilitate knowledge exchange, by providing a clear framework for what is shared and what is private knowledge.

Second, our research builds on earlier work showing the existence of a concave relation between innovation collaboration and importance of appropriability strategies for manufacturing firms (Laursen and Salter, 2014), and extends this for KIBS firms. We find that the importance of innovation collaboration with clients goes hand-in-hand with the importance of formal appropriability mechanisms, although a negative relation appears when firms assign

very high importance to formal appropriability mechanisms. Collaboration for innovation with clients is crucial both at the early stage of the creation of innovation (Love et al., 2011) and at the final stage of project implementation (Dyer and Singh, 1998; Lehrer et al., 2013). It may be the case that modest levels of emphasis on formal appropriability mechanisms may prevent conflicts over ownership of co-produced knowledge assets and knowledge leakages (or even provide signals for potential partners).

Our results are also consistent with the view that very high levels of emphasis on these mechanisms can act as a barrier to important knowledge exchanges (especially regarding partly tacit knowledge) at the stages of the project definition and implementation required for the development of innovation by KIBS firms in the course of specific projects with clients. For example, tight control of knowledge assets through strict rules by legal departments, intended to ensure the patentability of future inventions, can limit incentives to exchange and transfer knowledge and co-develop innovations by either KIBS firms or their clients (Alexy et al., 2009; Leiponen, 2008). It must be acknowledged that an alternative interpretation for the U-shaped association uncovered may be some heterogeneity in firm behaviour between leading innovators and followers (Arora et al., 2016). The explanation would be that leading innovators may be more likely to stress formal appropriability mechanisms in order to prevent knowledge leakages, but may not value strongly innovation collaboration. Further empirical investigation, however, indicated that this is unlikely to be the dominant explanation driving the negative part of the estimated association for our sample of KIBS firms.[10]

This inverted U-shaped relation may also hold for the relation between the importance of collaboration for all other partners and that of *contractual* appropriability mechanisms. Contractual appropriability mechanisms are regarded in the literature and by our own sample firms as the most important methods of capturing value from innovation for KIBS (Leiponen, 2008; Miles et al., 2000). When used in modest amounts, contractual appropriability mechanisms appear to be very effective in the governance and control of innovation collaboration with external partners (Poppo and Zenger, 2002). But high levels of emphasis on contractual appropriability mechanisms (e.g. by having very restrictive clauses on exclusivity, excessive secrecy, or barriers to labour mobility, such as non-compete clauses) may be associated with less willingness to undertake collaboration with external partners for innovation, or act as a barrier to knowledge creation and transfer. Excessive secrecy, complex confidentiality agreements (difficult due to the intangibility of the service) and contracts limiting mobility of employees to competitors for a long period after they leave the company, may create suspicion and erect barriers to collaboration with external organisations, such as competitors or research organisations (which could conceivably "poach" those valuable high-skilled professional employees).

Third, our research sheds light on the importance for innovation collaboration by KIBS firms of formal, contractual and strategic appropriability mechanisms. Besides the inverted U-shaped relations described above, we also find that innovation collaboration with clients is more important when *strategic* appropriability mechanisms are either of low or high importance. The finding that achieving a favourable position in terms of specialised complementary assets, lead-time advantages and service design complexity may facilitate collaboration with clients to co-produce new service offerings is well documented in the literature (Desyllas and Sako, 2013; Teece, 1986). Nevertheless, the finding that a low emphasis on strategic appropriability mechanisms is associated with placing high importance on collaboration with clients requires explanation. It is possible that there may be interaction effects, which could be explored in further research. It may be the case that, when the formal appropriability regime is relatively strong, innovators may be able to rely less heavily on strategic appropriability mechanisms.

The finding of the relation between higher R&D investments and high importance of innovation collaboration with external partners may be interpreted in terms of the concept of absorptive capacity (Cohen and Levinthal, 1990). Firms that are more active in R&D may be more capable of translating external knowledge into internal capabilities, more knowledgeable about how to manage inter-organisational collaboration for innovation, and better positioned to develop a more adequate appropriability strategy.

Thus, our theoretical and empirical contributions suggest that innovation features that are "heightened" in KIBS firms, including the continuous transfer of knowledge in collaboration with other organisations (especially clients) and the reliance on highly-skilled graduates, has to be accompanied by a careful strategy for protecting the firm's knowledge. Our study demonstrates the importance of formal, contractual and strategic appropriablity in the context of innovation collaboration for KIBS firms. It also may suggest that very high levels of emphasis on such mechanisms can undermine the trust and reciprocity needed in (tacit) knowledge transfer or complex development in innovation collaboration, or reduce incentives to collaborate. We conclude that KIBS firms need to be aware that the choice of the type of appropriability mechanisms should take into account the possible implications that such choices may have on the capacity of the firm to exchange knowledge and collaborate for innovation with different external partners.

The findings from this study indicate that KIBS firms' managers should not overlook the important role of appropriability mechanisms (including formal mechanisms, such as patents) when collaborating for innovation, especially with clients. Admittedly, the study set out to explore associations (and not causal relationships) between appropriability strategy and innovation collaboration. Nevertheless, a possible interpretation of our findings is that managers should account for the importance of collaborative relationships (and with different partners) for the success of an innovative project; and that this criterion should be an integral part of the firm's intellectual property strategy and management.

Our findings also have implications regarding the development of a deeper understanding of innovation in services. Some KIBS firms play central roles in innovation processes throughout the economy, as sources of innovations, agents of transfer and diffusion of knowledge, or innovation support for other sectors. Our results pave the way for a better understanding of both inter-organisational collaboration for innovation and the role of the functioning of the intellectual property rights system for KIBS firms.

Finally, the results contribute to the understanding of firm appropriability strategy and innovation collaboration, especially in sectors where formal appropriability mechanisms (such as patents) are regarded as playing a less important role in capturing rents from innovation. The results also offer new insights on the choices of appropriability mechanisms and innovation collaboration in sectors where tacit knowledge exchanges, especially with clients, are very frequent and important for innovation. This is ever more

[10] Our regression results (column 2 in Table 4) show that the number of innovations introduced by firms is positively associated with firms' perception of the importance of innovation collaboration with clients (the coefficient is about 0.005 if we report the estimate up to 3 digits). Furthermore, we repeated the regression (using column 2 specification in Table 4) adding an extra control variable '*percentage of last year's income from innovation*' as an additional proxy for innovation leadership. The regression results (not reported here) were in line with the existing findings, i.e., inverted U-shaped association between importance of innovation collaboration with clients and the importance of formal appropriability mechanisms). We also obtain a positive and statistically significant coefficient ($p < 0.1$) for the added variable. The results suggest a positive association between KIBS firms' innovativeness and the importance assigned to collaboration with clients for innovation.

significant, as manufacturing firms shift from selling products to selling product-service systems (Neely, 2008).

6. Limitations and future research

As with all empirical research, this study is subject to limitations, and these should be acknowledged. Our dependent and independent variables focus on the perceived importance of organisational actions, processes and practices; we implicitly assume that this is associated with actual organisational practices and behaviour. There is some evidence of broad consistency between our sample firms' perceived importance of patents as means of value capture from innovation and their actual patenting activity. But the possibility that the proxies only measure perceptions and mental models of the interviewees of our sample firms, as opposed to reflecting the firms' actual behaviour, should be acknowledged.

In addition, firms that did not introduce any innovation between 2009 and 2011 are excluded from the analysis. Thus, the paper addresses the relationship between appropriability mechanisms and innovation collaboration only for firms that have introduced innovations. We acknowledge, however, that some firms might collaborate with external partners and use the various appropriability mechanisms for the governance of the relationship but fail to introduce innovations. We can not comment on the role that appropriability mechanisms play in such a relationship.

Further research, using different indicators and set in different empirical contexts, is needed to strengthen confidence in, and deepen our findings. For instance, the role played by appropriability mechanisms in innovation collaboration when firms fail to introduce innovations could be explored. Another possibility is to explore whether KIBS leaders and followers have different behaviour in terms of appropriability mechanisms and collaboration for innovation (see Arora et al., 2016).

Moreover, future research needs to analyse further the underlying mechanisms that explain the distinctive patterns of firms' appropriability strategies and innovation collaboration that this study has uncovered. This is likely to require in-depth studies of the ways in which firms make the strategic choices that we have begun to unveil. Further studies could uncover in more detail the characteristics, strengths and disadvantages of each of the different types of appropriability mechanisms – formal, contractual and strategic – in the context of KIBS firms when collaborating with clients and other external partners.

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Appendix A.

Table A1
Assessing non-response bias using the characteristic comparison method.

	Non-respondents Count (Column percentage)	Respondents Count (Column percentage)	Total Count (Column percentage)
CHI-SQUARE TEST FOR INDEPENDENCE			
Country			
UK	314	92	406
	(15.13%)	(41.26%)	(17.67%)
US	1761	131	1892
	(84.87%)	(58.74%)	(82.33%)
Total	2075	223	2298
	(100%)	(100%)	(100%)
Pearson chi2(1) = 94.466; $p = 0.000$			
Industrial sector (2-digit SIC code)			
48	118	12	130
	(5.69%)	(5.38%)	(5.66%)
60	547	45	592
	(26.36%)	(20.18%)	(25.76%)
62	136	15	151
	(6.55%)	(6.73%)	(6.57%)
63	110	11	121
	(5.30%)	(4.93%)	(5.27%)
67	264	21	285
	(12.72%)	(9.42%)	(12.40%)
73	618	85	703
	(29.78%)	(38.12%)	(30.59%)
87	159	22	181
	(7.66%)	(9.87%)	(7.88%)
Others	123	12	135
	(6.00%)	(5.38%)	(5.87%)
Total	2075	223	2298
	(100%)	(100%)	(100%)
Pearson chi2(7) = 10.770; $p = 0.149$			
MEANS TEST COMPARISON			
Firm size (the number of employees)			
Observations	2075	223	
Mean	3897.15	11968.21	
SE	448.62	3735.29	
t(2296) = −4.3982; $p = 0.000$			

Table A2
Number of granted patents per firm by "perceived patent significance" class.

	Perceived significance of patents for value capture [1–5]				
	All sample US firms	[1–2)	[2–3)	[3–4)	[4–5]
Firm number	88	33	10	22	23
Mean patent number	37.6	0.1	1.1	20.1	124.0
St.dev. patent number	217.8	0.7	2.6	85.2	412.0

Notes: patents granted to sample US firms during the period 2007–2011 were collected from Derwent patent database.

Appendix B. : Survey data quality

An implicit assumption inherent in our empirical measures of the variables is that the perceived importance of organisational actions, processes and practices reflects, lead to, or at least are associated with, actual organisational practices and behaviour. However, one should acknowledge the possibility that our proxies only measure perceptions and mental models by the interviewees of our sampled firms as opposed to actual behaviour. In order to get a sense of the possible differences between perceptions and actions, we carried out a more detailed analysis of patenting behaviour in firms. For this purpose, we collected information from the Derwent patent database on the actual number of patents granted to our sample US firms during the period 2007–2011 and compared it with their recorded scores of perceived significance of patents as value appropriation mechanisms. As can be seen from Table A2, the average number of patent grants is indeed monotonically increasing with the recorded score of perceived patent significance, although there is considerable variation in patent numbers across firms within groups. Of course, one should not expect a one-to-one correspondence between the reported patent significance score and the recorded number of patents, since a small number of patents may have been critical to the capturing of returns from innovation. So at least in the case of patenting, there seems to be a fair degree of consistency between perceived importance and actual reliance on patents. Furthermore, to assess common method bias arising from self-reported measures, we applied Harman's (1967) one factor test. Un-rotated factor analysis of variables that are used in the analysis resulted in 12 factors with an eigenvalue greater than 1, thus common method bias can be regarded as insignificant in this study (Podsakoff and Organ, 1986).

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