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Which types of knowledge-intensive business services firms collaborate with universities for innovation?

Hsing-fen Lee[a,*], Marcela Miozzo[b]

[a] Middlesex University London, Middlesex University Business School, The Burroughs, Hendon, London, NW4 4BT, UK
[b] King's College London, King's Business School, Bush House, 30 Aldwych, London, WC2B 4BG, UK

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ABSTRACT

Drawing on data from an original survey of UK and US publicly traded knowledge-intensive business services (KIBS) firms, we investigate what types of KIBS firms collaborate with universities and consider the collaboration important for their innovation. First, we find that science-based KIBS firms (those engaged in a science, technology, and innovation [STI] mode of organizational learning), like science-based manufacturing firms, are active collaborators with universities for innovation. This relationship is further enhanced if these firms also provide highly customized services. Second, in contrast to the existing literature suggesting that firms engaged in a doing, using, and interacting (DUI) mode of organizational learning do not regard collaboration with universities as important for their innovation, we find that KIBS firms engaged in a DUI mode of organizational learning and offering highly customized services are active collaborators with universities for innovation, despite the fact that they may not possess highly formalized scientific knowledge. These findings suggest that KIBS firms co-create knowledge with universities differently than manufacturing firms. Moreover, the findings highlight the wide variety of roles that KIBS firms play in innovation networks with universities.

1. Introduction

Recent research stresses the growing relevance of external sources of knowledge for innovation and the opening up of organizational boundaries of firms to collaborate for innovation (Chesbrough, 2003; Laursen and Salter, 2014). These contributions provide evidence of the increasingly distributed and "interactive" process of innovation rooted in knowledge generation and diffusion. The growth of inter-organizational collaboration for innovation between industrial organizations and universities (Freitas et al., 2013; Perkmann and Walsh, 2007) provides important evidence of such a process. Indeed, the impetus behind the innovation collaboration between industry and universities is the result of both shifts in legislation, such as the introduction of the Bayh-Dole Act in the USA (Mowery et al., 2004) and similar legislation in other countries, and policy pressure for universities to contribute to national competitiveness (Wilson, 2012). Manifestations of the growing importance of such collaborations include the diffusion and growth of technology transfer offices (Siegel et al., 2003), the rise in patenting by universities (Nelson, 2001), and the increased revenues earned by universities from licensing (Thursby and Thursby, 2002).

This paper addresses an area that is overlooked in the existing literature. Even though the service sector accounts for over 70% of economic growth and employment across OECD countries and this growth relies notably on the expansion of knowledge-intensive business services (KIBS)[1] (OECD, 2015), our understanding of the external sources of knowledge and of collaboration patterns for innovation for services firms and KIBS firms remains limited. In particular, we know very little about which types of services firms—and especially which types of KIBS firms—collaborate with universities.

A growing stream of research has begun to explore the innovation collaboration patterns of services firms, especially those of KIBS (Chesbrough, 2011; Love et al., 2011; Miozzo et al., 2016). Despite acknowledging the diversity of roles played by KIBS in systems of innovation (Howells, 2006; Miles et al., 1995; Muller and Zenker, 2001), often as innovation "bridges" for industrial organizations (Czarnitzki and Spielkamp, 2003), and acknowledging the need for KIBS firms to access sophisticated technologies and infrastructure (Miozzo and Soete, 2001), the findings on the patterns and importance of innovation collaboration between services firms and universities conflict. Some contributions argue that services/KIBS firms regard universities as a less important source of innovation when compared to manufacturing firms (Howells et al., 2012; Love et al., 2011; Rodriguez et al., 2017), yet

* Corresponding author.
E-mail address: h.lee@mdx.ac.uk (H.-f. Lee).

[1] KIBS are services that rely heavily on technical or professional knowledge to solve the problems of their clients (Miles et al., 1995).

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others argue the contrary (Mina et al., 2014; Segarra-Blasco and Arauzo-Carod, 2008). One problem that obfuscates our understanding of these patterns of innovation collaboration is that services firms (and KIBS firms) are very diverse. This means that it is very difficult to make generalizations about their innovation behavior, let alone their innovation collaboration patterns.

We suggest that further light can be shed on these conflicting results by exploring the relation between KIBS firms' knowledge base and modes of organizational learning and their collaboration with universities for innovation. Studies argue that firms whose organizational learning is based on the application of formalized scientific knowledge (that is, the science, technology, and innovation [STI] mode of organizational learning) are associated with innovation collaboration with universities, while those whose learning is grounded in interactions that mobilize tacit knowledge (that is, the doing, using, and interacting [DUI] mode of organizational learning) are associated instead with collaboration along the supply chain or with competitors (Fitjar and Rodríguez-Pose, 2013; Jensen et al., 2007; Parrilli and Heras, 2016). Interrogating the different types of organizational learning modes of KIBS firms can offer valuable insight, since KIBS firms vary in certain important dimensions, including their human resources (Consoli and Elche-Hortelano, 2010; Miles et al., 1995) and their approach to innovation and value creation (Evangelista, 2000; Miozzo and Soete, 2001).

This paper addresses the debate on the extent to which universities are important innovation partners for KIBS firms. Rather than exploring answers to a dichotomous question of whether universities are or are not important innovation partners for KIBS firms, we ask what types of KIBS firms collaborate with universities by looking into how the characteristics of the knowledge base of different KIBS firms and their modes of organizational learning affect their innovation collaboration with universities and its importance. We draw on an original survey of 202 publicly traded KIBS firms in the UK and the USA and hypothesize that the characteristics of their knowledge base and their organizational learning mode affect their innovation collaboration patterns with universities. Our research takes into account the heterogeneity of KIBS firms and highlights the wide variety of roles that these firms may play in innovation networks with universities. We thus address simultaneously the calls for a better understanding of firms' constraints in accessing academic knowledge (Filippetti and Savona, 2017), for more research into service innovation (Biemans et al., 2016), and for how organizations in an open service innovation system can co-develop effectively (Storey et al., 2016).

The paper is organized into five sections. The next section reviews the literature and derives the hypotheses. The third section reports the data and methods of analysis. The fourth section outlines the findings. The fifth section contains the discussion and conclusion.

2. Theoretical framework

One stream of research shows that organizations that are able to process science-based knowledge collaborate successfully with universities. Moreover, studies show that collaboration with universities is more important for firms in science-based industries (e.g., chemical, biomedical, and computer industries) than for those in other sectors (Asheim and Coenen, 2005; Meyer-Krahmer and Schmoch, 1998; Schartinger et al., 2002). This is supported by research that shows that firms interact with universities for technological competence building or to gain access to cutting-edge scientific knowledge and technologies (Ankrah et al., 2013; Santoro and Chakrabarti, 2002). Indeed, firms that actively pursue formalized R&D activities are more likely to use knowledge from universities for innovation (Fitjar and Rodríguez-Pose, 2014; Jensen et al., 2007; Laursen and Salter, 2004). These studies, however, are largely based on evidence from firms in the manufacturing sector and high-tech industries in particular.

KIBS firms, like universities, are knowledge users, carriers, and producers (Miles et al., 1995). The growth of KIBS firms and their role in their clients' innovation is regarded as an important indicator of the increasingly distributed nature of the innovation process (Gallouj, 2010).[2] KIBS firms not only innovate for their own development but also co-create innovation with clients in various sectors. There is ample evidence to show that KIBS firms support the innovation process of manufacturing firms, including small and medium-sized firms, through knowledge generation and diffusion (Ciriaci et al., 2015; Muller and Zenker, 2001), and they also support the innovation process of organizations in the public sector (Windrum, 2013). Indeed, KIBS firms, together with universities, are identified as key players in the consultancy market (Bessant and Rush, 1995), and there are potential complementarities in supporting regional development (Pinto et al., 2015).

Little is known, however, about the nature of the interactions between KIBS firms and universities. The few studies that explore this yield conflicting results. On the one hand, one study shows that services firms are less likely than manufacturing firms to rate universities as important innovation partners (Howells et al., 2012). Other studies show that the interaction between KIBS firms and universities does not contribute to improved innovation performance in KIBS firms (Love et al., 2011) and is even associated negatively with the innovation performance of such firms (Rodriguez et al., 2017). On the other hand, Mina et al. (2014) point out that collaboration with universities and research organizations is particularly important for business services firms. Segarra-Blasco and Arauzo-Carod (2008) report that KIBS firms are more likely than other firms to collaborate with universities for innovation. Regardless of the conclusions they draw regarding the importance of innovation collaboration with universities, these studies tend to consider services/KIBS firms as a homogeneous sector (see also Djellal and Gallouj, 2010), which may be problematic as different KIBS sub-sectors may have different patterns of innovation collaboration with universities.

Our understanding of innovation collaboration between KIBS firms and universities faces additional challenges. Unlike high-tech manufacturing firms, with a few exceptions, services firms do not have well-defined R&D departments governed by scientific research norms, which are argued to facilitate the effective absorptive capacity of knowledge from universities. Also, they may not have well-developed network career models across universities and industry (Lam, 2011). In contrast to many manufacturing firms (while recognizing that certain manufacturing and services sectors may be converging), innovation by services firms typically requires the effective management of client and network relationships, tacit knowledge, and tailored expert solutions (Drejer, 2004). Employees' discretion and cognitive ability to provide solutions to client problems, where the goals may be well defined but problem-solving strategies more inductive, are particularly critical (Consoli and Elche-Hortelano, 2010). These features raise questions about the extent to which formalized scientific knowledge from universities may be directly (or indeed the only) relevant knowledge for innovation in many KIBS firms.

In the following section, we discuss the characteristics of service innovation and their implications for innovation collaboration between KIBS firms and universities.

2.1. Heterogeneity in the knowledge base of KIBS firms

In this section, we combine insights from the literature on service innovation and modes of organizational learning to explore the heterogeneity of KIBS firms. We suggest that firms with different

[2] Gallouj (2010) refers to this as the "Schumpeter III" model of innovation. This involves a shift from the conventional entrepreneurial model (Schumpeter I) and the corporate R&D-dominated model (Schumpeter II) to the professional services dominated model of innovation.

knowledge bases and different modes of organizational learning may reveal different patterns of innovation collaboration with universities.

2.1.1. Formalized scientific knowledge in KIBS firms

Scholars of service innovation discuss the differences in innovative services firms and their approaches to innovation. Miozzo and Soete (2001) distinguish between "science-based," "scale-intensive," and "supplier-dominated" services firms. The distinction between the three types of firms is based on their technological trajectories, sources of innovation, and means of appropriability. Science-based firms comprise firms in sectors such as software and specialized business services. They innovate through product differentiation and in-house R&D. Their target users are sensitive to performance. In contrast, scale-intensive services comprise firms in sectors such as financial services, insurance, and telecommunications (whose operations depend on information networks) and transport and wholesale trade (whose operations depend on large-scale physical networks). The users of these scale-intensive services firms are price sensitive. Supplier-dominated firms, such as personal services, rely on suppliers for innovation. Alternatively, Miles et al. (1995) distinguish between technology-related KIBS (T-KIBS) and professional services (P-KIBS) based on occupational classifications. T-KIBS comprise firms in sectors such as IT services, engineering services, and R&D services, which require specialized scientific and technical knowledge. These firms' employees possess formal scientific qualifications, since their job tasks require the application of formalized scientific knowledge. P-KIBS firms include accountancy, market research, legal services, financial services, and personnel services, which may not be technology based but they can be intensive users of new technology.

Existing studies point out that there are similarities in terms of the way knowledge is produced and in the role in economic development of "science-based" and "technology-related" KIBS firms, on the one hand, and manufacturing science-based firms, on the other. The innovation processes of science-based/technology-related KIBS firms align with the literature on scientific research that highlights the importance of creativity and autonomy for research and invention (Stephan, 1996). Based on in-depth case studies of design services firms, Lehrer et al. (2012) argue that although client co-creation for service innovation is vital, KIBS firms may require certain autonomy and limited input from clients at the stage of generating creative ideas in order to be innovative. Services provided by R&D services firms also seem to cover those of a typical manufacturing firm's R&D department. For instance, Probert et al. (2013) show how R&D services firms provide solutions for clients, from contract research to product development. Similarly, Castellacci (2008) proposes a sectoral taxonomy outlining the sources of knowledge of several sectors and suggests that some KIBS firms—particularly IT services firms, R&D services firms, engineering services firms, and consultancy firms—perform functions similar to those of high-tech specialist suppliers in manufacturing and act as knowledge providers to firms in other sectors.

This suggests that some KIBS firms that use highly formalized scientific knowledge and carry out R&D activities may have a mode of organizational learning that resembles what Jensen et al. (2007) call a science, technology, and innovation (STI) mode of organizational learning. This places an emphasis on formalized knowledge and on "knowing why." The more scientific knowledge stock that a firm possesses, the greater its capability to identify, assimilate, create, develop, and accumulate knowledge (Cohen and Levinthal, 1990). Apart from highly formalized in-house R&D activities to develop and incorporate scientific understanding in the context of firms' innovation activities, characteristics of the STI mode of organizational learning include the use of highly skilled scientific human resources to perform relevant R&D activities (Jensen et al., 2007). Firms pursuing an STI mode of learning have been shown to engage in innovation collaboration with universities (Fitjar and Rodríguez-Pose, 2013; Jensen et al., 2007; Parrilli and Heras, 2016).

Indeed, many science-based/technology-related KIBS firms have internal R&D units with staff holding PhD-level qualifications (The Royal Society, 2009), and there is evidence of formalized research collaborations occurring between such KIBS and universities. Based on official data on Knowledge Transfer Partnerships (KTPs)[3] funded jointly by the UK government and industry, it is estimated that around 19% of the current partnerships are between KIBS firms and universities. Among these, the majority of the partnerships are between science-based/technology-related KIBS and academic partners in science and engineering departments.[4] Furthermore, Bruneel et al. (2009) report that 37% of firms that responded to their survey of firms involved in projects funded by the Engineering and Physical Sciences Research Council (EPSRC)[5] were KIBS firms. In addition to carrying out joint research, many of the EPSRC-funded projects were associated with the establishment of Centres for Doctoral Training (CDT)[6] sponsored by KIBS firms to cultivate doctoral talent in emerging technologies that are expected to bring about radical innovations in the KIBS sector.[7]

In sum, the existing literature suggests that firms whose knowledge base comprises highly formalized science-based knowledge collaborate for innovation with universities and benefit from such collaboration. It also points out the similarities in how knowledge is produced and in the roles in economic development of science-based/technology-related KIBS firms and science-based manufacturing firms. Empirical evidence of such collaborations exists. From this, we thus derive the following hypothesis:

H1. *There is a positive association between KIBS firms' orientation toward an STI mode of organizational learning (i.e., science-based/technology-related KIBS firms) and the importance of collaboration with universities for innovation.*

2.1.2. Doing, using, and interacting by KIBS firms

For many innovative KIBS firms, possessing the ability to articulate formalized scientific knowledge is neither sufficient nor necessary to fulfill their organizational goals. This is because service innovation in KIBS firms can take the form of unique client solutions (ad hoc innovation), newly developed expertise (new expert-field innovation), or the application of new methods and techniques to make service outputs more explicit and tangible (formalization innovation) (Gadrey and Gallouj, 1998). Sometimes, services firms develop innovation through the reflection of practices gradually co-created with their clients and will make an effort to replicate this in other contexts (Toivonen and Tuominen, 2009). Services firms can also be involved in bricolage as a form of innovation by doing things differently through making adjustments to their protocols using existing resources (Fuglsang and Sørensen, 2011). All these contributions indicate that the knowledge and skills required for service innovation extend beyond the application

[3] A Knowledge Transfer Partnership is partly funded by the UK government and partly by an industrial partner. The partnership then involves the industrial partner, a research student, and a higher/further education institution. It is designed to foster direct knowledge transfer from academia to industry through the placement of the research student in the industrial partner with the supervision of the academic partner. More information is available online at: http://ktp.innovateuk.org/ (accessed on 9 Feb. 2019).

[4] We estimated these figures based on the database of current KTPs available online, with partnerships that have partner firms' SIC code information available. The database is available online at: https://info.ktponline.org.uk/action/search/current.aspx (accessed on 9 Feb. 2019).

[5] EPSRC is the UK's main funding agency for research in engineering and physical sciences.

[6] Each CDT offers thematic PhD scholarships and students are expected to have an industrial collaborator and to spend a considerable time in the company during the doctoral training. More information is online available at: http://www.epsrc.ac.uk/skills/students/centres/ (accessed on 9 Feb. 2019).

[7] An example is the UCL DTC in Financial Computing and Data Sciences based at the Computer Sciences Department. Information is available at: https://financialcomputing.org/ (accessed on 9 Feb. 2019).

of formalized scientific knowledge or the recruitment of highly qualified scientific personnel. Indeed, Consoli and Elche-Hortelano (2010) demonstrate the critical role of non-routine cognitive staff skills for KIBS, such as active learning and listening, complex problem-solving and decision-making, coordination, and critical thinking. Others highlight KIBS firms' ability to integrate knowledge from clients, suppliers, and multiple business units for problem-solving (Aarikka-Stenroos and Jaakkola, 2012; Gardner, 2015; Miozzo et al., 2012; Pino et al., 2016). Therefore, alternative learning mechanisms other than formalized R&D activities or the recruitment of scientific human resources must be in place in order to facilitate such capabilities for innovation.

Many KIBS firms are engaged in what can be called a doing, using, and interacting (DUI) mode of organizational learning (which is facilitated through network interactions, learning by doing, and experience) and flexible organizational structures to enhance collective and interdisciplinary learning (Jensen et al., 2007). Firms with a DUI mode of organizational learning focus on fostering the capabilities of "knowing how" and "knowing who" for innovation. Because the DUI mode of organizational learning aims at mobilizing tacit knowledge and cultivating cognitive skills, it is argued to be more effective for stimulating non-technological innovation (Parrilli and Heras, 2016). This mode of learning stresses the development of skills needed for solving client problems through effective coordination among team members, suppliers, and internal business units. Unique and innovative client solutions are often the result of capitalizing on the ability to recognize and integrate knowledge from multiple business units with a plurality of skills (Gardner, 2015; Miozzo et al., 2012) and to develop interactions with clients, suppliers, and other actors in the supply chain (Fitjar and Rodríguez-Pose, 2013).

The existing literature (which is mostly concerned with manufacturing firms) suggests that firms with a DUI mode of organizational learning may not engage in innovation collaboration with universities but rather collaborate with firms in the supply chain and internal business units because of their lack of focus on formalized scientific knowledge (Fitjar and Rodríguez-Pose, 2013; Jensen et al., 2007; Parrilli and Heras, 2016). There are indications, however, that KIBS firms that actively engage in a DUI mode of organizational learning may also find collaboration with universities important for their innovation. First, for many KIBS firms outside of the science-based sectors, one of the most important sources of technological innovation is collaboration with specialized suppliers of technology and infrastructure (Miozzo and Soete, 2001). For instance, financial services firms often utilize technological innovations rooted in other sectors. It is possible that to gain access to external cutting-edge technologies from innovators in different fields (including universities), engaging in a DUI mode of organizational learning by these firms may be useful to overcome barriers to collaboration given the differences in their knowledge bases. Indeed, there is evidence to show that financial services firms work closely with universities not only to gain access to talented graduates but also to gain access to technologies in internet security and artificial intelligence.

Second, we know from the service innovation literature that KIBS firms can act as "bridges for innovation" in systems of innovation (Czarnitzki and Spielkamp, 2003), helping other firms/organizations to innovate (Ciriaci et al., 2015; Muller and Zenker, 2001; Windrum, 2013). Thus, there is reason to believe that KIBS firms may also act as intermediaries in universities' knowledge commercialization activities (Wright et al., 2008). Indeed, by analyzing the collaborative projects of innovation partnerships among firms, public research organizations, and universities, Howells (2006) reveals the diversity of KIBS firms' intermediary functions, as they assist in both the upstream (e.g., intelligence) and downstream (e.g., IP protection and commercialization) innovation activities of their clients and support their clients' diversification into new industries and their entry into new markets. KIBS firms might also be partners in research programs with universities and contribute with aspects of the knowledge development tasks (OECD, 2006), or they may maintain informal contacts with universities to source complementary knowledge (Jakobsen and Lorentzen, 2015). This suggests that the nature of the collaboration between KIBS firms and universities can be very complex. In these collaborations, universities may not only or always play the role of problem-solvers for KIBS firms. When KIBS firms collaborate with universities, KIBS firms may also contribute their expertise as innovation partners or act as important innovation intermediaries for universities. In that case, the issue may not be whether KIBS firms can internalize the solutions resulting from the scientific knowledge produced in universities but whether the firms are able to network effectively with universities.

Therefore, for KIBS firms, engaging in a DUI mode of organizational learning to maintain the relationships within their networks may also facilitate effective collaboration with universities, whether the nature of their interaction with universities is to access technologies, to act as innovation intermediaries, or for informal networking. Hence, we derive the following hypothesis:

H2. *There is a positive association between KIBS firms' orientation toward a DUI mode of organizational learning and the importance of collaboration with universities for innovation.*

2.2. KIBS firms' approaches to value creation

We suggest that further differences in KIBS firms' approaches to value creation may affect their modes of organizational learning and patterns of innovation collaboration with universities. The intangible nature of service offerings implies that it is difficult to demonstrate their quality in advance (Illeris, 1989). Thus, clients often cannot fully assess the service offerings before they make their purchase, but they may have "expectations" regarding the service quality (Sundbo, 2002). Service production and consumption often happen simultaneously, and customers are usually integrated directly into the service production and delivery process (Gallouj and Weinstein, 1997). In other words, firms can only offer value propositions and cannot create or deliver value independently—value is typically co-created with customers and ultimately determined by the beneficiary of the service (Vargo and Lusch, 2004, 2008). What is key to services firms' competitiveness is how to provide value propositions for clients in advance of their purchases and the extent to which firms integrate clients' requirements relationally in the simultaneous service production and delivery process in order to satisfy the clients' needs. With the pressure of cost and productivity on the one hand and the objective of meeting individual customers' needs on the other, services firms face the ultimate challenge of positioning their service offerings according to two broad spectra of value proposition: customization/individualization and standardization/mass production (Sundbo, 1994).

Firms supplying customized services offer clients an experience that is tailored, novel, one-off, ad hoc, and unique or simply the best. In contrast to firms offering standardized services—for which competition is based on cost reduction or efficiency—firms offering customized services focus on innovation, responsiveness, flexibility, and attention to the development of client solutions (Sundbo, 2002; Treacy and Wiersema, 1995). Research suggests that firms competing through customized services may demonstrate further variation in focus. Indeed, Treacy and Wiersema (1995) argue that firms may achieve differentiation by providing cutting-edge service products through innovation or by building special bonds with customers and fulfilling their specific needs. Miozzo et al. (2012) extend this typology. Through an exploration of design firms, they propose another type of services firms whose competitive advantage lies in the ability to offer unique services resulting from the mobilization and integration of knowledge from multiple business units with a plurality of skills in order to develop bespoke solutions to customers. In contrast, firms supplying standardized services require employee knowledge to execute service delivery precisely and efficiently. The latter's value proposition is operational

excellence, which is realized through streamlined operational processes (such as ordering, sales, and delivery), cost-effectiveness, and a hassle-free customer experience (Desyllas et al., 2018; Sundbo, 2002; Treacy and Wiersema, 1995).

For services firms to compete effectively through customization, they must simultaneously engage in a DUI mode of organizational learning through developing sophisticated cognitive ability of their employees to fulfill clients' unique needs, and coordination among internal and external business units for information exchange (Madhavaram and Hunt, 2017). For instance, a specialized venture capital firm can provide one-off tailored solutions for individual entrepreneurs in different industries through the mobilization of a network of the firm's internal and external sources of expertise.

We do not suggest that all firms engaging in a DUI mode of organizational learning also offer customized services. Some firms may be highly interactive but compete through standardized services in the market—in fact, many financial services firms fall into this category. We argue that firms with both a DUI mode of organizational learning and an ability to offer customized services are likely to experience synergy and achieve a superior innovation performance. These firms that are in search of specialist knowledge or technologies for their "unique" client solutions or to serve in the highly specialized and heterogeneous market of the commercialization of science may be even more likely to turn to universities for collaboration for innovation. We therefore derive the following hypothesis:

H3. *KIBS firms' customization strengthens the relationship between the importance of firms' collaboration with universities for innovation and an orientation toward a DUI mode of organizational learning.*

KIBS firms that offer customized services face unique challenges. While they may be able to develop client solutions that are highly unique and one-off, they face difficulties in replicating or formalizing these innovations. The ability to approach, analyze, and synthesize formal scientific knowledge can be a particular strength of KIBS firms offering highly customized solutions for recombination and future applications in other contexts (Gallouj and Savona, 2009). Therefore, if KIBS firms have a high level of customization capability and are science based/technology related, they may be particularly capable of realizing their full innovation potential, since these firms can customize and formalize knowledge simultaneously. Indeed, research shows that employees' technical competence and professional services firms' customization ability are positively associated (Madhavaram and Hunt, 2017). Typical examples of KIBS firms that compete through highly formalized scientific knowledge and customization are R&D services firms and specialist IT services firms that offer bespoke solutions. For these firms, due to their high innovation capability, there may be an increased probability of seeking novel client solutions in collaboration with universities. We therefore expect that, in the case of those firms oriented toward an STI mode of organizational learning, there is a positive moderation effect of customization on the likelihood of KIBS firms' collaboration with universities. We thus derive the following hypothesis:

H4. *KIBS firms' customization strengthens the relationship between the importance of firms' collaboration with universities for innovation and an orientation toward an STI mode of organizational learning.*

3. Data and methods

The study is based on an original survey of KIBS firms in the US and the UK conducted between September and December 2012. Based on firms in Datastream, the sampling frame is the list of 406 UK and 1892 US publicly traded knowledge-intensive services firms in the telecommunications, IT services, R&D services, engineering services, financial services, market research, business and management consultancy, and legal services sectors (US SIC codes: 48, 60, 62, 63, 67, 73, and 87). The survey obtained 223 firm responses (from 92 UK and 131 US firms) and yielded an overall response rate of 10.3% (23% for the UK and 7% for the US firms). We used the characteristic comparison method (Lawton and Parasuraman, 1980) to assess the survey's non-response bias. We compared firm location, firm size (the number of employees), and industrial sector (2-digit SIC code) between respondents and non-respondents. The results showed that there is no significant difference between them in terms of their industrial sector. However, UK firms and large firms were over-represented. We thus weighted the data with the firm size and the firm location based on the inverse response propensity through logistic regression modeling (David et al., 1983; Kalton and Flores-Cervantes, 2003). Excluding those with missing data, 202 firms were used for the analysis. The analyzing unit was firms, the analyzing method was multinomial logistic regression, and the analyzing tool was STATA 13.

The dependent variable was constructed through two survey questions. First, one question asked each firm's representative whether the firm collaborated with universities. If the firm collaborated with universities, the representative was then asked to rank how important universities were to the firm's innovation on a score from 1 to 5. If the firm did not collaborate with universities for innovation, a score of zero was given. Thus, the dependent variable "importance of universities for innovation" was constructed based on the two survey questions. The original values of the variable ranged from 0 to 5. To ensure the robustness of the regression analysis, we refined the variable further, keeping the score of 0 to indicate that there was no collaboration with universities (69% of the respondents) and recoding scores 1–3 as 1 to indicate collaboration with universities as less important for innovation (18% of the respondents) and scores 4–5 as 2 to indicate collaboration with universities as being of high importance to innovation (13% of the respondents).

We explore the association between KIBS firms' modes of organizational learning and approach to value creation and the importance of collaboration with universities for innovation. The independent variables were constructed by focusing on the two modes of organizational learning of KIBS firms (STI and DUI). For the STI mode of organizational learning, we used three indicators. The first indicator is related to the type of KIBS firms that use more formalized scientific knowledge to produce and transfer scientific/technological knowledge for their client solutions. We followed the classification proposed by Miles et al. (1995) and singled out the T-KIBS firms. The second is the respondents' answer to the question of whether the firm conducted R&D internally. The third is their response regarding the percentage of the firm's staff with university degrees or equivalent qualifications in the sciences/engineering.

As for indicators related to the DUI mode of firms' organizational learning, following Fitjar and Rodriguez-Pose (2013), Jensen et al. (2007), Miozzo et al. (2012), Parrilli and Heras (2016), and Thoma (2017), we used measures of the collaboration with internal business units, clients, suppliers, and competitors. The DUI mode of organizational learning, however, also involves organizational mechanisms that foster the diffusion of organizational best practices and the management of innovative ideas (Jensen et al., 2007; Parrilli and Elola, 2012), along with employees' ability to identify, access, share, and integrate each other's expertise (Gardner, 2015). We thus added two further indicators of the DUI mode of organizational learning—one indicating the presence of organizational knowledge reviewing systems and the other signifying the use of knowledge sharing mechanisms. Details of these measures are shown in Table 1.

We then carried out a factor analysis of all the measures discussed above. We used polychoric correlations in the factor analysis because our data are either ordinal or binary and there is evidence that superior results are achieved in such cases (Holgado-Tello et al., 2010). We followed the literature on best practices for factor analysis and employed a maximum likelihood factor as the extraction method, an oblique oblimin rotation method to allow for correlations between factors, and a scree plot to determine the number of factors (Costello and

Table 1
Details of measures used for factor analysis (weighted results; N = 202).

Measures	Type	Description	Mean	Std. Err.
Sciences	Categorical/binary	The percentage of staff in the company with university degrees or equivalent qualifications in the sciences and engineering is equal to or above 50% (yes = 1 and no = 0).	0.184	0.030
R&D activities	Categorical/binary	Whether the company spent in year 2011 more than 1% of its turnover conducting R&D internally in support of innovation (yes = 1 and no = 0).	0.569	0.039
T-KIBS	Categorical/binary	US SIC codes in which the company operates are in 48 (communications services), 737 (computer services), 871 (engineering/architectural/survey services), and 873 (R&D services) (yes = 1 and no = 0).	0.240	0.033
Systematic knowledge reviewing systems	Categorical/binary	Whether the company was an innovator and applied systematic ways of reviewing performance and learning from past experience/service provision (yes = 1 and no = 0).	0.678	0.036
Systems to locate expertise for knowledge sharing	Categorical/binary	Whether the company was an innovator and used information systems or social media to enable internal specialists to locate expertise and exchange knowledge among themselves (yes = 1 and no = 0).	0.610	0.038
Collaborations	Ordinal	Whether the company collaborated for innovation with each of the following types of partners between 2009 and 2011 (yes = 1 and no = 0) and how important these types of partners were for innovation (scores from 1 to 5; 5 being highly important).		
		1) internal business units	1.983	0.147
		1) clients/customers	3.009	0.145
		1) suppliers	2.069	0.149
		1) competitors	1.325	0.137

Osborne, 2005; Fabrigar et al., 1999). We identified three factors: one indicating firms with an STI mode of organizational learning and two with a DUI mode of organizational learning (one related to organizational knowledge management mechanisms and the other associated with innovation collaboration with different types of partners). The three factors are labeled "STI," "DUI_ORG," and "DUI_COLL," respectively (see Table 2). We used the regression method to obtain factor scores. We assessed the quality of the constructs (details in Table 2). The values of Cronbach's alpha and those of the average variance extracted (AVE) and composite reliability (CR) for all constructs are either above the recommended threshold (Hair et al., 1998)[8] or considered acceptable (Bowling, 2002; Fornell and Larcker, 1981).[9]

We further identified firms' approaches to value creation by evaluating the extent to which firms provide customized or standardized services. We asked each respondent to assess the importance of one-off services to the firm's overall revenues (ranging from minor to moderate and substantial). We then constructed a dummy variable, "customization," to identify those firms for which those one-off services were of substantial importance to their revenues. We also asked the respondents to assess the importance of standardized services to their overall revenues (from minor to moderate and substantial). Similarly, we constructed a dummy variable, "standardization," to indicate when standardized services were of substantial importance to firms' overall revenues.

We then controlled for the extent to which employees directly interact with clients, industry stage (whether market is emerging or not), the number of new products/services introduced, firm size, and firm location (UK or US). We further controlled for the degree of radical innovation because there is evidence to show that collaboration with universities is associated with the development of radical innovation (Faems et al., 2005; Fitjar and Rodríguez-Pose, 2011). Finally, we incorporated an indicator of firm value (natural logarithm of Tobin's Q as a proxy) in the model specification to control for the "quality" of the firms (since firms may collaborate with universities to enhance their corporate image) (Ankrah et al., 2013). Details of the construction of the variables, descriptive statistics, and correlations are shown in Tables 3 and 4.

The nature of this study is exploratory. We explore associations and not casual relationships between KIBS firms' knowledge base/modes of organizational learning and the importance of collaboration with universities for innovation. That is to say, we do not imply the existence of a one-way relationship in which KIBS firms simply establish their knowledge base and define their approach to value creation first and then decide whether it is important to collaborate with universities. The reverse is possible. It is possible that because of the importance of firms' collaboration with universities for innovation, their knowledge base and approaches to value creation, and thus their mode of organizational learning, evolve in particular ways. Nonetheless, in the paper we propose potential mechanisms outlining how the abilities of KIBS firms to articulate formalized scientific knowledge and interact with or use knowledge from their innovation partners effectively may help them to overcome barriers to collaboration with universities for innovation.

Furthermore, while the STI and DUI modes of organizational learning are conceptualized based on seemingly contrasting ways of learning, with the former focusing on formalized scientific knowledge and the latter emphasizing cognitive skills, firms may excel at both types of learning through simultaneously engaging in both the exploration and exploitation of scientific knowledge and well-designed organizational procedures and strategies. Jensen et al. (2007) find that

[8] Hair et al. (1998) suggest the threshold of 0.5 for AVE and 0.7 for CR to ensure convergent validity of a construct.

[9] Fornell and Larcker (1981) indicate that a value of AVE above 0.4 might be acceptable. Bowling (2002) suggests that a value of 0.5 or above for Cronbach's alpha can be acceptable for a construct with short item scales.

Table 2
Factor analysis results.

	Items	Factor loading	AVE	CR	Cronbach's alpha
STI	Sciences	0.708	0.508	0.749	0.573
	R&D activities	0.524			
	T-KIBS	0.864			
DUI_ORG	Systematic knowledge reviewing systems	0.982	0.853	0.920	0.769
	Systems to locate expertise for knowledge sharing	0.862			
DUI_COLL	Collaboration with internal business units	0.777	0.434	0.749	0.683
	Collaboration with clients	0.588			
	Collaboration with suppliers	0.717			
	Collaboration with competitors	0.520			

in their Danish study, nearly 40% of business services firms belonged to this category and these firms were more likely to be large firms. Similar trends are found in our study.

4. Findings

Figs. 1–3 illustrate some preliminary insights into the inter-relationships between firms' perceptions of the importance of collaboration with universities for innovation, their orientation toward the STI and the DUI modes of organizational learning, and the degree to which their services are customized. We can see from Fig. 1 that KIBS firms that value collaboration with universities for innovation tend to be highly oriented toward an STI mode of organizational learning. The ones that offer highly customized services exhibit a particularly strong orientation toward an STI mode of organizational learning. Similar trends do not hold for firms oriented toward the DUI_ORG mode of organizational learning (Fig. 2) but they do hold for firms oriented toward a DUI_COLL mode of organizational learning (Fig. 3). It seems that the firms in general make an effort to integrate internal expertise. We do not observe large variation in such efforts between firms competing through high or low customization. A higher orientation toward the DUI_ORG mode of organizational learning is associated with firms that collaborate with universities but do not see universities as highly important innovation partners.

We show the regression results in Table 5.[10] We addressed and assessed the common methods bias and found it not to be significant.[11] We further tested the independence of irrelevant alternatives (IIA) assumption for multinomial logit regressions. We ran two separate logistic regressions excluding alternative choices of the dependent variable each time (i.e., one regression to compare scores 0 and 1 for "importance of universities for innovation" and another to compare scores 0 and 2). We found that the results are fully consistent with those of our main regression (Appendix Table A1). Comparing KIBS firms that reported that they did not collaborate with universities for innovation to those that ranked collaboration with universities as being of low importance for innovation, we found some indication that firms that emphasize practices based on reviewing and sharing internal knowledge may be more likely to collaborate with universities (Table 5). However, the separate regression focusing on these two groups of respondents only (Column 1 in Appendix Table A1) shows that this finding needs to be treated with caution due to model fit. Nevertheless, we can clearly distinguish between KIBS firms that did not collaborate with universities and those that regarded collaboration with universities as highly important for their innovation. Therefore, we report the results focusing on the latter set of comparisons.

Focusing on the comparisons between KIBS firms that did not collaborate with universities and those that regarded collaboration with universities as highly important for their innovation, we can see that Column 2 in Table 5 shows a positive and statistically significant coefficient for firms with an STI mode of organizational learning. This indicates that KIBS firms oriented toward an STI mode of organizational learning are more likely to collaborate with universities and find this collaboration highly important for their innovation. Therefore, hypothesis H1 is supported. Column 2 in Table 5 shows that the coefficients for firms with a DUI_ORG or a DUI_COLL mode of learning are positive but not statistically significant. This indicates that there is no significant association between KIBS firms' orientation toward a DUI mode of organizational learning and the perceived high importance of collaboration with universities for innovation. Therefore, hypothesis H2 is not supported. The results are consistent with the existing literature on manufacturing firms, and confirm that there is a positive association between firms engaged in an STI mode of organizational learning and innovation collaboration with universities and a less relevant role for universities in innovation for firms that pursue a DUI mode of organizational learning (Fitjar and Rodríguez-Pose, 2013; Jensen et al., 2007; Parrilli and Heras, 2016).

The above results, however, are conditioned by firms' orientation toward customization. When we consider jointly firms' orientation toward customization and toward a DUI mode of organizational learning, an interesting pattern emerges. Column 3 in Table 5 shows that when we compare those firms that rated collaboration with universities as highly important for innovation and those that did not collaborate with universities, the coefficient for the interaction term between KIBS firms oriented toward a DUI_COLL mode of organizational learning and customization is statistically significant and positive. As the regression model is non-linear, we follow Brambor et al. (2006) to interpret the interaction effect. Fig. 4 shows the relationship between the importance of collaboration with universities for innovation and KIBS firms' orientation toward a DUI_COLL mode of organizational learning according to whether firms engage in high customization or low customization. We can see that the relationship between KIBS firms' orientation toward a DUI_COLL mode of organizational learning and innovation collaboration with universities is strengthened as the orientation toward customization increases.

[10] We used the robust heteroscedasticity-consistent estimator to account for any presence of heteroscedasticity of unknown form (White, 1980). There is no significant evidence of multicollinearity, as the maximum value of the variance inflation factor of the variables is 1.47, which is well below the recommended threshold value of 10 (Cohen et al., 2003).

[11] We addressed the common method bias in the following ways. Our questionnaire was designed to ask respondents to answer survey questions in different formats, some questions asking for numbers (i.e., percentages), others for scores (e.g., Likert scale), and yet others for categories. We also incorporated external data such as industry classification (SIC code), the number of employees, firm location, and Tobin's Q from Datastream in the regression. As our variables were largely from responses of a single rater for each firm, we further evaluated potential common method bias by assessing the effect of a single unmeasured latent method factor (i.e., using the common latent factor analysis) (Podsakoff et al., 2003). We found that the common method variance is less than 1%. Furthermore, for the relationship between the dependent and the independent variables, we theorized a nonlinear model including interaction effects. Research suggests that a complex model such as ours is less affected by common method bias (Chang et al., 2010; Siemsen et al., 2010).

Table 3
Descriptive statistics for variables (weighted results; N = 202).

Variables	Types of variables	Description	Mean	Std. Err.
Importance of universities for innovation	Ordinal	Whether the company collaborated for innovation with universities between 2009 and 2011 (yes = 1 and no = 0) and how important universities were for innovation (scores from 1 to 5; 5 being highly important). Scores were recoded to three categories: 0 = no collaboration (original score 0), 1 = less important (original scores 1–3), 2 = highly important (original scores 4–5).	0.419	0.054
Customization	Ordinal	The extent to which one-off services are important to the respondent's overall revenues (1 = minor, 2 = moderate, 3 = substantial). Scores were recoded to 2 categories: 0 = minor to moderate and 1 = substantial.	0.199	0.031
Standardization	Ordinal	The extent to which standardized services are important to the respondent's overall revenues (1 = minor, 2 = moderate, 3 = substantial). Scores were recoded to 2 categories: 0 = minor to moderate and 1 = substantial.	0.477	0.039
STI	Index: factor scores from regression methods	Factor analysis results; see Table 2.	0.343	0.030
DUI_ORG	Index: factor scores from regression methods	Factor analysis results; see Table 2.	0.597	0.035
DUI_COLL	Index: factor scores from regression methods	Factor analysis results; see Table 2.	2.253	0.110
Front desk staff	Continuous	The percentage of the company's staff dealing directly with customers (%).	55.840	2.142
Emerging market	Categorical/binary	Self-reported degree of market development for the firm's main services (yes = 1 and no = 0).	0.184	0.031
Number of innovations	Continuous	The number of products innovations between 2009 and 2011.	3.206	0.426
Radical innovation degree	Ordinal	Percentage of product innovations new to the market between 2009 and 2011 (1 = 0%; 2 = up to 10%; 3 = up to 20%; 4 = up to 30%; 5 = up to 40%; 6 = up to 50%; 7 = up to 60%; 8 = up to 70%; 9 = up to 80%; 10 = up to 90% and 11 = up to 100%)	1.604	0.232
Tobin's Q	Continuous	Natural logarithm of the average of Tobin's Q between 2009 and 2011.	0.630	0.098
US firm	Categorical/binary	Whether the company is located in the USA (yes = 1 and no = 0).	0.831	0.020
Number of employees	Continuous	The number of employees.	3375.605	839.017

To confirm the interaction effect, Fig. 5 shows that the difference in the predicted probability of perceiving innovation collaboration with universities as being highly important for innovation between firms that offer highly customized services and firms that offer less customized services increases as the orientation toward a DUI_COLL mode of organizational learning increases (i.e., the second derivative is positive). In addition, Fig. 5 shows that for all values of firms' orientation toward a DUI_COLL mode of organizational learning, the difference in the predicted probabilities and the lower and upper bounds of the 90% confidence intervals are all above zero. This confirms the significant interaction effect. Nevertheless, we found no interaction effect for firms engaged in highly customized services that simultaneously pursue a DUI_ORG mode of organizational learning. This is in line with what we observed earlier. Internal knowledge reviewing and sharing practices are fundamental to KIBS firms and the majority of firms make an effort to implement such practices, regardless of whether they engage in high customization. Hypothesis H3 is thus partly supported. The findings verify that customization strengthens the relationship between firms with a DUI mode of organizational learning (associated with collaboration with different types of partners) and innovation collaboration with universities. The findings are significant as they unveil new circumstances under which universities can be highly important for innovation for KIBS firms that are oriented toward a DUI mode of organizational learning, firms that the existing literature would not expect to collaborate with universities.

Similarly, Column 3 of Table 5 shows that the coefficient for the interaction term between KIBS firms' orientation toward an STI mode of organizational learning and customization is statistically significant and positive when we compare KIBS firms that rated collaboration with universities as being of high importance for innovation and those that did not collaborate with universities. Again, Fig. 6 shows the relationship between the importance of collaboration with universities for innovation and an orientation toward an STI mode of organizational learning by level of customization. Fig. 7 shows how the difference in importance of collaboration with universities for innovation between firms engaged in high or low customization is strengthened by an increase in firms' orientation toward an STI mode of organizational learning. Thus, hypothesis H4 is supported. This confirms that the ability to analyze and synthesize scientific knowledge reinforces customization capacity, which in turn helps to produce more new knowledge. Firms with such capabilities are disproportionally more likely to collaborate with universities for innovation than firms pursuing the STI mode of organizational learning but engaging in low customization.

Consistent with the existing literature, the regression results further show that the importance of collaboration with universities for innovation is associated with radical innovation and firm quality (Tobin's Q). The importance of such collaboration, however, is lower when KIBS firms operate in a market that is emerging.

5. Discussion and conclusion

This paper explores patterns of innovation collaboration between KIBS firms and universities. We investigate what types of KIBS firms collaborate with universities and consider that collaboration to be important for their innovation. Our results reveal interesting insights into the dynamics of such collaboration. We confirm the need to take into account the heterogeneity of KIBS firms. Science-based KIBS firms are active innovation collaborators with universities. This relationship is further enhanced if these firms also provide highly customized services. The results are in line with the existing literature exploring manufacturing firms and consistent with studies suggesting that firms involved in an STI mode of organizational learning are more likely to collaborate with universities, in contrast to those engaged in a DUI mode of organizational learning.

But that is where the similarities end. Our results reveal evidence to show that KIBS firms interact with universities differently than

Table 4
Correlation table (weighted results).

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Importance of universities for innovation	1.000												
2. Customization	–0.009	1.000											
3. Standardization	–0.004	–0.054	1.000										
4. STI	0.284***	0.050	–0.017	1.000									
5. DUI_ORG	0.104	0.092	0.110	0.012	1.000								
6. DUI_COLL	0.184**	0.084	0.224***	0.353***	0.213***	1.000							
7. Front desk staff	–0.107	–0.013	0.147*	–0.371***	0.087	–0.062	1.000						
8. Emerging market	–0.082	0.001	–0.187**	0.109	–0.019	0.050	–0.075	1.000					
9. Number of innovations	0.018	0.210	–0.009	0.100	0.314**	0.289**	0.002	–0.067	1.000				
10. Radical innovation degree	0.225**	–0.067	0.014	0.296***	0.158**	0.143**	–0.040	0.228**	0.095	1.000			
11. Tobin's Q	0.161	0.101	–0.007	0.272*	–0.017	0.028	–0.064	0.201*	0.062	0.166	1.000		
12. US firm	0.021	–0.005	0.030	–0.049	0.051	0.098*	0.016	0.059	–0.039	–0.164**	0.119***	1.000	
13. Number of employees	–0.009	–0.011	0.078	0.034	–0.001	0.046	–0.008	–0.037	–0.023	–0.015	–0.030	–0.092*	1.000

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

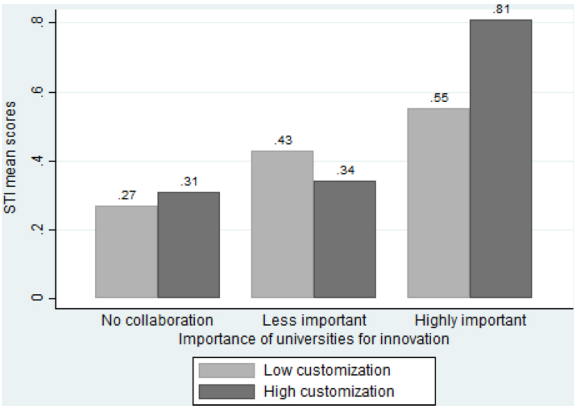

Fig. 1. Importance of collaboration with universities for innovation, level of customization, and mean scores of orientation toward the STI mode of organizational learning (weighted results).

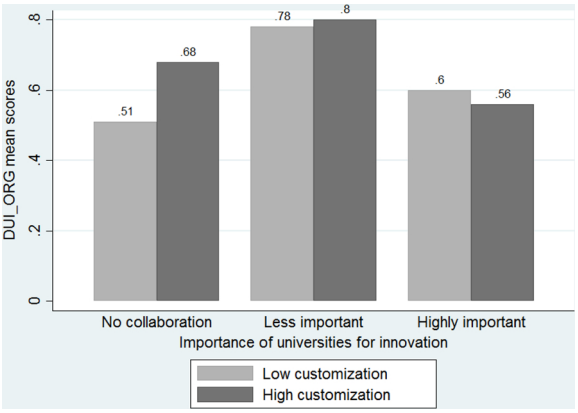

Fig. 2. Importance of collaboration with universities for innovation, level of customization, and mean scores of orientation toward the DUI_ORG mode of organizational learning (weighted results).

manufacturing firms. Our findings demonstrate that KIBS firms engaged in a highly collaborative and interactive mode of organizational learning and in supplying highly customized services collaborate with universities for innovation, too. Although whether firms engage in a DUI mode of organizational learning—either emphasizing collaboration with different types of partners or internal knowledge reviewing and

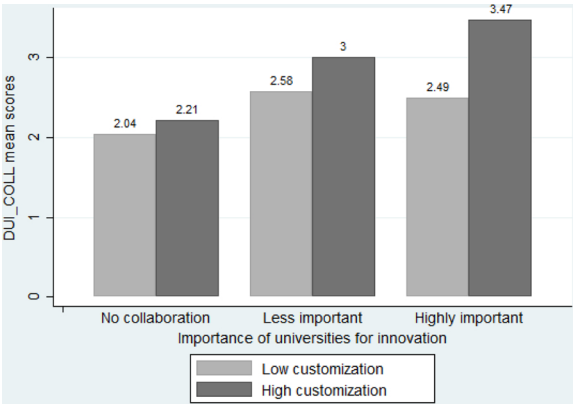

Fig. 3. Importance of collaboration with universities for innovation, level of customization, and mean scores of orientation toward the DUI_COLL mode of organizational learning (weighted results).

sharing mechanisms—is not itself an enabler of innovation collaboration between KIBS firms and universities, when firms engage in a DUI mode of organizational learning and also offer highly customized services, there is a synergy in these firms' innovation collaboration with universities.

From a case-by-case investigation, we can see that many of these are non-technology-related professional services firms and include specialist recruitment firms, marketing firms, and firms specializing in IP commercialization. This confirms observations made in previous work. For example, in a UK biotechnology knowledge transfer network between university and industry, 94% of the academics involved reported using IP or legal firms, and about 60% reported that they worked with management consultants (Wright et al., 2008). Our findings also echo observations made by Howells (2006) regarding the wide diversity of the functions of intermediaries in public–private collaborative innovation networks. Our results thus provide further evidence to show that KIBS firms may partner with universities both upstream and downstream in the process of innovating and commercializing knowledge produced in universities.

Our results extend the literature on service innovation to highlight the characteristics of KIBS firms that are able to fulfill such roles, in terms of their knowledge base and approach to value creation. Our findings confirm prior suggestions that KIBS firms play a wide variety of roles in their innovation networks with universities. On the one hand, there are science-based KIBS firms that work with universities, and this collaboration may rely on knowledge integration. But there are also

Table 5
Regression results (weighted results).

	(1) Coef. (Robust Std. Err.)	(2) Coef. (Robust Std. Err.)	(3) Coef. (Robust Std. Err.)
Importance of universities for innovation = 1[a]			
Customization		–0.507 (0.600)	–0.777 (1.820)
Standardization		0.250 (0.475)	0.291 (0.500)
STI		0.907 (0.713)	1.013 (0.821)
DUI_ORG		1.268 (0.592)**	1.350 (0.644)**
DUI_COLL		0.170 (0.177)	0.104 (0.208)
Customization × STI			–0.331 (1.092)
Customization × DUI_ORG			–0.210 (1.652)
Customization × DUI_COLL			0.243 (0.411)
Front desk staff	–0.009 (0.007)	–0.007 (0.008)	–0.007 (0.008)
Emerging market	–0.668 (0.674)	–0.682 (0.678)	–0.635 (0.687)
Number of innovations	0.033 (0.030)	0.007 (0.038)	0.001 (0.040)
Radical innovation degree	0.181 (0.078)**	0.129 (0.079)	0.127 (0.080)
Tobin's Q	–0.539 (0.306)*	–0.648 (0.397)	–0.666 (0.412)
US firm	0.908 (0.496)*	0.732 (0.503)	0.721 (0.508)
Number of employees	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Constant	–1.676 (0.574)***	–3.049 (0.747)***	–2.995 (0.745)***
Importance of universities for innovation = 2[a]			
Customization		–0.034 (0.603)	–8.427 (3.646)**
Standardization		–0.739 (0.653)	–0.973 (0.671)
STI		1.306 (0.711)*	0.924 (0.665)
DUI_ORG		0.358 (0.622)	0.475 (0.736)
DUI_COLL		0.282 (0.214)	0.220 (0.229)
Customization × STI			6.561 (3.143)**
Customization × DUI_ORG			0.764 (1.533)
Customization × DUI_COLL			1.237 (0.542)**
Front desk staff	–0.012 (0.010)	–0.004 (0.012)	–0.002 (0.012)
Emerging market	–1.705 (0.722)**	–1.947 (0.700)***	–1.968 (0.623)***
Number of innovations	–0.037 (0.053)	–0.075 (0.056)	–0.103 (0.042)**
Radical innovation degree	0.195 (0.061)***	0.137 (0.060)**	0.151 (0.066)**
Tobin's Q	0.414 (0.210)**	0.395 (0.165)**	0.488 (0.186)***
US firm	0.185 (0.554)	–0.005 (0.578)	–0.007 (0.568)
Number of employees	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Constant	–1.669 (0.582)***	–2.813 (0.850)***	–2.558 (0.824)***
N	202	202	202
Wald statistics	25.76**	50.65***	54.45***
Log pseudo likelihood	–1556.671	–1447.724	–1395.455

Note:
[a] Importance of universities for innovation = 0 as the reference category.
*** significant at the 1% level.
** significant at the 5% level.
* significant at the 10% level.

KIBS firms that are highly interactive and engage in highly customized services that work with universities more as knowledge facilitators or intermediaries by sharing their commercialization expertise with universities and fostering effective knowledge flows between university and industry. These firms, through collaboration with specialist partners like universities, may be strengthening their own innovation capabilities rather than integrating highly formalized knowledge from universities. In other words, KIBS firms not only play the role of facilitators of knowledge transformation in innovation for manufacturing firms (Ciriaci et al., 2015), including small and medium-sized firms (Muller and Zenker, 2001) and the public sector (Windrum, 2013), but also for research organizations such as universities. Examples of this may include firms that specialize in marketing, recruitment, or IP that work with university incubators to help with the development of their tenant firms (Aaboen, 2009).

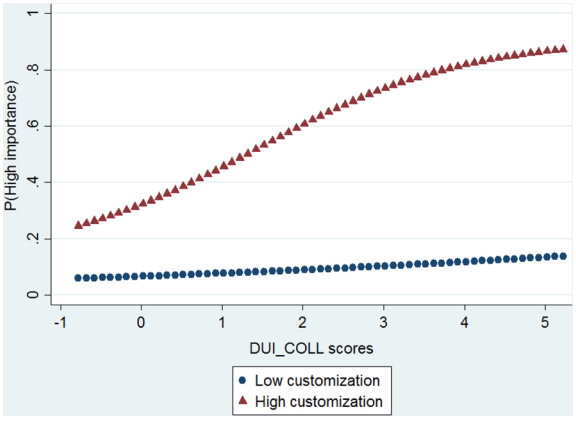

Fig. 4. Predicted probability of perceiving collaboration with universities as being of high importance for innovation by scores for the DUI_COLL mode of organizational learning orientation between high-customization and low-customization firms.

A case in point is that of IP Group, a UK top 250 publicly traded company specializing in the commercialization of science, which is characterized as "honing a unique approach to building businesses and providing support along the journey… from cradle to maturity… tailored to suit [the] individual requirements" of academic start-ups.[12] At the same time, while partnering with leading market analysts, brokers, bankers, solicitors, and independent auditors, IP Group has "pioneered the concept of the long-term partnership with UK universities," collaborating closely with 18 UK, 5 US, and 8 Australian leading

[12] Further company information is online available at https://www.ipgroupplc.com/ (accessed on 6 Oct 2018).

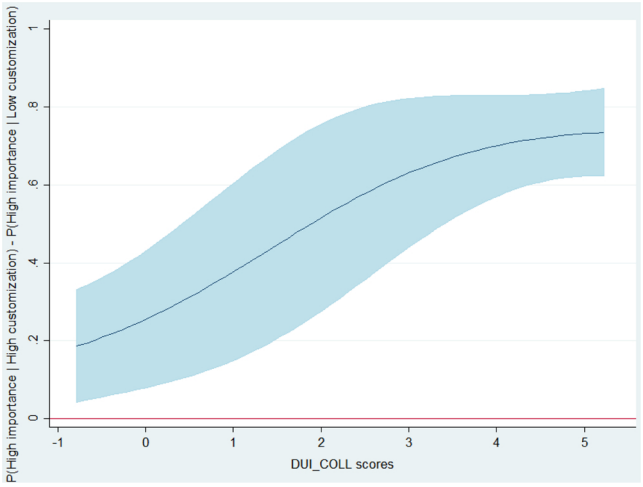

Fig. 5. Difference in predicted probability of perceiving collaboration with universities as being of high importance for innovation between high-customization and low-customization firms by scores for the DUI_COLL mode of organizational learning orientation, with 90% confidence intervals.

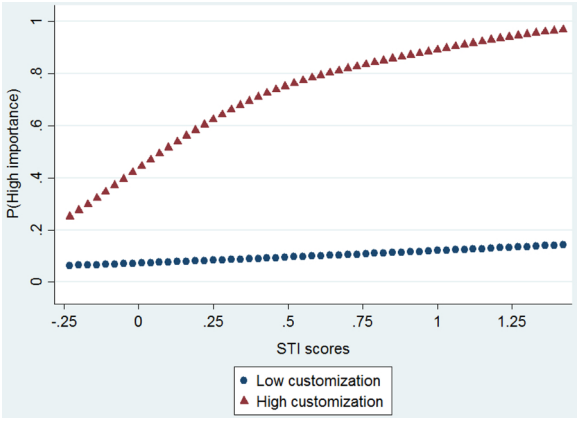

Fig. 6. Predicted probability of perceiving collaboration with universities as being of high importance for innovation by scores for the STI mode of organizational learning orientation between high-customization and low-customization firms.

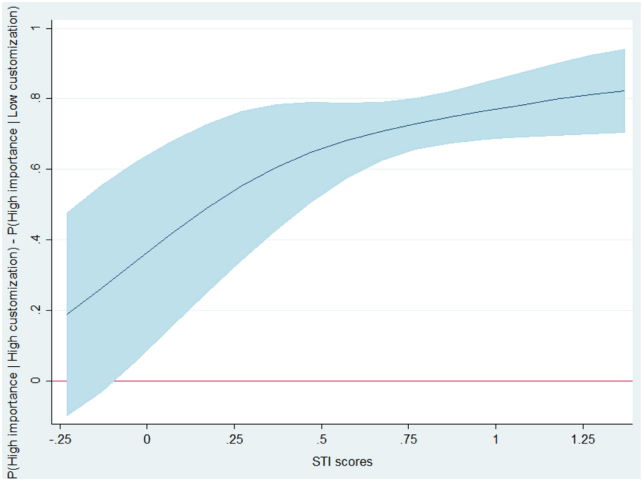

Fig. 7. Difference in predicted probability of perceiving collaboration with universities as being of high importance for innovation between high-customization and low-customization firms by scores for the STI mode of organizational learning orientation, with 90% confidence intervals.

universities. These partnerships enable IP Group to provide knowledge and resources for its clients, including funds, co-founders, and services such as executive search, legal support, and corporate finance advice, contributing to accelerated company growth. This confirms that KIBS firms may be simultaneously knowledge clients and knowledge suppliers for university.

This study contributes to the literature in service innovation. In particular, we contribute to the debate on the importance of universities for innovation in services firms (Howells et al., 2012; Love et al., 2011; Mina et al., 2014; Rodriguez et al., 2017; Segarra-Blasco and Arauzo-Carod, 2008). We show that universities are important innovation partners for two sets of KIBS firms: science-based KIBS firms and KIBS firms that are highly interactive and engaged in highly customized services.

This finding further challenges the view that universities are less relevant as a source of innovation to firms with a DUI mode of organizational learning. Thus, this study also contributes to the literature on learning in open innovation systems. In contrast to existing accounts that show that universities are not important innovation partners for firms pursuing a DUI mode of organizational learning (Fitjar and Rodríguez-Pose, 2013; Jensen et al., 2007; Parrilli and Heras, 2016), we shed light on the circumstances under which universities can be highly relevant to firms pursuing this mode of learning. We find that KIBS firms oriented toward that mode of learning may work effectively with universities to facilitate universities' knowledge transfer activities through the cultivation of their customization capabilities.

The main managerial implication of this research is that while managers in KIBS firms need to be aware of the need to improve their firms' capabilities in terms of absorbing knowledge from universities, they may also need to assess the knowledge and strategic orientation of their firms and seize opportunities to partner with universities to promote the commercialization of academic research. This research also has implications for universities and policymakers. Universities interact differently with KIBS firms than they do with manufacturing firms. To effectively transfer knowledge from academia to industry and to effectively situate KIBS firms in the innovation networks with universities, government policies may focus not only on fostering the STI mode of organizational learning between KIBS firms and universities but also on mobilizing the DUI mode of organizational learning in their interaction. For instance, government policies to identify and promote suitable and competent KIBS firms to partner with universities could result in further positive impacts on the outcome of universities' existing research commercialization activities.

There are some limitations in the present research. First, while we uncover the determinants of innovation collaboration between KIBS and universities, we do not distinguish between different types of collaboration between KIBS firms and universities. Questions that remain unanswered include whether some types of KIBS firms act as knowledge suppliers and others as clients, or even as competitors in the collaborative relationship with universities. Do the same types of KIBS firms sometimes play the role of knowledge supplier and at other times the role of client or competitor? Also, we do not differentiate between formal and informal collaboration or examine whether they are motivated and coordinated at the organizational level or at the individual level of KIBS firms. Individual consultants' social ties to universities may affect the propensity to collaborate.

Second, we treat the university as a homogeneous entity. It is likely that the collaboration patterns between KIBS firms and sciences/engineering departments differ from those between KIBS firms and business/social sciences/humanities departments. Further research may look into the details of these collaboration dynamics. Third, we explore the association and not the causation of the relationship of innovation collaboration between KIBS firms and universities. More research can be done to uncover the underlying mechanisms by collecting longitudinal data or through carrying out in-depth interviews. For instance, further contributions could be made by examining how the innovation

collaboration relationship between KIBS firms and universities evolves over time, how the roles of KIBS firms and universities change, and what are the enablers of the change. Finally, the research presented in this paper is based on data from a small-scale survey focusing on KIBS firms in the UK and the US. Additional internationally comparative research involving KIBS firms from different countries may help to elucidate whether the collaborative relationship between KIBS firms and universities differs in other national innovation systems.

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Appendix A

Table A1
Test of IIA assumption.

	(1) [b] Coef. (Robust Std. Err.)	(2) [c] Coef. (Robust Std. Err.)
Importance of universities for innovation = 1 [a]		
Customization	–0.610 (1.816)	
Standardization	0.362 (0.504)	
STI	0.860 (0.783)	
DUI_ORG	1.308 (0.664)**	
DUI_COLL	0.099 (0.209)	
Customization × STI	–0.134 (1.160)	
Customization × DUI_ORG	–0.286 (1.760)	
Customization × DUI_COLL	0.190 (0.398)	
Front desk staff	–0.007 (0.008)	
Emerging market	–0.601 (0.652)	
Number of innovations	0.004 (0.038)	
Radical innovation degree	0.110 (0.074)	
Tobin's Q	–0.528 (0.441)	
US firm	0.708 (0.512)	
Number of employees	0.000 (0.000)	
Constant	–2.974 (0.733)***	
Importance of universities for innovation = 2 [a]		
Customization		–8.149 (3.396)**
Standardization		–0.938 (0.706)
STI		1.062 (0.755)
DUI_ORG		0.322 (0.763)
DUI_COLL		0.235 (0.225)
Customization × STI		5.999 (3.074)*
Customization × DUI_ORG		1.134 (1.468)
Customization × DUI_COLL		1.226 (0.475)***
Front desk staff		–0.002 (0.011)
Emerging market		–1.903 (0.601)***
Number of innovations		–0.119 (0.051)**
Radical innovation degree		0.178 (0.067)***
Tobin's Q		0.482 (0.185)***
US firm		–0.140 (0.546)
Number of employees		0.000 (0.000)
Constant		–2.492 (0.811)***
N	178	168
Wald statistics	16.30	35.90***
Log pseudo likelihood	–833.6584	–517.0738

Note: (a) Importance of universities for innovation = 0 as the reference category.
(b) Respondents with "importance of universities for innovation" = 0 or 1.
(c) Respondents with "importance of universities for innovation" = 0 or 2.
*** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

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