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Which types of knowledge-intensive business services firms collaborate for innovation with universities and benefit from such collaboration?

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Abstract

Recent research stresses the growing relevance of external sources of innovation for companies, and particularly collaborative relationships for innovation with universities. Less attention has been paid, however, to the role of strategic and knowledge relatedness in such process. Using data from an original survey, this paper explores what determines whether knowledge-intensive business services (KIBS) firms collaborate with universities and whether they consider this collaboration as important for innovation. We find that technology-driven KIBS firms, which share a high level of knowledge relatedness with universities, both collaborate with universities and consider them important for innovation. There is some evidence that strategic relatedness matters: while KIBS firms providing customised services value universities for innovation, they do not collaborate with them; and, while product innovation leaders collaborate with universities, they do not regard such collaboration an important source of innovation. Managers and policymakers need to take into account the role of knowledge relatedness and thus formulate more tailored strategies to foster knowledge flows from university to companies effectively.

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Key words: services, KIBS, industry-university relations, collaboration, knowledge relatedness

1. Introduction

Recent research stresses the growing relevance of external sources of innovation (Arora et al., 2016; Chesbrough, 2006), and also point to the particular importance of innovation collaboration with universities for high-tech firms (Freitas et al., 2013; Perkman and Walsh, 2007). These collaborations have received impetus both as a result of shifts in legislation, such as the introduction of the Bayh-Dole Act in the USA (Mowery and Nelson, 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) and increased revenues from licensing by universities (Thursby and Thursby, 2001). We know little, however, about which firms collaborate with universities and why. In particular, we know very little about which services firms, especially knowledge-intensive business services (KIBS) firms, collaborate with universities.

Research on the importance of innovation collaboration by service firms with universities is inconclusive. On the one hand, some contributions argue that service firms are less likely than manufacturing firms to collaborate for innovation with universities and rate universities lower as a source of innovation than manufacturing firms (Arundel et al., 2007; Love et al. 2011). On the other hand, alternative contributions find that KIBS firms attach more importance to knowledge from universities and public research organisations in their open innovation activities than manufacturing firms (Mina et al., 2014). One of the problems that obfuscates our understanding of the patterns of collaboration for innovation by services firms is that services are very diverse, meaning that generalisations about their innovation behaviour, let alone their innovation collaboration strategy, is very difficult.

To explore this further, we draw on an original survey of 162 publicly-traded KIBS firms in the UK and the USA. Our paper advances our understanding of the role of strategic and knowledge relatedness and KIBS collaboration with universities. The role of relatedness has attracted much attention in M&A research (Hagedoorn and Duysters, 2002; Makri et al., 2010; Ramaswamy, 1997)

and in firms' diversification strategy (Davis et al., 1992; Farjoun. 1998; Markides and Williamson; Rumelt, 1974), but has been less explored for innovation collaboration. We find that technology-driven KIBS firms, which share a high level of knowledge relatedness with universities, both collaborate with universities and consider them important for innovation.. There is some evidence that strategic relatedness matters: while KIBS firms providing customised services value universities for innovation, they do not collaborate with them; and, while product innovation leaders collaborate with universities, they but do not regard such collaboration an important source of innovation. Managers and policymakers need to take into account the role of knowledge relatedness and thus formulate more tailored strategies to foster knowledge flows from university to companies effectively

The paper is organised into five sections. The next section explores the literature on relatedness and innovation collaboration and described the framework that drives the analysis. The following section outlines the data and the analysing methods. The fourth section reports the findings. The final section contains the discussion and conclusion.

2. Conceptual framework: relatedness and innovation collaboration

Building on knowledge-based and organisational learning perspectives, we focus on services firms as learning organisations, constantly configuring and reconfiguring knowledge and resources from internal and external environment to innovate products and services (Kogut and Zander, 1992; Teece et al., 1997). Knowledge outside the boundary of a firm becomes important for innovation as innovation process become increasingly distributed and can involve different actors from diverse sectors (Chesbrough, 2003; Laursen, 2012). To maximise synergy in an innovation collaboration, firms do not choose their partners randomly, but based on strategic fit and resource compatibility (Brouthers et al., 1995; Hagedoorn and Duysters 2002; Medcof, 1997). At an operational level, managers need to assess which potential candidates fit into their collaboration agenda and which do not. Studies show that relatedness among participants from different organisations facilitates partners' ability to capture greater value from a partnership (Darr et al., 2000; Porter, 1987; Ramaswamy, 1997; Nielsen, 2010). Porter (1987) pointed out that relatedness comes from at least two sources: shared

business activities and transferrable skills/expertise. Shared business activities enhance efficiency and transferable skills/expertise make communication from different parties meaningful. Darr et al. (2000) and Ramaswamy (1997) argued that similarity in firms' strategic orientations, i.e. strategic relatedness, which has direct impact on firms' resource allocations and business activities, is significant in effective knowledge transfer within collaboration partners. Similarly, Nielsen (2010) developed a framework of strategic fit in alliances, where when cost-reduction focused firms collaborate, synergy can be achieved through economies of scale, and when innovation-driven firms collaborate, synergy is realised through the exploration of new products, markets or opportunities. We discuss relatedness in line with existing literature and consider a firm's strategic orientation as the template for shared business activities within the organisation. We interpret transferable skills/expertise as shared knowledge base. The two domains of relatedness and how these factors may affect KIBS firms' collaboration with universities are discussed below.

2.1. Strategic relatedness

Research in strategic alliance has long established that, when alliance partners are similar in business activities in the areas of product, market, operation or scientific research, the shared relatedness in their business activities reduces information asymmetry and enhances synergy in collaboration (Koh and Venkatraman, 1991; Merchant and Schendel, 2000; Rumelt, 1974). Porter (1987) argued that firms with product or market relatedness share a commonality in their experience and business problems. Based on accumulated product and market expertise, when these firms collaborate, they can identify opportunities beneficial to all more effectively. Shared operational activities enhance production efficiency and reduce costs. By contrast, when task relatedness is low, the barrier to communication between partners rises (Daft and Lengel, 1986).

According to Nelson and Winter (1982), business activities of members in an organisation, whether they are related to product/market development or operations, are guided by organisational rules and routines. At the higher level, managers make conscious decisions hoping for intended business outcomes. At the functional level, employees conduct their job tasks in order to implement the intended business outcomes. Within the organisation, when actions between higher-level decision-

making processes and lower level function tasks become coherent and when mutual understanding is embedded in the organisation, the organisation exhibits well-coordinated organisational rules and routines. The coherent actions between higher-level decision making processes and lower level function tasks demonstrate a firm's learning capabilities (Kogut and Zander, 1992; Teece et al. 1997). In a learning organisation, members at every level know what to do and how to get things done and, collectively, organisational goals are fulfilled. Evidence shows that those organisations whose focused business activities are aligned with their competitive strategies are high performers (Dess and Davis, 1984). In other words, in a learning organisation, business activities mirror the organisational rules and routines, and organisational rules and routines mirror the organisation's strategic orientation. Strategic business activities underpin how an organisation strategically competes in the market (Markides and Williamson, 1994).

Thus when organisations share a similar strategic orientation, they are also more likely to share similar past experience, similar patterns of resource allocations, similar business problems, similar problem-solving attitudes and similar focuses of functional tasks. When organisations share a variety of such strategically relevant features, they are seen as having a higher degree of strategic relatedness (Markides and Williamson, 1994; Ramaswamy, 1997). Following the argument that task relatedness creates synergy in collaboration, firms exhibiting higher degree of strategic relatedness are more likely to benefit more from forming alliances (Markides and Williamson, 1994; Altunbaş and Marqués, 2008; Darr et al., 2000; Porter, 1987; Ramaswamy, 1997; Nielsen, 2010). Markides and Williamson (1994) studied manufacturing firms and found that when firms with similar service orientations (providing high service requirement and serving a concentrated customer segment) collaborate, they outperform others. In the context of services firms' search for innovation partners, Darr et al. (2000), based on a study of pizza-delivery franchise organisations in England, found that communication among stores with similar business strategies is more effective and is associated with enhanced store performance (reduced production costs). When firms that offer highly differentiated products (reputational factor, product leadership, etc.) form an alliance, there is an extra reputational/competitiveness gain for these firms (Dranove et al., 1998). Ramaswamy (1997) reported

that in the US banking sector, when a bank that focuses on operational excellence merges with another highly customisation-focused bank, there is a negative impact on their performance after the merger. The same negative effect was found also for firms in the EU banking sector (Altunbaş and Marqués, 2008).

The service sector is peculiar in several ways. The intangible nature of service offerings implies difficulties in demonstrating and storing these products (Illeris, 1989). Clients cannot often fully assess service offerings before purchase; clients, however may have "expectations" about the service quality (Sundbo, 2002). Service production and consumption often happen simultaneously; usually customers are directly integrated into the service production and delivery process (Gallouj and Weinstein, 1997). What is important for service firms' competitiveness is how to create expected value for clients before the purchase and the extent to which firms integrate clients in the simultaneous service production and delivery process. It is argued that, 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 spectrums of value proposition: standardisation/mass production and customisation/individualisation (Sundbo, 1994). Standardising services requires employees to execute service delivery precisely and efficiently. The value proposition for firms pursuing the strategy is realised through streamlined operational process (ordering, selling, delivery, etc.), cost-effectiveness and hassle-free customer experience (Sundbo, 2002; Treacy and Wiersema, 1995). On the other hand, customised services offer customers experience that is tailored, novel, one-off, ad-hoc, unique or simply the best. The basis of competition for firms which such a strategy is not cost reduction or efficiency, but innovation, responsiveness, flexibility and attention to the development of client solutions (Sundbo, 2002; Treacy and Wiersema, 1995).

Following the argument that when firms with a similar strategic orientation collaborate, a greater synergy can be generated, we may expect that, standardisation-based KIBS firms, which in order to meet production efficiency are more likely to exploit existing resources to excel in the production and delivery of existing services, are more likely to collaborate with suppliers providing standardised

products and interact with clients who are looking for standardised services. By contrast, firms that are competing through a customisation strategy by highly individualising their products/services will be more likely to collaborate with partners with such a similar strategy. Among all potential types of external partners, academics are the most obvious type of partners that pursue originality, novelty and uniqueness for each individual project. We thus suspect that firms that are highly specialised in offering ad-hoc and customised services are less likely to source highly novel or unique ideas from ordinary partners (along the supply chain). There is a good reason to believe that, compared to standardisation-based KIBS firms, highly customisation-based KIBS firms benefit more from collaboration with universities, as they both share a common objective of producing the most novel and the best solution to each individual problem.

Similarly, we would expect KIBS firms engaged in innovation activities to share similarities in operational and problem-solving activities with universities. The challenge here is to find appropriate indicators or measures of the intensity of these innovation activities, as, although some KIBS firms invest heavily in R&D, it is well known that R&D underrepresents innovation activities of service firms (Miles, 2007).

2.2. Knowledge relatedness

In the context of knowledge transfer, strategic relatedness indicates whether partners share common business problems and common problem-solving attitudes. The concept of strategic relatedness, however, does not contemplate the knowledge domain of learning, or how learners identify, differentiate, assimilate and absorb external knowledge (Cohen and Levinthal, 1990). Theories on effective knowledge transfer suggest that organisations sharing a higher level of relatedness in knowledge base among each other are more likely to create synergy in collaboration (Nonaka, 1994; Zara and George, 2002). Indeed, the concept of knowledge relatedness has been conceptualised in terms of the transferability of employee skills/knowledge (operationalised as profiles of industry expertise based on official occupational classification or formal qualifications) (Porter, 1987; Farjoun, 1998), similarity in scientific knowledge in subject areas (often operationalised in terms of journal citations), and technological knowledge in industrial fields (based on patent citations) (Makri et al.,

2010; Miozze et al., 2016). The idea is that when organisations with a higher level of knowledge relatedness work together, it is easier for them to recognise, absorb and recombine knowledge effectively. Firms' interaction with universities however might be challenging. Ankrah et al (2013) studied the Faraday Partnership Initiative in the UK and found that industrial firms collaborate with academia to access cutting edge knowledge and technologies. Studies show that knowledge relatedness matters and collaboration with universities is found to be more important in science-based industries than in other sectors (e.g. Meyer-Krahmer and Schmoch, 1998; Schartinger et al., 2002). For instance, based on patent data, Meyer-Krahmer and Schmoch (1998) showed that the co-production of scientific knowledge between industry and academia is more common in the fields of chemistry, biomedicine and computer sciences. Only firms that are able to process highly science-based knowledge are able to collaborate with universities to create positive effect for their innovation.

Among KIBS firms, it is possible to identify a segment of science-based firms (Miozzo and Soete, 2001). Miles et al. (1995) distinguished between technology-driven services (T-KIBS) and professional services (P-KIBS). T-KIBS comprises sectors such as IT services, R&D services, and engineering/design services. Studies show similarities in terms of the way knowledge is produced and the role in economic development between T-KIBS firms and science-based organisations. For instance, although client co-creation for service innovation is vital, based on in-depth interviews of design service firms, Lehrer et al. (2012) pointed out that at the stage of the generation of creative ideas, design service firms may require certain autonomy with limited input from clients in order to be innovative. The finding is in line with literature in scientific research stressing creativity and autonomy (e.g. Stephan, 1996). Pina and Tether (2016) showed that IT/software and engineering services are highly based on analytical knowledge, which emphasises the application of formal scientific knowledge. Robert et al (2013) showed how R&D services firms could provide solutions from contract research to product development. This shows that the services provided by R&D service firms can be seen to cover what a normally fully functioning manufacturing firm's R&D department would do. Tether and Tajar (2008) argued that some KIBS firms serve a similar role as universities and public research organisations as specialist knowledge providers for firms in the various sectors.

Similarly, Castellacci (2008) proposed a sectoral taxonomy outlining sources of knowledge of several sectors, and suggested that KIBS firms, in particular the IT service firms, R&D service firms, engineering service firms and consultancies, perform functions similar to the high-tech specialist suppliers in manufacturing and act as knowledge providers to firms in other sectors.

Drawing on these findings, one may suggest that, among KIBS firms, T-KIBS firms and universities share a higher level of knowledge relatedness, and are thus more likely to collaborate with universities and benefit from the collaboration. Indeed, Castellacci (2008) theorised that software services, R&D services, engineering services and consultancy services would be more likely to link with universities for innovation in that these firms have a very high level of technological capability and are able to produce complex knowledge. Also, Bonaccorsi et al. (2013) examined the link between university knowledge specialism and new firm creation. They found that the creation of new KIBS firms is positively associated with regional universities' specialism in applied sciences and engineering, but not with basic sciences or social sciences and humanities. This suggests that the link between KIBS firms and universities rests in the field of applied sciences. Based on descriptive statistics of a German survey, Czarnitzki and Spielkamp (2003) also showed that T-KIBS firms exhibit a greater tendency to regard knowledge from universities as an importance source for innovation.

We have examined the determinants of effective knowledge transfer according to the concept of relatedness in both the domains of competitive strategy and knowledge. The study follows an exploratory approach and focuses on how KIBS firms may selectively enter a partnership with universities accordingly. The paper intends to answer the following questions:

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

3. Data and methods

The study is based on an original survey of KIBS firms in the US and the UK. The survey was conducted between September and December 2012. We use a list of UK and US publicly-traded knowledge-intensive service firms in Datastream as the sampling frame. The sampling frame comprises 406 UK and 1892 US publicly traded firms. The survey obtained 223 firm responses (92 UK and 131 US firms) and the overall response rate is 10.3% (23% for the UK and US 7% for the US firms). The assessment of the survey's non-response bias using the characteristic comparison method (Lawton and Parasuraman, 1980) showed that UK firms and large firms are over-represented.[1] We thus weighted the data with firm size and the firms' country of origin, based on the inverse response propensity as assessed using logistic regression modelling (David et al., 1983; Kalton and Flores-Cervantes, 2003). In this paper, excluding missing data, 162 firms are used for the analysis. The analysing units are firms. The analysing method is logistic regression and the analysing tool is STATA 13.

Dependent Variables

There are two binary dependent variables used for two sets of regressions. The first dependent variable is constructed through a survey question asking for each firm, whether the firm collaborated with universities between 2009 and 2011 (yes=1 and no=0). If the firm collaborated with universities, the firm was asked to score between 1 and 5, how important are universities for the firm's innovation. When the firm did not collaborate with universities for innovation, a score of zero was given. Thus, a second dependent variable indicating the importance of universities for innovation is constructed through collapsing the scores. When firms gave a score 4 or 5, we consider that universities are very important for their innovation (coded 1). Otherwise, universities are considered to be of low importance for firms' innovation (coded 0).

Independent Variables

[1] We compared respondents and non-respondents by country, firm size (number of employees) and industrial sector (2-digit SIC code).

We firstly construct variables to indicate firms' strategic orientation. We asked firms to assess from minor (coded 1), to moderate (coded 2) and to substantial (coded 3), the importance of each of the following types of service in their overall revenues: 1) one-off services, 2) major modification of standardised services, 3) minor modification of standardised services and 4) highly standardised services. We carried out a factor analysis of the four items (principal component analysis as the extraction method, Varimax as the rotation method, and an Eigenvalue greater than 1 as factor selection criteria) and identified two factors representing two types of service orientation: "modification" and "standardisation" (Table 1). The two factors explain 65% of the variances. Results from Table 1 also indicate that for the factor of "standardisation", a very high factor score shows a high orientation towards the provision of standardised services. On the other hand, a very low factor score suggests a high orientation towards the provision of one-off services. We further single out the population of firms whose orientation in "modification" is low (below the average score) and orientation in "standardisation" is low (below the average score). We label the population as firms providing "highly customised services mainly". That is, these firms provide relatively lower level of any modified or standardised services and relatively higher level of one-off services. Following the same procedure, we single out the population of firms whose orientation in "modification" is low (below the average score) but orientation in "standardisation" is high (above the average score), and label the population as firms providing "highly standardised services mainly". These firms provide relatively lower level of any modified or one-off services and relatively higher level of standardised services.

[Insert Table 1 about here]

Also, it has been argued that R&D activities are important strategic assets for firms and in a learning organisation, R&D activities are alight with firm strategic orientation (Markides and Williamson, 1994). We constructed an index "R&D intensity" reflecting whether the firm was engaged in the following activities (Cronbach's $\alpha = 0.657$): 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). Following the same

argument, leading innovators are likely to be associated with firms that highlight R&D activities. We construct the variable of innovation leaders by using the percentage of firms' income from product or process innovation in 2011.

The second set of independent variables is related to the heterogeneity of knowledge base within KIBS firms. We use two indicators as the proxy for knowledge base of KIBS firms. First, based on the notion that KIBS firms' knowledge base is closely linked to their individual employees and their formal qualifications (Larsen, 2001), for each firm, we asked the percentages of the firm's graduate staff from sciences/engineering, business/economics/social sciences, law/education, and culture/art. Secondly, the knowledge base of KIBS firms may be based on their job tasks, which is reflected in their official codes of occupational classification. We follow the classification proposed by Miles et al (1995) to define T-KIBS firms using NACE codes.[2] We then convert NACE codes to US SIC codes. Finally, we define T-KIBS firms as those operating in US SIC codes 48 (communications services), 737 (computer services), 871 (engineering/architectural/survey services) and 873 (R&D services).

There are several variables indicating firm and industry characteristics. The first is constructed through a survey question related to firms' organisational knowledge formalisation procedure, as one of the challenges for KIBS firms' learning is the ability of formalising organisational knowledge procedures (Gallouj and Weinstein, 1997). For each firm, we asked whether the firm has: 1) an explicit manual or blueprint that describes systematically the firm's corporate processes and operating practices (yes=1 and no=0), 2) systematic ways of reviewing performance and learning from your experience of service provision (yes=1 and no=0), and 3) a system in place to locate internal experts with specialist knowledge to facilitate knowledge exchange and reuse (yes=1 and no=0). An index "formalised organisational procedure" is constructed based on the above three items (Cronbach's α = 0.422). Laursen and Salter (2004) explore manufacturing firms and showed that besides R&D intensity, (manufacturing) large firms and firms that are more open are more likely to collaborate with universities. We thus control for these variables. In order to capture KIBS firms' special relationship with suppliers and clients, we asked whether the firm collaborate for innovation with suppliers (yes=1

[2] T-KIBS sector comprises firms belonging to NACE codes 72.1, 72.5, 72.21, 72.22, 72.3, 72.4, 72.6, 73, 74.2 and 74.3.

and no=0) and clients/customers (yes=1 and no=0). We then constructed an index 'collaboration with vertical partners' based on answers to the two items (Cronbach's $\alpha = 0.578$).We use the natural logarithm of the number of employees to proxy firm size. Freitas et al. (2013) reported that firms in high-tech emergent industries - characterised by turbulent influx of knowledge, tacit knowledge and new knowledge that has not yet embedded in industrial organisations - seek knowledge from suppliers and universities. We thus also control the degree of the market development of the industries (emerging, growing or mature) the firm are in. Other control variables include the location of the firm (UK or US) and whether the firm has in-house experts to deal with issues related to intellectual property.

4. Findings

Descriptive statistics and correlation table are shown in Table 2 and Table 3. Regression results are shown in Table 4. There is no significant evidence of multicollinearity, as the maximum value of the variance inflation factor of the variables is 2.36, which is well below the recommended threshold value of 10 (Cohen et al., 2003). We also assessed the common method bias using Harman's one factor test (Harman, 1967). Form the two model specifications (with two different knowledge relatedness indicators), we extracted seven (model specification using the percentage of firms' graduates from sciences and engineering as an indicator for knowledge relatedness) and five factors (model specification using T-KIBS as an indicator for knowledge relatedness) with eigenvalues greater than 1. The extracted factors explain 63.90% and 60.26% of the variances respectively.

[Insert Table 2, Table 3 and Table 4 about here]

There are several key findings emerging from the regression results. First, we find that knowledge relatedness is an important factor in explaining whether firms collaborate with universities and consider universities as highly important for their innovation. We used two indicators of knowledge relatedness between firms and universities, i.e. the percentage of firms' graduates from sciences and engineering and whether firms operate in selected sectors (T-KIBS firms), to explore how knowledge relatedness may be associated with firms' likelihood of interacting with universities. We found

consistently that these two variables are positively associated with collaboration with universities (columns 1 and 2 in Table 4), and also with firms' perception of universities as very important for their innovation (columns 3 and 4 in Table 4). The higher the proportion of KIBS firms' graduate staff from sciences or engineering, the more likely the firms collaborate with universities and value universities highly. Similarly firms operating in T-KIBS sectors collaborate with universities and are more likely to value this collaboration for their innovation.

Second, we find that strategic relatedness is an important factor in explaining either whether firms collaborate for innovation with universities or consider universities as highly important for their innovation (but not both). On the one hand, there is some evidence that firms focusing on providing mainly one-off services value highly collaboration with universities for their innovation when they enter an innovation partnership with universities (column 4 in Table 4). However, because not all of our regressions show a consistent statistically significant positive association between strategic relatedness and the perceived importance of innovation collaboration with universities (columns 3 and 4 in Table 4), this finding needs to be treated with caution. On the other, the greater the share of firms' income from product innovation (product innovation leaders), the more likely that firms will collaborate with universities (columns 1 and 2 in Table 4), although the firms do not consider universities as important for their innovation (columns 3 and 4 in Table 4).

Finally, in line with the existing literature, firms in growing markets and large firms are more likely to collaborate with universities and perceive them as important partners for innovation. Firms that collaborate with suppliers and clients for their innovation also tend to collaborate and value universities for innovation.

6. Discussion and conclusion

Our study contributes to the understanding of the determinants of innovation collaboration, and particularly the determinants of innovation collaboration by KIBS firms with universities. The key finding is that knowledge relatedness plays a key role in understanding both which KIBS firms collaborate with university and which consider universities as important for their innovation.

Quadrant IV in Figure 1 represents this: technology-driven KIBS firms both collaborate with universities and consider this collaboration as important for their innovation. This can be explained by relatedness in their knowledge base. Our study thus builds on existing literature stressing the critical role of firms' ability to identify, differentiate, assimilate and absorb external knowledge (Cohen and Levinthal, 1990).

[Insert Figure 1 about here]

Our results offer greater granularity to existing studies pointing out that R&D intensity is associated with manufacturing firms' collaboration with universities (e.g. Laursen and Salter, 2004). We suggest that special attention needs to be paid to the role of knowledge relatedness when discussing KIBS firms' relation with universities.. KIBS firms are highly heterogeneous in their knowledge bases and their R&D activities are hard to define, conceptualise and measure (Miles, 2007; Miozzo and Soete, 2001). The strategy of KIBS firms to collaborate for innovation collaboration with universities may not be shaped so much by their R&D-intensity (R&D being a poor measure of innovation activities for service firms), but about the extent to which the firms are able to integrate the highly science-based external knowledge flows. We have shown that KIBS firms with higher proportion of graduates from science and engineering and which operate in communication, computer and engineering/architectural/survey services (i.e., they are T-KIBS firms) are more likely to collaborate and consider the collaboration with universities important for their innovation.

Strategic similarity also matters, but to a lesser extent. Quadrant III in Figure 1 indicates a group of KIBS firms offering customised services which consider collaboration with universities as important to their innovation. These firms share strategic relatedness with universities in that their main services also focus on providing novel solutions to individual problems. Interestingly, as a group, these firms do not show a greater tendency of collaborating with universities, compared to KIBS firms. In order to understand further this finding, we examined the detailed collaboration pattern of firms with universities (Table 5). Results show that firms which regard collaboration with universities as a highly importance source of innovation tend to offer highly customised services. This also suggests that there

might be further heterogeneity within this strategic group. That is, only a small proportion of firms offering highly customised services show a greater likelihood of collaborating with universities and valuing the collaboration highly. Further research may explore within the group of firms offering highly customised services, what types of customisation strategy, i.e. novelty, customer intimacy, or uniqueness (Miozzo et al., 2012), may be more likely to collaborate and consider the collaboration with universities as important for innovation.

[Insert Table 5 about here]

Quadrant III in Figure 1 points out a group of firms who collaborate with universities but do not consider this collaboration as important for innovation. This group of firms is characterised by a high level of income from product innovations. Like KIBS firms offering customised services, these innovation-intensive firms share strategic relatedness with universities in the way they organise their operational and problem-solving activities. This finding is consistent with results from a previous study of a sample of manufacturing and service firms which found that the development of product innovation, rather than process innovation, is positively associated with firms' collaboration with universities (Fitjar, 2003). For service firms, Janeiro et al. (2013) also found that innovation leaders, who are more successful in capturing value from their innovations, are more likely to collaborate with universities. Innovation leaders' knowledge searching behaviour, however, is complex. Cassiman and Valentini (2016) showed that innovation leaders' open innovation strategy comprises a mix of buying external knowledge and selling their knowledge assets in the marketplace. Furthermore, Santoro and Chakrabarti (2002) found that resourceful firms are more likely to collaborate with universities for the areas that are not their core competences. This suggests that for product innovation-leading KIBS, the main motivation to collaborate with universities might be less for direct inward knowledge transfer for their core knowledge area, but more for creating further opportunities in the market.

Our results suggest that managers may need to pay attention to strategic and knowledge relatedness when developing their innovation collaboration strategy. This may also involve linking to their human resources management strategies. KIBS firms wishing to benefit from collaboration with universities

may need to recruit talented science and engineering graduates to bridge firm's requirement of internal and external sourcing of knowledge from universities. Although trained traditionally for scientific careers in manufacturing, increasingly, science and engineering graduates are working in technical or professional services firms and applying their high levels of analytical skills and problem solving capabilities in the production of expert solutions (Lee et al., 2010). In addition, managers should be aware of the importance of alignment between firm competitive strategy and collaboration strategy.

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Table 1: Factor analysis results

	Modification	Standardisation
One-off services	0.3895	**-0.6948**
Major modification of standardised services	**0.8177**	-0.0033
Minor modification of standardised services	**0.7115**	-0.017
Highly standardised services	0.1353	**0.8677**

Table 2: Descriptive statistics (weighted data)

	Mean	**Std. Dev.**
Collaboration with universities	0.272	0.446
Universities important for innovation	0.119	0.325
Highly customised services mainly	0.180	0.385
Highly standardised services mainly	0.281	0.451
Collaboration with vertical partners	0.655	0.392
% graduates in sciences/engineering	21.167	28.704
% graduates in business/economics/social sciences	35.432	28.667
% graduates in law/education	6.504	10.028
% graduates in culture/art	4.302	6.681
TKIBS	0.235	0.425
Formalised organisational procedure	1.204	0.274
RD intensity	0.102	0.686
% income from product innovation	13.622	22.841
% income from process innovation	9.016	21.303
Growing market	0.459	0.500
Mature market	0.342	0.476
US firms	0.803	0.399
Log the number of employees	5.189	2.472
In-house IP expertise	0.457	0.500

Table 3: Correlation table (weighted results)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. Collaboration with universities	1.000																		
2. Universities important for innovation	0.601	1.000																	
3. Highly customised services mainly	0.033	0.096	1.000																
4. Highly standardised services mainly	-0.110	-0.040	-0.293	1.000															
5. Collaboration with vertical partners	0.254	0.148	-0.028	-0.034	1.000														
6. % graduates in sciences/engineering	0.312	0.290	0.146	-0.182	0.109	1.000													
7. % graduates in business/economics/social sciences	-0.003	-0.054	-0.151	0.134	-0.116	-0.357	1.000												
8. % graduates in law/education	-0.039	0.038	-0.121	0.026	-0.121	-0.170	0.144	1.000											
9. % graduates in culture/art	0.031	-0.041	-0.219	0.102	0.157	0.010	0.105	0.084	1.000										
10. TKIBS	0.259	0.255	0.173	-0.142	0.195	0.438	-0.229	-0.182	-0.114	1.000									
11. Formalised organisational procedure	-0.051	-0.030	0.135	-0.163	0.036	0.009	-0.237	0.005	-0.015	0.098	1.000								
12. RD intensity	0.145	0.161	0.130	0.042	0.327	0.334	0.048	-0.120	0.043	0.362	-0.340	1.000							
13. % income from product innovation	0.221	0.163	0.014	-0.006	0.237	0.207	0.020	-0.072	0.119	0.281	0.013	0.236	1.000						
14. % income from process innovation	0.040	0.056	-0.010	-0.032	0.223	0.053	0.107	-0.060	0.146	0.080	-0.186	0.187	0.441	1.000					
15. Growing market	0.124	0.193	-0.082	0.035	0.034	0.072	-0.064	-0.098	0.034	-0.032	-0.080	0.049	0.131	0.248	1.000				
16. Mature market	-0.061	-0.127	-0.021	-0.030	0.022	-0.185	0.013	0.057	-0.107	-0.082	0.046	-0.123	-0.261	-0.241	-0.663	1.000			
17. US firms	0.056	0.032	0.081	0.029	0.046	-0.021	0.269	0.016	-0.009	-0.036	-0.242	0.176	-0.050	0.117	0.053	-0.137	1.000		
18. Log the number of employees	0.202	0.139	-0.033	-0.255	0.124	0.071	-0.131	-0.127	0.111	0.052	-0.156	0.043	-0.095	-0.118	-0.005	0.235	-0.196	1.000	
19. In-house IP expertise	0.057	0.033	0.081	-0.144	0.047	0.031	-0.014	0.069	-0.088	0.030	-0.118	0.071	-0.067	-0.045	-0.052	0.098	-0.074	0.396	1.000

Table 4: Regression results (weighted results)

	Collaboration with Universities		Universities important for innovation	
	(1)	(2)	(3)	(4)
	Coef. (Robust Std. Err.)	Coef. (Robust Std. Err.)	Coef. (Robust Std. Err.)	Coef. (Robust Std. Err.)
Highly customised services mainly	0.634	0.370	1.842	1.353*
	(0.669)	(0.623)	(1.256)	(0.798)
Highly standardised services mainly	-0.179	-0.403	0.929	0.389
	(0.582)	(0.560)	(0.900)	(0.758)
Collaboration with vertical partners	2.269***	1.760***	2.236***	1.417*
	(0.743)	(0.631)	(0.861)	(0.802)
% graduates in sciences/engineering	0.034***		0.038*	
	(0.012)		(0.022)	
% graduates in business/economics/social sciences	0.019		0.020	
	(0.013)		0.025	
% graduates in law/education	0.020		0.070**	
	(0.028)		(0.034)	
% graduates in culture/art	-0.016		-0.097**	
	(0.035)		(0.047)	
T-KIBS		1.149**		1.566**
		(0.563)		(0.642)
Formalised organisational procedure	-0.827	-1.121	0.257	-0.635
	(0.940)	(1.069)	(0.965)	(1.111)
RD intensity	-0.383	-0.214	-0.119	0.080
	(0.469)	0.421	(0.746)	(0.443)
% income from product innovation	0.026***	0.024**	0.019	0.014
	(0.009)	(0.011)	(0.013)	(0.012)
% income from process innovation	-0.016	-0.016	-0.008	-0.008
	(0.011)	(0.011)	(0.015)	(0.012)
Growing market	1.357**	1.101*	2.456**	2.073*
	(0.648)	(0.649)	(1.229)	(1.152)
Mature market	0.978	0.514	0.991	0.524
	(0.785)	(0.721)	(1.377)	(1.342)
US firms	0.499	0.727	0.289	0.439
	(0.558)	(0.534)	(0.789)	(0.685)
Log the number of employees	0.233**	0.221**	0.364***	0.305***
	(0.095)	(0.094)	(0.116)	(0.110)
In-house IP expertise	-0.157	-0.093	-0.033	0.146
	(0.473)	(0.474)	(0.546)	(0.649)
Constant	-6.118***	-3.895**	-10.824***	-6.991***
	(2.093)	(1.874)	(3.429)	(2.001)
N	162	162	162	162
Wald statistics	Wald chi2(16)= 36.34***	Wald chi2(13)= 32.66***	Wald chi2(16)= 26.30**	Wald chi2(12)= 34.02***
Log pseudo likelihood	-713.026	-764.986	-409.308	-453.946

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

Figure 1: KIBS and collaboration with universities

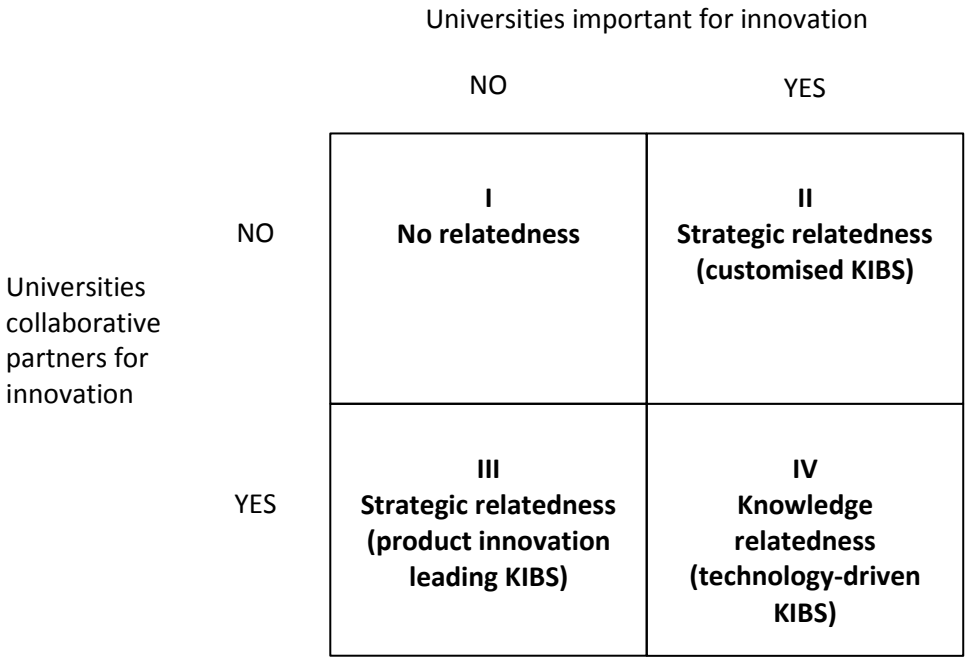

Table 5: Highly customised KIBS firms and importance of collaboration with universities (weighted results)

		Importance of collaboration with universities for innovation						
		No collaboration	Of limited importance 1	2	3	4	Highly important 5	Total
Highly customisation-based one-off services firms?	No	83%	81%	80%	90%	84%	**51%**	82%
	Yes	17%	19%	20%	10%	16%	**49%**	18%
	Total	100%	100%	100%	100%	100%	**100%**	100%