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International collaboration and innovation in professional and technological knowledge-intensive services

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Abstract

In this paper we explore the impact of international collaboration on innovation in technological and professional knowledge-intensive business services. We propose that the benefits of international collaboration differ depending on the activity sector and the location of the foreign partner. Specifically, we argue that the nature of knowledge and innovation processes in professional and technological knowledge-intensive business services may explain different effects of international collaboration on innovation performance. Our empirical analysis is based on a large sample of knowledge-intensive business services for the period 2004-07. We specify two bivariate probit models to test our hypotheses. The results confirm the hypotheses and show that proximity to international partners is more important for professional knowledge-intensive services, while diversity in international collaboration is more important for technological knowledge-intensive services.

Keywords: International collaboration, service innovation, professional knowledge-intensive business services, technical knowledge-intensive business services
**Introduction**

Collaboration permits firms to establish links with other agents who provide them with access to resources and capacities that are not available in-house (Oxley and Sampson 2004). In fact, technological collaboration has been shown to exert a positive effect on the innovation performance of firms in both domestic (Belderbos, Carree, and Lokshin 2004; Faems, Van Looy, and Debackere 2005) and international alliances (Ebersberger and Herstad 2013; Rodríguez and Nieto 2012). In the case of international collaboration, the evidence reveals that this is a rapidly growing phenomenon that constitutes an area of increasing interest for firms (Antcliff 2012; National Science Board 2008), academia (Duyster and Lokshin 2011; Hinds, Liu, and Lyon 2011; Leung 2013; Narula 2003; Narula and Hagedoorn 1999) and policy makers (Hotterott and Lopes-Bento 2014). Consequently, over recent years different papers have analyzed diverse aspects of effective collaboration across countries (Metiu 2006; Levina and Vaast 2008; Pandza, Wilkins, and Alfoldi 2011), geographical dispersion of work groups (O’Leary and Cummings 2007; O’Leary and Mortensen 2010; Wilson, O’Leary, Metiu, and Jett 2008), and collaboration via virtual work (Yates and Orlikowski 2002; Schultze and Orlikowski 2010). Despite the importance of international collaboration, further work is still required on the area of innovation activities (Herstad, Aslesen, and Ebersberger 2014). Specifically, few studies have examined how sectoral characteristics and the geographical origin of partners may influence the relation between international collaboration and innovation (Miotti and Sachwald 2003; Rodríguez and Nieto 2012). In this paper we advance in this stream of research by exploring the differentiated role of international collaboration in the context of services, more precisely in knowledge-intensive business services (henceforth KIBS).

KIBS can be defined as firms that trade with knowledge; most of the work of these firms is of an intellectual nature and their main asset is highly qualified human capital (Alvesson 1995,
2001, 2004; Starbuck 1992). For these firms, social networks play a key role in generating and supporting knowledge creation and exchange (Salter and Tether 2006). KIBS are seen as knowledge brokers and intermediaries (Hipp and Grupp 2005; Howells 2006). Their role as knowledge providers (Miles 2005) makes KIBS a highly strategic sector. They are particularly relevant in today’s economies, which are ever more commonly based on services and knowledge. These services are estimated to represent on average 15 percent of the volume of business of market services in European economies, as well as being the main activity of 3.2 million firms in the EU-27 in 2005 (Eurostat 2008).

KIBS have particular characteristics related to knowledge and innovation management (Hansen, Nohria, and Tierney 1999; Leiponen 2005, 2006; Robertson, Scarbrough, and Swan 2003). The literature on innovation developments highlights that firms in knowledge-intensive sectors innovate differently from those in other sectors (Tether 2003; Tether and Hipp 2002; Tödling, Lehner, and Trippl 2006; Vence and Trigo 2009). Innovation in KIBS depends more on qualified personnel and collaborative relationships with other organizations than on activities such as formal R&D (Leiponen 2005; Rodríguez and Nieto 2010). In addition, the tendency of KIBS to collaborate in order to exchange knowledge and develop innovations differs from that of other services (Trigo and Vence 2012; Vence and Trigo 2009). KIBS are notable for the importance of their interaction with other agents (Tether and Hipp 2002), most commonly exchanging information with clients to generate knowledge (Bettencourt, Ostrom, Brown, and Roundtree 2002; Skjøtsvik, Løwendahl, Kvalshaugen, and Fosstenløkken 2007) and innovations (Muller and Zenker 2001; Tether and Hipp 2002; Toivonen and Tuominen 2009). This makes them an especially interesting subject for an analysis of the effects of international collaboration. Beyond this, since it is possible to distinguish different activities within KIBS, they provide a suitable context for understanding how the impact of international collaboration can differ depending on the characteristics of
the firm’s activity. In this paper we distinguish between professional KIBS (henceforth P-KIBS) and technological KIBS (henceforth T-KIBS). We make this distinction because the knowledge that underpins services and innovations is different for P-KIBS and T-KIBS (Freel 2006; Pina and Tether 2016). P-KIBS include firms that deal with business services such as legal or management consultancy activities, while T-KIBS include firms that deal with technical and experimental services, such as software and hardware consulting or engineering activities. The characteristics of the knowledge in each of these contexts are likely to have an impact on knowledge generation and sharing – and ultimately on the innovation processes and performance of these firms. For these reasons, we consider that the potential pros and cons of sharing knowledge internationally will be different for P-KIBS and T-KIBS. Specifically, this paper examines how collaboration with partners located abroad exercises a differentiated impact on the innovativeness of P-KIBS and T-KIBS. In this study we understand innovation to be the development of new or improved services or processes (e.g., support activities or distribution methods) by KIBS. Innovation patterns in KIBS, however, are not homogeneous, but differ considerably between P-KIBS and T-KIBS (Freel 2006). In P-KIBS, innovation mainly results from the effort put forth by their employees to resolve problems, while in T-KIBS innovation is essentially related to satisfy needs with new technology. Regarding the role of technology in KIBS’ innovation process, T-KIBS are more active in shaping new technologies and P-KIBS are more intensive users of technology (Miles et al. 1995).

To improve understanding of the finer points of international collaboration on innovation in KIBS, we focus our attention on two dimensions: proximity and diversity among international partners. On the one hand, the proximity of the partner can be a decisive factor, contingent on the characteristics of the knowledge shared in the collaboration (Enkel and Heil 2014; Gertler 2003; Herrmann, Taks, and Moors 2012). And on the other, international collaboration allows firms to share information with partners from different countries, which produces benefits by
increasing the variety of knowledge and thereby the likelihood of boosting innovation performance (Rodan and Galunic 2004). The diversity inherent to each national context, however, may hamper effective collaboration (Levina and Vaast 2008; Parkhe 1991). This study goes on to examine the effects of these two dimensions of international collaboration on innovation performance: i) proximity of the partners (‘closeness’ argument); and ii) diversity among these partners (‘diversity’ argument).

The contribution of this paper centers on increasing our knowledge of the characteristics of KIBS and understanding how international collaboration can improve their innovation performance. To do this, we link the literature on KIBS, service innovation and collaboration. In this way, the paper contributes to several literatures and some current discussions. On a theoretical level, the paper contributes to the highly topical knowledge-intensive business services literature (Doloreux, Freel, and Shearmur 2016; Ritala, Hyötyla, Blomqvist, and Kosonen 2013; Najafi-Tavani, Giroud, and Sinkovics 2012), with particular relevance to the innovation literature on KIBS (Amara, Landry, and Traoré 2008; Gotsch and Hipp 2012; Miozzo, Desyllas, and Miles 2016; Musolesi and Huiban 2010; Salavisa, Sousa, and Pontes 2012; Toivonen and Tuominen 2009). The paper joins studies that analyze collaboration across countries in business services (Metiu 2006; Levina and Vaast 2008) and broadens our limited understanding of the potential effects of international collaborations on the innovation results of KIBS. As far as we are aware, only Rodriguez and Nieto (2012) consider the impact of international collaboration on innovation performance in KIBS. Our paper goes beyond simply identifying the foreign partner’s origin by analyzing the impact of international collaboration depending on the geographical location of the partner and the technological or professional nature of the KIBS. Moreover, the paper contributes to the discussion on variety in the knowledge base and patterns of innovation in P-KIBS and T-KIBS (Consoli and Elche-Hortelano 2010; Freel 2006; Pina and Tether 2016). We focus on different knowledge bases
and innovation processes and propose different effects of international collaboration on the innovation performance of P-KIBS and T-KIBS, which enables us to advance our understanding of these firms. On an empirical level, we test our hypotheses by examining the impact of international collaborations with partners located in Europe, the US and other countries on the innovation results of Spanish KIBS for the period 2004-2007, differentiating between service and process innovations. KIBS provide a useful empirical context for exploring the relationships between knowledge and innovation management (Leiponen 2006). Furthermore, given that the proportions of service firms in Spain are similar to those in OECD and EU countries (Eurostat 2009, 2016), the findings of this paper should be widely generalizable to other contexts.

Theory and hypotheses

International collaborations, knowledge and innovation performance

Since the transfer and integration of knowledge play a critical role in the firm’s ability to generate innovations (Phene, Fladmoe-Lindquist, and Marsh 2006), the capacity to apply knowledge to the innovation process is a critical source of competitive advantage (Bierly, Damanpour, and Santoro 2009). Indeed, extensive research suggests that knowledge from beyond a firm’s organizational and technological boundaries is useful for innovation (Grant 1996; Galunic and Rodan 1998; Kogut and Zander, 1992). The sharing and use of knowledge from external sources expands a firm’s knowledge base (Leonard-Barton, 1995; Nonaka and Takeuchi, 1995) and provides access to new ideas that promote the generation of innovation (Grant and Baden-Fuller 2004; Rosenkopf and Nerkar 2001). In particular, knowledge intensive firms need to continually renew their knowledge-based structures to remain innovative (Anand, Gardner and Morris 2007). Research indicates that business service improvements and new service introductions are significantly associated with external
sourcing of knowledge (Leiponen 2005). In particular, collaborations in KIBS are relevant for both gaining access to and generating new knowledge (Muller and Zhenker 2001). This is the case since KIBS interact with manufacturing and their outputs are used as inputs for other sectors (Boersma and Van Ark 2007), thereby potentially increasing productivity via knowledge spillovers (Miozzo and Grimshaw 2006). Apart from being highly innovative, then, KIBS are seen as facilitators, transporters and even sources of innovation (Miles et al. 1995; Den Hertog 2000). Bearing this in mind, it is important to understand the key factors for innovation in KIBS (for improving processes and generating new services) and the role of international collaboration.

*Proximity among partners in collaborations*

The degree of proximity among partners is a highly important factor to understand the dynamics of inter-organizational collaborations (Balland 2012; Knoben and Oerlemans 2006). As Vissers and Dankbaar (2013) point out, knowledge-related processes benefit from proximity. Although the concept of proximity encompasses various dimensions, we tend to associate it with geographical or spatial distance. In this way, geographical proximity may be essential for some forms of knowledge exchange (Morgan, 2004). Specifically, geographical proximity is likely to increase the chances that firms will interact and share repertoire elements because they act in more similar contexts (Teixeira, Santos, and Oliveira-Brochado 2008).

The concept of proximity, however, goes beyond the geographical dimension to include other extremely relevant factors such as cognitive, organizational (Aguiléra, Lethiais, and Rallet 2012), social and institutional dimensions (Boschma 2005). While geographical proximity is defined as spatial distance between actors, cognitive proximity refers to what extent the actors share the same reference and knowledge space; organizational proximity refers to how far the
actors share the same space of relations (understood as the way in which the actors interact and work together either within or between organizations); social proximity refers to the socially-embedded relations between actors at the micro-level (when relations between actors involve trust); and institutional proximity refers to the institutional framework, including both formal institutions (laws and rules) and informal institutions (cultural norms and habits).

Institutional proximity (especially its cultural dimension) is associated with geographical proximity, and in turn the organizational, social and institutional dimensions of proximity are tightly interconnected (Knoben and Oerlemans 2006) given that organizational relations are deeply embedded in institutional settings.

All these dimensions of proximity are essential to understand interactive learning and innovation (Boschma 2005). Cognitive proximity permits people who share the same knowledge base to learn from one another. Thus, cognitive proximity favors effective communication and increases the capacity of firms to absorb new knowledge (Boschma and Lambooy 1999). Partners in collaborations, therefore, require cognitive proximity in terms of a shared knowledge base to communicate, understand, absorb and process new information and knowledge successfully, since the effective transfer of knowledge requires absorptive capacity to identify, process and exploit new knowledge (Cohen and Levinthal 1990). Likewise, organizational, social and institutional proximity are strongly linked to effective learning. Interactive and effective learning requires a common language, shared habits and a culture of shared trust that facilitates information transfer, as well as a legal system that guarantees the intellectual property rights necessary to protect innovation (Maskell and Malmberg 1999).

Despite the numerous dimensions that surround the concept of proximity, they are all highly interrelated (Knoben and Oerlemans 2006) and it can be difficult to consider their effects on knowledge acquisition and exploitation processes separately (Presutti, Boari, and Majocchi

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Geographical proximity is related to social, cultural and cognitive proximity and vice versa (Gertler 1995). For this reason, then, geographical proximity should implicitly capture the degree of cognitive, organizational and institutional proximity among partners collaborating in different countries. In line with this argument, the theoretical expectation is that geographical proximity among international partners can boost interaction and knowledge sharing, as well as bringing greater proximity in other dimensions, which is critical for learning and innovation, especially in settings such as KIBS.

Diversity in international collaborations

The extent of external knowledge is not the only relevant factor, as the diversity of technological knowledge resources is also important (Almeida and Phene 2004). This heterogeneity of knowledge is of great importance for innovation performance (Rodan and Galunic 2004) because the mixture of a firm’s own knowledge with acquired knowledge will improve the chances of novel ideas and innovations. Increased diversity in partners’ industrial, organizational and national backgrounds will make it possible to achieve greater benefits in terms of resources and learning (van Beers and Zand 2014), in addition to expanding the knowledge base of firms. Cross-border alliances can provide complementary capabilities (Lane, Salk, and Lyles 2001) and enhance different knowledge bases and learning (Lubatkin, Florin, and Lane 2001). Diversity, then, emerges as a crucial factor in technological collaboration (Nieto and Santamaría 2007), a factor which makes it possible for firms to gain access to different –and occasionally complementary– knowledge. Although diversity brings benefits, it also increases the complexity and costs of collaboration (Jiang, Tao, and Santoro 2010), along with some other difficulties. The greater the technological diversity among firms in the alliance, the more each firm has to learn from the other –but the more difficult it is to share this knowledge.
Problems of knowledge sharing within a global context are amplified. Thus, the possession of highly dissimilar knowledge by the parties involved may raise particular difficulties for its shareability.

The heterogeneous nature of knowledge and international collaboration

Collaboration agreements involve firms in the difficult task of intensive knowledge sharing. Knowledge is a complex and ambiguous term (Alvesson, 2001), and its management is no simple matter (Hansen et al. 1999; Leiponen 2006). The heterogeneous nature of knowledge and its degree of context specificity can have an impact on its shareability (Aslesen and Freel 2012). Therefore, information about its characteristics, creation process and management is particularly important when the aim is sharing knowledge to innovate. Regarding the characteristics of knowledge, we follow Tsoukas (1996) in arguing that tacit knowledge is present in all knowledge. Thus, we assume that all knowledge has a certain degree of tacitness, which can be understood as a continuum as opposed to a dichotomy (tacit-codified) (Vissers and Dankbaar 2013). The proportion of tacit knowledge managed by organizations will be a factor, then, when analyzing its potential shareability, especially when long geographical distances separate partners (Gertler 2003; Howells 2000, 2002). Given the heterogeneity that exists among KIBS, they also differ in the primary knowledge base (Pina and Tether 2016). Thus, when analyzing the different effects of international collaboration on P-KIBS and T-KIBS, it is crucial to be aware of the heterogeneous nature of their knowledge systems, particularly regarding the degree of tacit knowledge and context specificity.

In P-KIBS, a high proportion of knowledge resides in individual experts (Lesson 1995; Starbuck 1992) who develop problem-solving techniques for specific clients (Løwendahl 2005). This is embodied knowledge that depends on people; it tends to be generated in the face-to-face discussions that occur during the delivery of the service and is typically rooted in
specific contexts (Blacker 1995). This type of knowledge is likely to be the most difficult to combine with other knowledge assets, because it is deeply embedded in individuals’ skills and practices (Leiponen 2006). The knowledge managed by P-KIBS, then, is overwhelmingly personal, with a high degree of tacitness and context specificity.

For their part, T-KIBS deal with technical and experimental knowledge. This kind of knowledge (once validated experimentally) is relatively easy to share, because it is usually interpreted in similar ways across contexts (including across nations) (Robertson et al. 2003). As T-KIBS supply services that are less context-specific, the task structure is more easily systematized and the degree of professional discretion is lower (Consoli and Elche-Hortelano 2010).

Since P-KIBS and T-KIBS differ in the nature and organization of knowledge production, the drivers of innovation in each sector will also differ (Pina and Tether 2016). In particular, collaboration (as a critical driver of innovation) will exert a different impact on innovation outcomes due to these differences. We allude to the nature of the knowledge related to the activities delivered and the innovation processes in order to understand the impact of different international partners in these two specific sectors. As a result of our assumption of the relative importance of the weight of tacit knowledge and context specificity in P-KIBS and T-KIBS, we hypothesize that international collaboration will affect their innovation results differently. With this in mind, we develop two arguments, one related to proximity (‘closeness’ argument) and the other to diversity (‘diversity’ argument). We argue that the importance of proximity and diversity vary depending on the firm’s activity and innovation process, an argument that leads us to predict different outcomes for the impact of international partners on innovation in KIBS.
**P-KIBS and the importance of proximity of partners: the ‘closeness’ argument**

The competitive advantage of P-KIBS fundamentally resides in their personnel, staff who are capable of generating tacit knowledge via their experience and interactive problem-solving abilities (Miles 2005; Miles et al. 1995). Therefore, firms involved in professional activities (e.g., legal or management consultancy) possess different learning patterns that have more to do with problem-solving strategies and the specific requirements of clients (Anand, et al. 2007; Løwendahl 2005). These are activities that depend on task-specific information that is difficult to store and closely related to the knowledge and expertise of specific employees (Starbuck 1992; Dougherty 2004). For these reasons, then, these activities are often difficult to standardize and replicate (Consoli and Elche-Hortelano 2010; Maister 1993; Tether, Hipp, and Miles 2001). As a knowledge-based organization, innovation in this type of firm is particularly challenging (Anand, et al. 2007; Leiponen 2006), with practice-based knowledge playing the lead role (Dougherty 2004).

Starting from the three levels of analysis –cognitive, organizational and societal– indicated by Lam (2000), we examine the difficulties P-KIBS may encounter when sharing knowledge with international partners, the difficulties related to the nature of the knowledge itself, and the degree of embeddedness of this knowledge in the context. At the cognitive level, we find that the degree of tacit and individual knowledge –embodied knowledge (Blacker 1995)– is particularly important when sharing knowledge among organizations (Orlikowski 2002), especially when they are geographically separated (Gertler 2003; Howells 2000, 2002). When the degree of tacitness is extremely high, the skills lie in the individuals, who generate knowledge through their everyday activity via knowing in practice and learning by doing (Orlikowski 2002). In this context, knowledge intensity mainly refers to knowledge embodied in individuals –human capital intensity (von Nordenflycht 2010). Given the ‘person-centric’ nature of knowledge intensity, knowledge sharing requires higher levels of interaction among
individuals and collaboration requires close contact and nearness. When such interaction and contact among the parties are absent, sharing knowledge that fundamentally resides in individuals becomes more difficult.

At the organizational level, the structure of coordination determines the capacity of the firm to mobilize and integrate different types of knowledge and shape the relationship between individual and collective learning. The knowledge structure in firms related to professional activities is largely task-specific and individual-based (Anand et al. 2007; Consoli and Elche-Hortelano 2010). This professional model encourages deep individual specialization and ownership of knowledge, thereby hindering cross-functional integration (Dougherty 2004; Lam 1997). Therefore, the advantages that flow from international collaboration are difficult to exploit at an organizational level because the knowledge fundamentally resides in individuals and interaction among these individuals is infrequent given the geographical distances separating partners.

At the societal level, it is important to note that institutions shape organizational routines and coordination rules. The nature of the institutional environment interacts with the organizational structures to generate different types of knowledge and patterns of learning and innovation (Lam 2000). Moreover, professional activities are highly dependent on the institutional context in which they operate (Miles 2005; Robertson et al. 2003). The fact that these activities relate to the specific needs and problems of clients makes social interaction and practical experience particularly useful in the context in which they take place. International collaboration with partners from highly different institutional contexts, then, may reduce the value of shared knowledge and practices when developing innovations.

We can conclude, therefore, that P-KIBS will encounter serious difficulties to share embodied knowledge in international collaboration in which the members of the different organizations do not understand or share experience, values, routines or operating procedures. International
collaboration will be beneficial when these difficulties are minimized; sharing knowledge and practices among the parties, then, will be easier when international partners are sufficiently ‘close’, not only in terms of geography, but also in terms of knowledge base, institutional settings and familiarity with the market. This ‘closeness’ argument suggests that P-KIBS should look for greater proximity in partners to take full advantage of the benefits for innovation associated with international collaboration. In accordance with this idea, we postulate the following hypothesis:

Hypothesis 1: In P-KIBS, international collaboration with ‘closer’ partners will increase the likelihood of innovation.

T-KIBS and the importance of diversity in international collaborations: the ‘diversity’ argument

As T-KIBS offer technology-related services, their competitive advantage is linked to the availability of knowledge and the exploitation of technological advances (Miles 2005) that may be present in highly different international contexts. Once again, we use the three levels of analysis –cognitive, organizational and societal– proposed by Lam (2000) to examine the impact of international collaboration in T-KIBS, paying special attention to the diversity of knowledge.

At the cognitive level, knowledge in T-KIBS is relatively more explicit and codifiable (as equivalent to a lower degree of tacit knowledge in the aforementioned continuum) (Amara, Landry, and Traoré 2008). This type of knowledge is more easily transferable within the organization and to collaborative partners as it may be more articulated and modular. At the organizational level, the greater systematization of knowledge in T-KIBS promotes the application of repetitive routines, which in turn favors the relation between individual and
collective learning. At the societal level, we expect less institutional embeddedness because knowledge does not depend so directly on interaction with the client and the context is almost neutral for the supply of more standardized service packages (Consoli and Elche-Hortelano 2010). This factor should lead to greater benefits from collaborating with partners from different societal settings, since new knowledge can be applied to different contexts of use (Robertson et al. 2003).

In the case of T-KIBS, the diversity of knowledge that can be shared via collaborating with partners from different backgrounds may be highly beneficial. Countries differ markedly in terms of the innovativeness of their firms (Furman, Porter, and Stern 2002). Thus, T-KIBS that collaborate with international partners from very different locations are able to gain access to heterogeneous knowledge that can boost their innovation performance. In as far as this knowledge is easily codifiable and less individual-specific (with greater scope for adaptation and use in a variety of contexts), T-KIBS will have fewer difficulties to integrate the different knowledge bases. Thus, taking advantage of the diversity supplied by relations with international partners will be easier and will deliver more benefits. These arguments lead us to put forward the following hypothesis:

*Hypothesis 2: In T-KIBS, greater diversity among partners in international collaboration will increase the likelihood of innovation.*

**Empirical analysis**

**Sample**

The empirical analysis is based on the Spanish Technological Innovation Panel (TIP). This panel is compiled by Spain’s National Statistics Institute, Science and Technology Foundation, and Foundation for Technical Innovation using data from the Spanish Community Innovation Survey (CIS). The TIP database supplies information on different
aspects of firm innovation and other general and economic information. Although the TIP collects data on firms from all sectors covered by the Statistical Classification of Economic Activities in the European Community (NACE), our analysis focuses only on firms identified as KIBS. We adopt the classification of KIBS put forward by Miles (2005) and distinguish between P-KIBS and T-KIBS (Freel 2006)—see table 1.

This data source has already been used by many other researchers (Cuervo-Cazurra, Nieto, and Rodríguez 2017; Rodríguez and Nieto, 2016; Santamaria, Nieto, and Miles 2012; Trigo and Vence 2012; Barge-Gil 2010; among others). Moreover, given that the TIP’s data are obtained from the Spanish CIS, they have been used by policy observers to provide innovation indicators and trend analyses, and by economists to analyze a number of innovation-related topics. This study, then, is constructed on widely accepted innovation indicators and variables (for a review of CIS-based studies, see van Beers et al. 2008; Hong, Oxley, and McCann 2012; Mairesse and Mohnen 2010).

The empirical analysis uses an unbalanced panel of 3,918 observations of Spanish KIBS for the period from 2004 to 2007, compiled on a yearly basis. Spain is an attractive context in which to examine this research question for several reasons. First, Spain has much in common with many countries, occupying a position in the middle of the technological ranking of countries (UNCTAD 2005). And second, Spain’s proportion of services in business economies is close to the European average (Eurostat 2009, 2016).

**Variables**

**Dependent Variables**

In order to capture the innovation outcomes of KIBS, we use two separate measures: service innovation and process innovation (Doloreux and Shearmur 2012). This distinction is
important as strong complementarities exist between different types of innovation in services, as recent empirical evidence reveals (Amara, Landry, and Doloreux, 2009). *Service Innovation* happens when the firm indicates: (i) new services have been introduced into the market; or (ii) existing services have been significantly improved or important changes have been made to their basic characteristics, intangible components or desired purposes. This is a dichotomous variable that takes value 1 when the firm introduces new services; otherwise its value is 0. *Process Innovation* happens when the firm indicates it has implemented new or significantly improved production processes, distribution methods or support activities for its services. Innovations that are merely organizational are excluded. This is also a dichotomous variable. For both *Service Innovation* and *Process Innovation*, it does not matter if the innovation was initially developed by the firm in question or by another firm; the novelty or improvement, though, must be new for the firm in question, though not necessarily for its sector or market.

**Independent variables**

The independent variables relate to international collaboration and aim to capture the two dimensions identified in the theoretical section: ‘closeness’ and ‘diversity’. As previously described, proximity is a multidimensional concept that includes several interrelated components that are difficult to separate (Presutti et al. 2011). We base our measurement of ‘closeness’ on a criterion of geographical location, accepting that it is related to social, cultural or cognitive dimensions (Gertler 1995). As regards diversity of collaboration, we analyze the geographical diversity of partners in a similar way to previous studies such as van Beers and Zand (2014), who consider collaborations with partners based in four geographical areas: home country, (rest of) Europe, USA and others (all other countries). Consequently, we identify four types of international partnerships: (i) collaborations with only European
partners (*Europe collaboration*), which we associate with ‘closer’ partners; (ii) collaborations with only US partners (*USA collaboration*); (iii) collaborations with international partners from other geographical areas (i.e., neither Europe nor the US) (*Other collaboration*); and (iv) collaborations with international partners belonging to more than one of the three previous geographical areas (*Diversity collaboration*). All these partnerships are measured via dichotomous variables for each year in the period from 2004 to 2007. The analyses, then, include information on whether the firm has collaborated yearly for each of the four categories.

To avoid problems of simultaneity with the innovation results, all the independent variables are lagged one period.

**Control variables**

The analysis includes controls for innovation decisions, firm-specific characteristics and yearly dummies. We must bear in mind that most firms that collaborate internationally also collaborate with national firms; this is important as the variables related to international collaboration could be capturing the effect of national collaboration (thereby complicating the interpretation of the net effect of international collaboration). For this reason, we use a dichotomous variable (*Domestic collaboration*) to control for whether the firm has collaborated with other national firms. We also control for innovative effort because it provides the firm with the absorptive capacity to recognize the value of external knowledge and enables it to acquire and combine diverse knowledge to create new products (Cohen and Levinthal 1990). *Innovative effort* is calculated by dividing the firm’s total innovation investments by its total sales (Nieto and Rodríguez 2011). These variables are lagged one period, given that they require some time to translate into innovative outputs (Belderbos et al. 2004). In addition, we control for the presence of qualified personnel in KIBS (Robertson and
Hammersley 2000) via a dichotomous variable that takes value 1 if the firm incurs training expenses (Training) (González, Miles-Touya and Pazó 2016).

In line with previous studies of collaboration and innovation, we include firm-specific control variables related to size, age, group membership, and the degree of internationalization (Belderbos et al. 2004). Size is widely recognized as one of the most important determinants for the innovation behavior of the firm (Becheikh, Landry, and Amara 2006). The classic Schumpeterian debate over which firms —large or small— are more able and more likely to innovate continues to arouse controversy today (Tsai and Wang 2005). Therefore, it is necessary to control for the effect of firm size in our analyses; we use the logarithm of the number of employees (Rodríguez and Nieto, 2016) to capture the dimension of the firm (Size). The age of the firm allows us to capture the firm’s experience and learning, and is also a commonly used variable in empirical studies of innovation (Kumar and Saqib 1996). We identify whether the firm has been founded recently through a dichotomous variable that takes value 1 if the firm has been set up in the previous two years (New firm). And as firms that belong to a business group can also receive resources that will help them innovate (Galunic and Eisenhardt 2001; Sung, Lee, and Ahn 2017), we control for membership of a group via a dichotomous variable (Group).

Internationalization is another factor that is relevant for the innovation process. Firms that are active in international markets acquire knowledge that helps them innovate (Frenz, Girardone and Letto-Gillies 2005). Accordingly, our analysis controls for the international presence of the firm via a dichotomous variable that takes value 1 if the firm sells its services abroad (International activity). In addition, firms that belong to foreign groups can receive knowledge and technology from other countries that help them innovate (Un 2011). Consequently, we identify whether the firm is foreign-owned through a dichotomous variable.
that takes value 1 if at least 50 percent of the firm’s capital is in foreign hands (Foreign ownership).

Table 2 contains the descriptive statistics of the independent and control variables used in this study (with the exception of yearly dummies). In addition, we perform an analysis of the variance inflation factor (VIF) to test for multicollinearity. The values obtained show that problems of multicollinearity do not exist in this study\(^1\).

****Insert Table 2 about here****

**Method of analysis**

To test our hypotheses, one model is specified in the setting of P-KIBS (model A), and another one in the setting of T-KIBS (model B). For our first hypothesis in the context of P-KIBS (model A), we expect the closest international partner (European collaborations) to be positively and significantly related to innovation outcomes. And for our second hypothesis in the context of T-KIBS (model B), we expect a positive and significant relation between diversity in international partnerships (Diversity Collaboration) and innovation outcomes.

As both dependent variables – Service Innovation and Process Innovation – are dichotomous, and the error terms are likely to be correlated, an extension of probit known as bivariate probit (Greene 2000) is usually a more appropriate estimator. The model has the following econometric specification:

\[
\text{Prob (Service Innovation)}_{it} = \alpha_p + \beta_{1p} (\text{European collaborations})_{it-1} + \beta_{2p} (\text{USA collaborations})_{it-1} + \beta_{3p} (\text{Other collaborations})_{it-1} + \beta_{4p} (\text{Diversity collaboration})_{it-1} + \beta_{5p} (\text{Domestic collaboration})_{it-1} + \beta_{6p} (\text{Innovative effort})_{it} + \beta_{7p} (\text{Training})_{it} + \beta_{8p} (\text{Size})_{it} + \beta_{9p} (\text{Group})_{it} + \beta_{10p} (\text{New Firm})_{it} + \beta_{11p} (\text{International activity}) + \beta_{12p} (\text{Foreign ownership}) + \beta_{13p} (\sum \text{Year})_{it} + \varepsilon_{it}
\]
\[ \text{Prob (Process Innovation)}_{it} = \alpha_p + \beta_{lp} (\text{European collaborations})_{it-1} + \beta_{3p} (\text{USA collaborations})_{it-1} + \beta_{3p} (\text{Other collaborations})_{it-1} + \beta_{lp} (\text{Diversity collaboration})_{it-1} + \beta_{3p} (\text{Domestic collaboration})_{it-1} + \beta_{lp} (\text{Innovative effort})_{it} + \beta_{lp} (\text{Training})_{it} + \beta_{lp} (\text{Size})_{it} + \beta_{lp} (\text{Group})_{it} + \beta_{lp} (\text{New Firm})_{it} + \beta_{lp} (\sum \text{Year})_{it} + \varepsilon_p \]

\[ (\varepsilon_p, \varepsilon_c) \sim N (0,0,1,1,\rho) \]

where \( \alpha_p \) and \( \alpha_c \) are the constant intercepts, \( \beta_p \) and \( \beta_c \) are the coefficient vectors, and \( \varepsilon_p \) and \( \varepsilon_c \) are the error terms, respectively for service and process innovations. The model also generates estimates of \( \rho \) (the correlation between the error terms of the equations). Our tests revealed that the correlation between the equations was statistically significant, which is an indicator that the bivariate model was more effective than the separate probit models (Greene 2000).

**Analysis and results**

*A preliminary descriptive analysis*

To contextualize the results, in table 3 we provide the distribution of international collaboration (via the location of the foreign partners) and the percentage of P-KIBS and T-KIBS that develop innovations (services and process) in the four categories of collaborations. For both P-KIBS and T-KIBS, the most common option is exclusive collaboration with partners located in Europe, followed by collaborations with international partners belonging to more than one of the three geographical areas. Apart from these two types of collaborations, a closer inspection reveals that P-KIBS collaborate more frequently with US-based partners, while T-KIBS collaborate with both US-based partners and partners based in other countries (with the latter being more common than the former). Concerning innovations in the four collaboration categories, P-KIBS and T-KIBS show higher percentages of both

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1 Correlations of the independent and control variables, as well as VIF tests are available upon request.
types of innovations when collaborating with European-based partners, with P-KIBS exhibiting the highest levels. Higher percentages of process innovations than service innovations occur with US-based partners, with P-KIBS showing the highest percentage. Collaboration with partners in other countries (neither Europe nor the US) is largely undertaken by T-KIBS, with this sector exhibiting higher percentages of service innovations than process innovations. Finally, both P-KIBS and T-KIBS engage in international collaboration with partners located in diverse geographic areas, though the innovation outcomes they achieve are different. When collaborating with more diverse international partners, P-KIBS achieve higher percentages of process innovations, while T-KIBS achieve higher percentages of service innovations.

****Insert Table 3 about here****

**Empirical results**

Table 4 displays the estimations of the two biprobit models specified to analyze the effect of international collaboration on the innovation outcomes of P-KIBs and T-KIBS, respectively. The $\rho$ parameter is highly significant in both models, signaling that the error structures of the equations are correlated. This suggests that service and process innovations are not independent and that the bivariate model is the correct specification in each case.

****Insert Table 4 about here****

We obtain support for hypothesis 1, as ‘closer’ partners (Europe collaboration) exert the highest impact on the innovation outcomes of P-KIBS. This result indicates that P-KIBS benefit more from greater proximity among international collaboration partners. This relation is significant for service innovations, but not for process innovations. This result may be due to the fact that –even in P-KIBS– innovations differ in their degrees of tacit knowledge. Specifically, process innovations tend to be based on routines and procedures, with their concomitant large doses of tacit knowledge. This circumstance increases the difficulty of
taking on board knowledge from international collaboration and sharing it to potential innovations.

We also obtain strong support for hypothesis 2, as indicated by the statistical significance of Diversity collaboration. These results reveal the positive impact of collaborating with partners from several geographical areas on the innovation outcomes of T-KIBS, both for service and process innovations. This result shows that these firms can benefit from the greater diversity offered by heterogeneous international partners.

Regarding the control variables relative to other innovation decisions, the results for P-KIBS and T-KIBS do not differ. Thus, collaboration with national partners exerts a positive and significant impact on innovation performance, for service and process innovations and in both sectoral contexts. For P-KIBS, this result also offers additional support for hypothesis 1 (‘closeness’ argument), given that national partners are those with higher proximity. Likewise, the coefficients for Innovative effort are positive and significant for both measures of innovation performance, indicating a positive effect on the likelihood of achieving new services and improved processes in P-KIBS and T-KIBS. The coefficients for Training are also positive in the two models, and for both innovation outcomes, reflecting the importance of training in these types of activities for the innovation process. We should note here that the coefficients for P-KIBS are markedly higher than those for T-KIBS. The high importance of training in P-KIBS makes this a fairly predictable result, particularly bearing in mind that these firms offer services –and introduce innovations– that depend greatly on their professional staff.

The coefficients for Size reveal that greater firm size is not an important factor for P-KIBS. In fact, the dimension of the firm is negatively related to the likelihood of achieving service innovations, which suggests that smaller P-KIBS are more likely to innovate than larger ones. No significant relation exists for process innovations. For T-KIBS, a positive and significant
relation between size and likelihood of innovation exists. Greater size in technological service firms, then, will have a positive impact on innovation performance. This finding throws new light on the classic Schumpeterian debate. Moreover, it reinforces the importance of taking into account the sectoral characteristics (i.e., differences in knowledge required and innovation processes) when gauging the impact of a variable on innovation performance.

The coefficients for New firm are not significant and do not permit us to reach conclusions on how the age of P-KIBS and T-KIBS influences the probability of innovation. Membership of a group does not have significant effects for P-KIBS either; it does, however, have significant and negative effects for T-KIBS. This finding shows that technological service firms that are integrated in groups achieve fewer service and process innovations than those that are not part of a group. These results may either be indicating that some of the innovations are declared by the parent firm or that innovations are centralized in specific parts of the group.

The coefficients for International activity are positive and significant for P-KIBS and T-KIBS (although in this latter case, only for service innovations). This result indicates the positive effect that an international presence exerts on innovation performance, as noted by previous studies. In contrast, the impact of Foreign ownership on the likelihood of innovation in P-KIBS is only present for process innovations, where it is positive. In T-KIBS, foreign ownership has a negative impact on both innovation outcomes, which could be due to a similar effect as that caused by membership of a group. In other words, the foreign parent firm may be responsible for developing and centralizing innovations, which are then shared with other participating firms.

**Discussion**

This study analyzes how the impact of international collaboration can differ depending on the characteristics of the firm’s activity. The diversity of knowledge that international
collaboration contributes is highly useful, as firms can generate new ideas and innovations by combining it with the knowledge base available in-house. The importance of richness of knowledge among partners, however, ceases to be a critical factor if the knowledge does not flow among them. In the context of KIBS, we show that the impact of international collaboration on innovation performance is different for P-KIBS and T-KIBS. This finding may be due to the relative ease or difficulty of sharing international knowledge and the dependency of context associated with each activity.

The analysis of international collaborations with partners located in Europe, the US and other countries also enables us to show what type of collaboration is more effective in each service setting. For P-KIBS, collaboration with ‘closer’ partners produces the greatest impact on service innovations. This result suggests the importance of interaction and similarity of knowledge to achieve improved innovation performance via international collaboration. Thus, the possession of highly dissimilar knowledge by parties may represent a particular difficulty for knowledge creation and sharing. In conjunction with the inherent problems of sharing knowledge internationally, this will hamper the ability of P-KIBS to benefit from such distinct perspectives. As this confirms the importance for innovation of proximity to partners in international collaborations, this result supports the ‘closeness’ argument for professional service firms. Greater spatial proximity with European partners brings with it a greater proximity in terms of both formal institutions (i.e., rules and laws) and informal institutions (i.e., cultural norms and habits). This is very important if we bear in mind that these are activities that are highly dependent on the institutional contexts where they take place and in which the knowledge fundamentally resides in people (Miles 2005). In the case of activities based on professional knowledge, then, international collaboration will be more beneficial when less divergence exists among international partners. The increased benefits associated
with lower divergence can be explained by two factors: the sharing of knowledge among partners is easier, as is its application in similar societal contexts.

For T-KIBS, the situation is different, with international collaboration with diverse organizations having the greatest impact on innovation performance. This result reveals the importance of gaining access to a more dissimilar base of knowledge and the relative ease of its shareability. This finding supports the ‘diversity’ argument and is in line with other studies that show the importance of collaborating with heterogeneous partners to improve innovation performance (Nieto and Santamaria 2007; van Beers and Zand 2014). Our results, therefore, reveal that collaborating with partners from other countries (neither from Europe nor the US) and with diverse international partners will give technology-based service firms the biggest boost to their levels of knowledge and innovation performance. These results may also be explained by the fact that the nature of knowledge inherent to these firms and their innovation processes makes sharing knowledge easier with partners from distant countries that possess more heterogeneous knowledge. This squares with Consoli and Elche-Hortelano’s (2010) description of T-KIBS as more standardized and less context-dependent services. In summary, then, in these sectors the knowledge shared in international collaborations among diverse partners may be taken advantage of by firms in highly different institutional settings.

**Conclusions and implications**

Our study allows us to draw conclusions on the benefits of international collaboration in different service settings where the knowledge required and innovation processes differ. Specifically, the results show that the dimensions of proximity and diversity have a differentiated effect on the innovation performance of the two contexts under analysis: P-KIBS and T-KIBS. Thus, our work with a large sample of Spanish knowledge-intensive business services reveals that proximity to international partners is an important factor for
improved innovation results in P-KIBS, while diversity in international collaboration is crucial in the context of T-KIBS.

Overall, this work contributes to research focused on knowledge development and innovation by linking different streams in the literature, such as KIBS, service innovation and collaboration. The study contributes to the academic literature by advancing our understanding of the implications of international collaboration via an analysis of its impact on different sectoral contexts with specific knowledge conditions and innovation processes. Our paper goes one step beyond previous work by considering the heterogeneous nature of knowledge and its embeddedness in different contexts. The study shows that the pros and cons of international collaboration differ depending on the setting in which the collaboration takes place. Differentiating between two types of innovation results (service and process innovations), then, allows us to extract conclusions on how international collaboration affects each one. In this way, we also contribute to advancing knowledge of the patterns of innovation in knowledge intensive services, particularly in P-KIBS and T-KIBS (Amara, Landry, and Doloreux 2009; Doloreux and Shearmur 2012; Freel 2006; Pina and Tether 2016; Tether & Hipp, 2002). As mentioned, the analysis is performed on a large sample of knowledge-intensive business services, thereby making it possible to reach conclusions for firms in activity sectors that are highly relevant in today’s economies. These conclusions may also be generalizable beyond KIBS to other activity sectors similar to those analyzed in our study, in so far as they have comparable knowledge systems and innovation processes. For example, the conclusions reached in this paper could be applicable to other sectoral settings that are also characterized by the need for interaction among partners, by specific levels of intensity of human capital or tacit knowledge, and by context dependency.

This paper’s results also make it possible to draw useful conclusions for management. Our findings explain the logic behind selecting an international partner to improve innovation
performance. Inter-organizational learning is believed to enhance innovation by facilitating access to resources and knowledge that lead to new ideas and services and is particularly important in international collaborations. In this paper, however, we reveal that managers should pay attention to certain factors that have an impact on the potential benefits of international collaboration. At least in the cases of P-KIBS and T-KIBS, we conclude that international collaborations differ substantially in regard to their impact on achieving innovations. Proximity of international partners is a highly important factor for professional service firms, while partner diversity is the most important factor for technological service firms. Consequently, managers need to re-think which international partners will make the biggest contribution to improving innovation performance.

This study’s limitations provide opportunities for future research. Analyzing the impact of international collaboration with other measures of proximity could be interesting, particularly with measures that take into account other intangible dimensions of distance among partners. Given that countries exhibit varying levels of innovation, it would be interesting to control for technological differences between the origin country and the international partner’s country to examine the impact of this collaboration on ‘innovativeness’. In this study we analyze larger geographical areas because we do not have country-specific information available on collaborations. Likewise, it would be extremely interesting to go beyond the study of diversity in terms of geography to include the knowledge base of each partner. Future researchers will need more precise information on the activity of partners to advance in these directions. It would also be useful to know more about the knowledge sharing instruments among partners. Situations where partners exchange personnel or organize interactions between teams from different firms, for example, could be used by researchers to set up moderating variables in the relation under study.
Lastly, our data do not allow us to identify in which country(ies) firms perform their international activities. This is important as when firms collaborate with partners from countries in which they are operating some of the conclusions linked to the ‘closeness argument’ could be affected. Future work, then, should analyze the impact of collaboration in these situations as this would deepen our knowledge of inward-outward international connections (Hernández and Nieto 2016) and its benefits for innovation. Similarly, previous experience of collaboration could be an area of interest for future work as it may be another factor that moderates the ‘closeness’ effect of international partners on innovation results.
References


<table>
<thead>
<tr>
<th>Professional and Technological Knowledge-Intensive Business Services</th>
<th>NACE Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technological knowledge-intensive business services</strong></td>
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</tr>
<tr>
<td></td>
<td>72.1: Hardware consultancy</td>
</tr>
<tr>
<td></td>
<td>72.2: Software consultancy and supply</td>
</tr>
<tr>
<td></td>
<td>72.3: Data processing</td>
</tr>
<tr>
<td></td>
<td>72.4: Database activities</td>
</tr>
<tr>
<td></td>
<td>72.5: Maintenance and repair of office, accounting and computing machinery</td>
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<td></td>
<td>72.6: Other computer-related activities</td>
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<td></td>
<td>73: Research and development</td>
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<tr>
<td></td>
<td>73.1: Research and experimental development on natural sciences and engineering</td>
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<tr>
<td></td>
<td>73.2: Research and experimental development on social sciences and humanities</td>
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<td>74.13: Market research and public opinion polling</td>
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<td>74.14: Business and management consultancy activities</td>
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<td>74.20: Architectural and engineering activities and related technical consultancy</td>
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<td>74.3: Technical testing and analysis</td>
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<td>74.5: Labor recruitment and provision of personnel</td>
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<td>74.8: Miscellaneous business activities n.e.c. (74.84: Other business activities n.e.c.)</td>
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**Source:** Adapted from Miles (2005)
Table 2.- Descriptive statistics of the independent and control variables

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<th>Mean</th>
<th>Standard deviation</th>
</tr>
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<td>0.050</td>
<td>0.227</td>
</tr>
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<td>2. USA collaboration&lt;sub&gt;t-1&lt;/sub&gt;</td>
<td>0.002</td>
<td>0.045</td>
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<tr>
<td>3. Other collaboration&lt;sub&gt;t-1&lt;/sub&gt;</td>
<td>0.003</td>
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<tr>
<td>4. Diversity collaboration&lt;sub&gt;t-1&lt;/sub&gt;</td>
<td>0.016</td>
<td>0.125</td>
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<td>5. Domestic collaboration&lt;sub&gt;t-1&lt;/sub&gt;</td>
<td>0.249</td>
<td>0.433</td>
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<tr>
<td>6. Innovative effort&lt;sub&gt;t-1&lt;/sub&gt;</td>
<td>0.084</td>
<td>0.153</td>
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<td>7. Training&lt;sub&gt;t&lt;/sub&gt;</td>
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<td>0.395</td>
</tr>
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<td>8. Size&lt;sub&gt;t&lt;/sub&gt;</td>
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<tr>
<td>9. New firm&lt;sub&gt;t&lt;/sub&gt;</td>
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<td>10. Group&lt;sub&gt;t&lt;/sub&gt;</td>
<td>0.216</td>
<td>0.411</td>
</tr>
<tr>
<td>11. International activity&lt;sub&gt;t&lt;/sub&gt;</td>
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<td>0.476</td>
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<tr>
<td>12. Foreign ownership&lt;sub&gt;t&lt;/sub&gt;</td>
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<td>0.268</td>
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Number of observations = 3,918
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<tr>
<th>Percentage of observations</th>
<th>P-KIBS (37.9 %)</th>
<th>T-KIBS (62.1 %)</th>
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<tr>
<td></td>
<td>Collaborate</td>
<td>Service innovation</td>
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<tr>
<td>USA collaboration</td>
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<tr>
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<tr>
<td>Diversity collaboration</td>
<td>21.9</td>
<td>13</td>
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Table 4. International collaboration and innovation performance in KIBS

<table>
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<tr>
<th></th>
<th>P-KIBS</th>
<th>T-KIBS</th>
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<tr>
<td></td>
<td>Service Innovation</td>
<td>Process Innovation</td>
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<tr>
<td>Europe collaboration$_{1-t}$</td>
<td>0.68**</td>
<td>0.35</td>
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<tr>
<td></td>
<td>(2.32)</td>
<td>(1.10)</td>
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<tr>
<td>USA collaboration$_{1-t}$</td>
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<td>5.66</td>
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<tr>
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<td>(0.00)</td>
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<tr>
<td>Other collaboration$_{1-t}$</td>
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<td></td>
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<tr>
<td>Diversity collaboration$_{1-t}$</td>
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<td></td>
<td>(-0.16)</td>
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<td>0.99***</td>
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<td></td>
<td>(7.10)</td>
<td>(8.07)</td>
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<td>3.18***</td>
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<td>(5.29)</td>
<td>(2.70)</td>
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<td></td>
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<td>Foreign ownership$_{t}$</td>
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<td></td>
<td>(0.12)</td>
<td>(1.75)</td>
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<tr>
<td>Intercept</td>
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<td>-0.92***</td>
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<tr>
<td></td>
<td>(-6.87)</td>
<td>(-6.24)</td>
</tr>
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** Wald test of full model ($\chi^2$)**

- P-KIBS: 339.28***
- T-KIBS: 365.09***

** Log. Likelihood **

- P-KIBS: -1156.27
- T-KIBS: -3074.75

** LR $\sim \chi^2 : \rho = 0$ **

- P-KIBS: 81.086***
- T-KIBS: 94.39***

** Number of observations **

- P-KIBS: 1,485
- T-KIBS: 2,433

***p<0.01, **p<0.05, *p<0.10. Yearly dummies are included in the models.