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**Knowledge interdependencies in innovation ecosystems: the effect of
relational competences on knowledge acquisition and co-creation
between universities and businesses**

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Abstract

University-business interactions is a key knowledge-based interdependence in well-functioning innovation ecosystems. We shed light on how businesses' ability to successfully achieve knowledge acquisition and knowledge co-creation objectives with universities is influenced by their relational competences. Building on a survey of 200 British firms that interact with universities, we find that communication competences are particularly important for successful knowledge acquisition while cognitive distance-reducing competences are of significant importance for successful knowledge co-creation. These findings allow us to draw implications about what relational competences businesses should nurture in order to engage in successful knowledge-based interactions with universities.

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Key words: knowledge acquisition, knowledge co-creation, university-business interactions, inter-organizational collaborations, relational competence, ecosystem process

JEL codes: O32 - Management of Technological Innovation and R&D ; O31 - Innovation and Invention: Processes and Incentives; L21 – Business Objectives of Firms ; L23 – Organization of Production;

INTRODUCTION

The increasing pace of technological change, the growing complexity of new technologies, the rapid growth of markets for technology, and the increasing modularization of knowledge have increased the knowledge-based interdependencies between actors within innovation ecosystems (Adner and Kapoor, 2010; Escribano et al., 2009; Brusoni et al., 2001; Arora et al., 2001). In the context of the wide array of interdependencies within any ecosystem, university-business interactions play a central role (Graham, 2014). Although universities generally do not constitute the most frequently used sources of external knowledge for businesses (Cohen et al., 2002; Arundel and Geuna, 2004; Abreu et al., 2008), they are among the most valuable, particularly for those with high research and development (R&D) intensity (Bishop et al., 2011; Petruzzelli, 2011)¹. However, research suggests that university-business interactions are often only moderately successful from the collaborating firm's perspective: for example, Pertuzé et al. (2010) found that, while about half of the university-business collaboration projects they studied resulted in major research outcomes, only 20 percent generated significant business impacts. It is therefore important to investigate what conditions allow firms to achieve their objectives through interactions with universities (Santoro and Betts, 2002; Pertuzé et al., 2010). This is the key aim of this study.

To do so, we first provide an important theoretical categorization of firms' main innovation-related objectives² when interacting with universities. Building on the literature on learning in the context of inter-organizational collaborations, we argue that by tapping into university knowledge firms may accomplish two main innovation-related objectives: (i) knowledge acquisition, whereby firms seek to receive knowledge from universities in order to develop

¹ For example, Arundel and Geuna (2004), focusing on the European firms that spend more on R&D (excluding France), found that in some sectors (aerospace and energy) the proportion of firms that considered research funded by the public sector as their main source of technical knowledge exceeded 50 percent, while in others (pharmaceuticals, foods, plastic and rubber) this share exceeded 20 percent.

² In the context of university-business interactions, firms can also pursue various other objectives not directly related to innovation, such as making financial gains, gaining increased reputation, building a network of contacts. These other objectives however are not the focus of the present study, which instead looks at how business tap into universities' knowledge to sustain their innovation processes.

their own knowledge base, which is then exploited in-house (Friedman and Silberman, 2003; Siegel et al., 2007); or (ii) knowledge co-creation, whereby firms seek to combine and integrate their market knowledge with the university's advanced technological knowledge during the interaction itself, in order to solve market-related challenges (Curley and Salmelin, 2013; Domingue, 2011). In the former case, the university and the firm play well-defined roles as knowledge producer and knowledge receiver respectively, since knowledge flows unidirectionally from one to the other; while in the latter case, although firms and universities remain specialists in their own domains, the knowledge producer and receiver roles are blurred (Mowery et al. 1996; de Silva et al. 2015; Yip et al. 2015).

While the literature on inter-organizational learning has argued that collaboration can facilitate both the co-creation of new knowledge and the transfer of existing knowledge, and that the two processes are distinct and require different facilitating mechanisms (Anand and , 2000; Kale et al., 2000; Lui, 2009), not many studies of university-business interactions have distinguished between these. The few studies that have acknowledged different objectives for university-business interaction processes, have focused on the universities' perspective (Perkmann et al., 2013). We know very little about firms' ability to achieve their objectives to acquire and co-create knowledge through their interactions with universities (Powers and McDougall, 2005a; Andersen and Rossi, 2011; Thorpe et al., 2011). Considering the key role played by inter-organizational knowledge flows in an ecosystem (Graham, 2014), investigating how businesses achieve their innovation-related objectives by tapping into sources of academic knowledge is core for ecosystem research.

This paper addresses this research gap by developing a conceptual model that highlights how different types of business competences relating to external relationship management – also called relational competences (Dyer and Singh, 1998) – influence firms' ability to

successfully achieve knowledge acquisition and knowledge co-creation objectives. We argue that relational competences may explain the heterogeneity between firms in achieving these objectives (Carmeli et al., 2009; Dyer and Singh, 1998; Lee et al., 2003). While the inter-organizational collaborations literature has focused to a greater extent on technical aspects of relationship management like planning, scheduling and project management methodology (Winter et al., 2006), more recently several scholars have highlighted the importance of the social and human aspects of the collaboration (Hanisch and Wald 2011). In fact, the knowledge-based view of the firm describes firms as repositories of knowledge and competences (Kogut and Zander, 1996; Spender, 1996; Yli-Renko, Autio and Sapienza, 2001) for whom building relational competences to acquire and exploit knowledge that sits outside the organization garners an essential source of competitive advantage (Kanter, 1994; Madhok and Tallman, 1998; Paulraj et al., 2008; Lado et al., 1997).

As relational competence is defined as a higher order construct (Woo and Ennew 2004) we have conceptualized three facets of firms' relational competences, which we denote respectively as relational closeness, relational communication and relational structuring competences (Jones-Evans et al., 1999; Bercovitz et al., 2001; Siegel et al., 2003; Un and Cuervo-Cazurra, 2004; Dimitratos et al., 2010; Ternouth et al., 2012). We develop three theoretical hypotheses on the relationship between relational competences and businesses' ability to achieve their knowledge acquisition and knowledge co-creation objectives when interacting with universities, and we then test them empirically using a dataset of 200 British firms. With this approach we seek to gain a better understanding of the business competences that underpin successful knowledge flows between universities and businesses within innovation ecosystems.

The identification of two distinct types of innovation objectives and the investigation of the relational competences that underpin their achievement are highly original aspects of the present analysis. Our findings are of interest to firms, which can assess and further develop their relational competences to achieve their knowledge acquisition and co-creation objectives. The findings are also of value to universities when selecting firms to collaborate with on the basis of their objectives and relational competences, as well as to policymakers who intend to put in place effective measures to support knowledge acquisition and co-creation.

The paper is organized as follows. In the next section, we present the theoretical framework that drives our empirical analysis, building upon a review of the recent literature on the role of relational competences in supporting inter-organizational collaborations in general, and university–business interactions in particular. In section 3 we present our data and methodology. Section 4 introduces our findings. We discuss implications in section 5.

THEORETICAL FRAMEWORK

Firms' knowledge acquisition and co-creation objectives when interacting with universities

In the inter-organizational learning literature, Grant and Baden-Fuller (2004) differentiate between knowledge acquisition and access. They argue that the former involves a firm gaining knowledge from an external source (such as another firm or a university), which is then assimilated and used to develop the firm's own knowledge. The latter involves combining and integrating knowledge from different external sources to achieve specific outcomes without necessarily internalising knowledge. This distinction has been applied, in different contexts and in slightly varied forms, by Tsang (1999) in relation to international strategic alliances, Inkpen and Currall (2004) in the case of joint ventures and Lui (2009)

with regards to supplier-buyer relationships. It is also evident in the literature that knowledge acquisition may comprise two stages; namely, knowledge exploration, in which knowledge is acquired to the organization, and exploitation, in which this knowledge is exploited in-house to achieve firm specific goals (Levinthal and March, 1993; Yli-Renko, Autio and Sapienza, 2001).

It is possible to apply this distinction to the case of university-business interactions. In this context, knowledge acquisition refers to firms' objective to acquire university knowledge, but not necessarily to work very closely with universities to exploit it. Here knowledge is transferred from universities to firms, usually in the early stages of the innovation process; the knowledge to be acquired needs to be related to firms' existing knowledge if they are to integrate it in their own knowledge base and exploit it at a later stage. This process can require a long time. Examples are the acquisition of fundamental academic knowledge embedded in codified documents like scientific papers and publications (Caloghirou et al., 2001); the acquisition of technology developed by universities (Balconi and Laboranti, 2006) via patent licensing (Geuna and Nesta, 2006); the acquisition of human talent through graduate employment (Blumenthal et al., 1996).

Knowledge co-creation implies that firms work with universities to combine and integrate knowledge from both parties in order to generate new knowledge (Hughes and Kitson, 2012; Garner and Ternouth, 2011) which they cannot produce independently, but which is required to solve specific market challenges (Blumenthal et al., 1996; Caloghirou, Tsakanikas and Vonortas, 2001; Tether, 2002; Lam, 2005; Markman, Siegel and Wright, 2008; Hughes and Kitson, 2012). In this process, firms' and universities' knowledge bases are complementary, and neither party is interested in acquiring each others' knowledge in order to integrate it in their own knowledge bases: rather, from the start they aim at combining their different bits of

knowledge to co-create a new knowledge base. This co-creation process can have immediate commercial application or societal impact (Curley and Salmelin, 2013; Domingue, 2011). For example, it may involve the combination of firms' market knowledge and universities' advanced technical knowledge to develop new products and processes, and more generally to develop technological, organizational, service, or marketing innovations that allow firms to gain strategic positioning in the market (Edmondson et al., 2012).

Table 1 summarizes the distinction between knowledge acquisition and co-creation focusing on four dimensions.

INSERT TABLE 1 HERE

Influence of relational competences on the firm's ability to achieve knowledge acquisition and co-creation objectives

The relational view, particularly in the supply chain and inter-organizational collaboration literature, argues that firms could achieve competitive advantage, yield productivity and reduce transaction costs by developing competences to leverage their relational resources during knowledge-based interactions with other parties (Dyer and Singh, 1998; Lane and Lubatkin, 1998; Yli-Renko, Autio and Sapienza, 2001). Since knowledge acquisition and co-creation are predominantly social processes (Kogut and Zander, 1992), the ability of a firm to manage its relationship with universities may determine its ability to achieve these objectives. In the literature, relational competence is viewed as a higher-order construct comprising different capabilities related to developing and managing relationships with other actors (Dyer and Singh, 1998; Woo and Ennew, 2004).

Since different studies have conceptualized the components of relational competence differently in order to suit the context³ (Ulaga and Eggert, 2006), we conceptualize three facets of relational competence that may influence the extent to which firms are able to achieve knowledge acquisition and knowledge co-creation objectives with universities. The three facets, developed by drawing on the inter-organizational collaboration and supply chain literature, are: relational closeness competence, which refers to the firm's ability to achieve a shared goal with the university by reducing the distance between itself and the university (Carmeli and Azeroual, 2009; Carmeli et al., 2009; Lee et al., 2003; von Krogh, 1998); relational communication competence, which denotes the firm's ability to maintain dialogue with the university by promoting communications based on openness, transparency and trustworthiness, and excluding hierarchical authority (Paulraj et al., 2008; Kale et al., 2000; Anderson and Weitz, 1992; Dyer and Singh, 1998; Kotabe et al., 2003; Takeishi, 2001; Chen and Paulraj, 2004); relational structuring competence, which refers to the firm's ability to negotiate the terms and conditions of the relationship and to develop an agreeable plan and structure as to how the relationship is expected to carry out (Vlaar et al., 2007; Kale et al., 2000; Srinivasan and Brush, 2006). The following sections develop hypotheses about how each of these facets may differently influence the firm's ability to achieve its knowledge acquisition and co-creation objectives when interacting with universities.

Relational closeness competence

A firms' ability to reduce the cognitive distance between itself and its partners is important in order to reach a shared understanding. This requires being able to manage people working in

³ For instance, in the relationship marketing literature, Woo and Ennew (2002) identify cooperation, adaptation, and atmosphere as sub constructs. In the inter-organizational collaboration literature, Dyer and Singh (1998) introduce the relational view of the firm as composed of relation-specific assets, knowledge sharing routines, complementary resources/capabilities, and effective governance. Similarly, in the supply chain management literature, Paulraj, Lado and Chen (2008) assert that relational competences comprise long-term relationship orientation, network governance and use of information technology. When discussing knowledge exploration and exploitation in young technology-based firms Yli-Renko, Autio and Sapienza (2001) conceptualize a relational view comprised of social interactions, network ties and relationship quality.

different contexts, with inherently different processes, objectives and cultures (Barnes, Pashby and Gibbons, 2002; Ambos et al., 2008) in order to reach a common vision and specific objectives (Steen, Buijs and Williams, 2014; Wallin et al., 2014). We denote this as relational closeness competence.

Since knowledge co-creation involves combining the complementary specialist knowledge of different parties, in which one does not have the expertise to verify the validity of the specialized knowledge of the other, the process is prone to uncertainty and trial and error (Lubatkin et al., 2001; Lui, 2009). The ability to reduce the cognitive distance between parties helps them to relate to each other (von Krogh, 1998) and prepares them psychologically (Carmeli et al., 2009) and behaviorally (Lee et al. 2003) for gaining new insights to solve common challenges through trial and error (Lee et al., 2003), which indeed leads to high quality knowledge generation (Thomke, 1998; von Krogh, 1998). During this process, becoming more familiar with each other's routines (Carmeli and Azeroual, 2009) and practices (Lorenzoni and Lipparini, 1999; Deken and Lauche, 2014) facilitates the co-creation of new knowledge (Carmeli and Azeroual, 2009). Firms with relational closeness competences are able to learn each other's strengths and weaknesses and identify effective and efficient ways to work together, which are of paramount importance for knowledge co-creation through close interactions (Doz and Hamel, 1997). Also, such firms regularly review and amend initially set goals and match practices of collaborators in support of reaching a shared understanding in dynamically evolving relationships (Deken and Lauche, 2014), without which they are unable to reap full benefits of knowledge co-creation.

In addition to developing competences in-house, a firm's relational closeness competences may also manifest in the use of specific institutions that link collaborators, since these third parties provide coordination, legal and administrative support services and resources required

to manage and sustain relationships and to reach a shared understanding (Siegel et al., 2003; Powers and McDougall, 2005b; Howells, 2006). These enable them to align the views of individual entities, which ensure parties sharing resources, risks and decisions jointly in order to co-create new knowledge (Brinckmann and Hoegl, 2011; Carmeli and Azeroual, 2009; Curley and Salmelin, 2013).

Hence, we posit that relational closeness competences are vital for knowledge co-creation between universities and firms. Instead, the effort to create a closer relationship might not be crucial for knowledge acquisition and possibly it may increase transaction costs, since universities and firms are not closely working together and only knowledge that is related to the firm's existing knowledge base is transferred, which involves lower uncertainty (Szulanski et al., 2004). This assertion leads to our first hypothesis:

H1: Relational closeness competences positively influence the firm's ability to achieve knowledge co-creation objectives when interacting with universities

Relational communication competences

Effective and efficient communication helps organizations to learn from each other and share knowledge (Paulraj et al., 2008). Open (Kale et al., 2000), transparent (Chakrabarti and Santoro, 2004) and trustworthy (Anderson and Weitz, 1992; Dyer and Singh, 1998) communication coupled with the exclusion of hierarchical authority (Zaheer and Bell, 2005) are crucial for knowledge-based collaboration success (Kotabe et al., 2003; Takeishi, 2001). We denote the firm's ability to communicate in this way as relational communication competences.

We assert that relational communication competences, which reduce operational and coordination costs and improve the quality of knowledge transfer, are more important for

knowledge acquisition than knowledge co-creation. Since knowledge acquisition involves transferring knowledge in the same domain as the firm (Lane and Lubatkin, 1998) and the exploitation of transferred knowledge occurs outside the relationship, effective communication is vital to ensure valuable knowledge is appropriately transferred to the firm by reducing potential loss of knowledge during the acquisition process. With regard to strategic alliances, Chen and Paulraj (2004) found that communication is key for the exchange of timely, accurate, and relevant knowledge. Effective communication enhances firms' ability to recognize and assess the value of the external knowledge, to acquire relevant knowledge (Yli-Renko et al., 2002), firms' incentive to process and use acquired knowledge (Zahra et al., 2000) and the willingness of external parties to share information with the firm. Such communication reflects an enhanced absorptive capacity of firms (Cohen and Levinthal, 1990), and therefore it facilitates not only the transfer of explicit knowledge, but also the transfer of tacit knowledge (Kogut and Zander, 1996).

H2: Relational communication competences positively influence firms' ability to achieve knowledge acquisition objectives when interacting with universities

Relational structure competence

Setting up the collaboration on the basis of clear and agreed upon rules is important for success (Siegel et al., 2003; Fink and Kessler, 2010). Having negotiations around the price, and terms of the contract, defining a clear working plan and setting clear goals (Ternouth et al., 2012) help to reduce uncertainty (Vlaar et al., 2007), discourage free riding (Dyer and Singh, 1998) and promote norms of reciprocity (Larson, 1992).

The firm's ability to structure the relationship, which we denote as relational structuring competence, is important for both knowledge acquisition and knowledge co-creation. On the one hand, firms that have this competence are good at explicitly stating, negotiating and

agreeing on internally made decisions on the types of knowledge to be acquired, which is key for knowledge acquisition. On the other hand, the relational structuring competence to specify obligations and specific duties of partners reduces conflicts and unnecessary monitoring and bargaining (Dyer and Singh, 1998), improves clarity, protects proprietary assets (Kale et al., 2000) and enables the parties to achieve targets smoothly (Srinivasan and Brush, 2006). When a relational structure is in place, firms are more likely to share and integrate knowledge than otherwise. Hence we hypothesize:

H3: Relational structuring competences positively influence firms' ability to achieve knowledge acquisition and knowledge co-creation objectives when interacting with universities

INSERT FIGURE 1 HERE

DATA AND METHODOLOGY

Data

This investigation builds upon data collected through an online survey aimed at gathering evidence on firms' experience with university interactions. The survey was carried out jointly by the Big Innovation Centre (BIC) and the UK's Intellectual Property Office (IPO). The BIC-IPO survey was sent (during March to April 2013) to 903 firms based in the United Kingdom (UK), drawn from a database of businesses maintained by the Work Foundation (which, at the time, was the Big Innovation Centre's parent company). Since the purpose of our study was to investigate practices adopted by firms that interacted with universities, the sample was chosen to include only users of university knowledge.

The BIC-IPO survey received 226 responses, 190 of which (21 per cent of those that were contacted) were usable after data cleaning. The set of respondents do not significantly differ

from the set of non-respondents in terms of number of employees, turnover per employee, age of the company, geographical location and UK SIC (2007) sector, (with two exceptions: firms based in Scotland and firms in the knowledge intensive business service and other services⁴ sector are overrepresented among the respondents compared to the non-respondents). Furthermore, the distribution of the set of 190 respondents in terms of size and sector is not significantly different from that of the set of approximately 800 British firms that interacted with universities according to the UK Innovation Survey (Department for Business, Innovation and Skills, 2010)⁵.

The BIC-IPO survey featured a set of questions, particularly those related to businesses' objectives to acquire and co-create knowledge when interacting with universities, and businesses' relational competences, which have not been covered in any national survey. The questionnaire comprised several questions⁶ focused on:

(i) The extent to which interactions with universities allowed firms to reach their innovation objectives; 6 objectives relating to knowledge acquisition and knowledge co-creation were presented, measured on a 3 item Likert scale (1–works very well; 2–works less well; 3–not applicable), listed in Table 2.

⁴ Sectors have been classified according to the United Kingdom Standard Industrial Classification of Economic Activities (SIC) 2007. The KIBS category comprises companies in Sections K Financial and insurance activities, J Information and communication, L Real estate activities, M Professional, scientific and technical activities and N Administrative and support service activities. The other services category comprises companies in Sections G Wholesale and retail trade; repair of motor vehicles and motorcycles, H Transportation and storage, I Accommodation and food service activities, R Arts, entertainment and recreation, S Other service activities. The difference is due in particular to professional, business and trade associations (section S) being overrepresented among respondents.

⁵ The UK Innovation Survey is a national survey of businesses, conducted by the Department for Business Innovation and Skills, which collects information on main sources of information on business innovation in the UK. One of the sources is universities and 5.6 percent of respondents have mentioned that they collaborate with universities. The size of the sample of this survey was 29000 and the response rate was 49 percent.

⁶ Respondents were also asked two more questions, which are not used in the present study, about how interactions with the university were usually initiated, and about their use of IP protection mechanisms when interacting with universities.

(ii) Relational competences; 9 elements relating to relational closeness, relational communication and relational structuring were presented, listed in Table 3, and firms were asked to rate their effectiveness on a 3 item Likert scale (1–typically works well; 2–typically works less well; 3–have not used).

(iii) The channels used by the firm in order to interact with universities; 15 possible channels were presented, listed in Table 4, and the respondents were asked to rate their effectiveness on a 3 item Likert scale (1–works very well; 2–works less well; 3–have not used).

(iv) Several questions on the firms’ characteristics (number of employees, turnover, sector, whether the company is part of a group) and the nature of their interactions with universities in the previous 12 months (number of universities the firm collaborated with, number of relationships per university, and share of collaborations with UK-based universities).

Further information about the 190 respondents was drawn from the FAME database (UK SIC 2007 sector, postcode, date of incorporation, number of employees and turnover) and from the Espacenet database (number of patents assigned to the firm).

INSERT TABLE 2 HERE

INSERT TABLE 3 HERE

INSERT TABLE 4 HERE

Empirical strategy

Based on the theoretical discussion presented in Section 2, we first perform a descriptive analysis on whether firms pursue each innovation objective and the extent to which they do so successfully. Secondly, we explore how the firms’ propensity to pursue and successfully achieve their knowledge acquisition and co-creation objectives is influenced by their

relational competences, while controlling for several factors. We run two different models: one (Model 1) in which we model the factors that influence firms' propensity to achieve knowledge acquisition objectives, and one (Model 2) in which we model the factors that influence firms' propensity to achieve knowledge co-creation objectives. The models have the same structure and covariates, but different dependent variables.

We employ a Heckman estimation procedure, which includes estimating both a selection equation that indicates whether firms are pursuing a certain type of knowledge-based objective (i.e. knowledge acquisition or knowledge co-creation) and an outcome equation in which we measure the influence of relational competences on the share of objectives that have been successfully achieved, controlling for several characteristics of the interaction and of the firm. The selection step is necessary because the firms that pursue innovation objectives in their interactions with universities are likely to be a self-selected group whose ability to pursue such objectives depends on several unmeasured factors (primarily, their innovation capability). Because the sample is not random but includes firms that have particularly high innovation capabilities, the estimation of the share of successfully achieved objectives in the absence of a selection equation would lead to an underestimation of the importance of the factors, such as relational competences, included in the outcome equation (as the firms that exploit their relational competences to achieve their objectives would not be compared with a random set of other firms, but with a set of particularly capable ones).

The selection equation will hence be as follows:

$$SEL_i = \begin{cases} 1 & \text{if } sel_i^* = z_i' \gamma + e_i > c \\ 0 & \text{if } sel_i^* = z_i' \gamma + e_i \leq c \end{cases} \quad (1)$$

where SEL is a binary variable that equals 1 if a firm declares to have pursued that type of objective, and sel* is a latent variable that measures the underlying ability of a firm to pursue

that objective. If such ability exceeds a certain threshold level c then the firm will claim that they pursue a certain type of objective. The success in pursuing an objective y , which depends on a set of variables x , will be observed only if SEL_i is equal to 1:

$$y_i = \begin{cases} y_i^* & \text{if } SEL_i = 1 \\ 0 & \text{if } SEL_i = 0 \end{cases} \quad \Leftrightarrow \quad y_i = \begin{cases} y_i^* = x_i' \beta + \varepsilon_i & \text{if } SEL_i = 1 \\ 0 & \text{if } SEL_i = 0 \end{cases} \quad (2)$$

In order to estimate the outcome equation we use the following linear model:

$$y_i = c + \sum_j \text{Competences}_{ij} + \sum_k \text{Interactions}_{ik} + \sum_l \text{Firm}_{il} + v_i \quad (3)$$

Where y_i measures the share of objectives successfully pursued by firm i , *Competences* denotes the type of relational competences exploited by the firm during its interaction with universities, *Interactions* denotes the type of interactions which occurred between the firm and the university (intensity and nature of engagement with universities, to proxy their general ability and propensity to engage), *Firm* indicates a set of firm-level characteristics and v_i is an idiosyncratic error term. In particular, the *Firm* set of variables comprises general firm characteristics like the firm's size, its age, its patent intensity.

The selection equation includes, besides variables capturing the types of interactions which occurred between the firm and the university and a set of firm-level characteristics, also two exclusion restrictions that are likely to affect the selection process (the firms' likelihood to pursue knowledge acquisition or knowledge co-creation objectives) but not the outcome (their success in achieving these objectives). As we explain in more detail in the next section, we suggest that firms are more likely to seek knowledge acquisition and co-creation objectives when their interactions with universities aim to exploit the universities' research and education capabilities. Therefore, we claim that firms that usually interact with universities using research and education-based channels are more likely to seek knowledge

acquisition and co-creation objectives, although they are not necessarily more successful in achieving them. The following section explains in greater detail how the variables used in the analysis have been constructed.

Variables construction

Dependent variables

Using the responses to question (i) in the questionnaire, we first created a binary variable named Knowledge_acquisition which takes value 1 if the firm pursues at least one of the following three objectives: acquiring new basic knowledge ; acquiring the technology the company need; acquiring university talent (and zero otherwise). We then created a continuous variable named Success_acquisition indicating the share of knowledge acquisition objectives successfully achieved by the firm (ratio between the number of knowledge acquisition objectives successfully achieved and the number of knowledge acquisition objectives pursued). Similarly, we created a binary variable named Knowledge_cocreation which is equal to 1 if the firm pursues at least one of the following three objectives: developing new products and processes with university; Interactive learning and co-creation of knowledge with university; gaining strategic market positioning through the integration of market knowledge and university knowledge (and zero otherwise). We then created a continuous variable named Success_cocreation indicating the share of knowledge co-creation objectives successfully achieved by the firm (ratio between the number of knowledge co-creation objectives successfully achieved and the number of knowledge co-creation objectives pursued).

In the selection equation, the dependent variable (SEL^*_i) measures whether the firm has pursued knowledge acquisition or knowledge co-creation objectives: therefore, in the selection equation the dependent variables are Knowledge_acquisition (in Model 1) and

Knowledge_cocreation (in Model 2). In the outcome equation, the dependent variable (y_i) measures the extent to which the firm achieved its knowledge acquisition or co-creation objectives: therefore, the dependent variables are Success_acquisition (in Model 1) and Success_cocreation (in Model 2).

Independent and control variables

We use the same independent and control variables in Models 1 and 2. In the outcome equation, we first include three variables that capture the types of relational competences exploited by the firms (Competences), building upon the responses to the question (ii). In order to form the variables by validating the conceptual categorization of relational competences emerged from our analysis of the inter-organizational collaborations literature, we have performed a principal component analysis (PCA) on the binary variables measuring whether a firm exploited each competence (these are binary variables that take value 1 if the firm states that it uses that competence successfully, zero otherwise). This exercise tells us which relational competences “go together” empirically on the basis of our data, which allows us to derive further information from our rich empirical dataset, rather than rely only upon the existing literature. The PCA was run on a subset of 9 competences; The PCA results reported below rely upon a Pearson correlation matrix, but we obtained similar results when using a tetrachoric correlation matrix.

As shown in the following Table 5 we found three main components with eigenvalues >1 . The Kaiser-Meyer-Olkin Measure is 0.724 (>0.5), indicating that the patterns of correlations are relatively compact and factor analysis should yield distinct and reliable factors. The sum of three components explains 65.3 percent of variance (i.e. C1–26.2 percent, C2–21.6 percent, C3–17.5 percent). All these results indicate that the components derived are appropriate for this analysis.

INSERT TABLE 5 HERE

By grouping the factors that load highly on each component (in Table 4, we have highlighted all loadings greater than 0.3) we came up with a qualitative description of the three main components. The first component includes what we have defined as relational communication competences: being more transparent, flattening hierarchical communication structures, and reducing opportunism in the course of the collaboration. The second component includes what we have defined as relational structuring competences, including negotiating price and other terms of the contract, negotiating with university technology support or business relations staff and having a strong programme structure with clear milestones. The third component includes what we have defined as relational closeness competences, referring to using institutions that link academics and businesses, reaching shared understanding, matching academic practices to business routines. The PCA therefore allows us to identify some meaningful categories of relational competences that, while strongly rooted in the empirical data, also reflect the conceptual categories emerging from our analysis of the inter-organizational collaborations literature.

Factor scores for each observation, called, *Relational_communication* (C1), *Relational_structuring* (C2) and *Relational_closeness* (C3) are used as data points for these three types of relational competence variables. Factor scores could be interpreted as the projections of the observations onto the principal components (Baskilevsky, 1983).

In the outcome equation we also include four sets variables that, in different ways, measure the firm's general ability to engage with universities. Firms that have experience of collaborating with many different universities (Subramaniam and Venkatraman, 2001), and firms that frequently interact with universities (Gustafsson, Kristensson and Witell, 2012), may enjoy greater ability to deal with academics and with university institutions. For

example, they may overcome cultural barriers thanks to having gained a better understanding of academic culture and university practices and having adapted their processes to better work with universities. Their cognitive and cultural proximity to universities may be high, and this in turn facilitates the transmission of knowledge, especially tacit knowledge (Javidan et al., 2005; D'Este and Iammarino, 2010). Therefore, we include the number of universities with which the firm interacted (a set of three dummies capturing whether the university interacted with one university, between two and ten, or more than ten universities) and the average number of relationships with each university (a set of three dummies capturing whether the university had one relationship, between two and ten, or more than ten relationships with each university)

Due to geographical and cultural proximity favouring the transmission of tacit knowledge, firms that interact with universities that are geographically close may be more likely to be successful particularly where tacit knowledge is important, although this may not be crucial for firms that are involved in collaborations around mainly codified knowledge (Caloghirou, Tsakanikas and Vonortas, 2001; Bodas Freitas, Rossi and Geuna, 2014). Therefore we include three dummies capturing the proportion of a firm's interactions occurring with UK universities (less than a quarter, approximately half, more than three quarters).

We also include some controls relating to firm characteristics. Abundant evidence suggests that while large companies are better able to successfully interact with universities, small and medium sized enterprises (SMEs) encounter several barriers (Witty 2013). Also, large firms seem to value interactions with universities more than SMEs do (Howells et al., 2012). This could be due to their resource abundance when compared with the scarcer financial and human resources of SMEs (Acs and Audretsch, 1990). Similarly, firms with greater absorptive capacity (Cohen and Levinthal, 1990), that is firms that are better able to absorb

external knowledge and successfully integrate it in their innovation processes (Tsai, 2001), may be more likely to achieve knowledge acquisition and co-creation objectives. Absorptive capacity is usually proxied by variables capturing a firm's research or patent intensity or the skill profile of its workforce (Zahra and George, 2002). We control for the firm's size measured by the number of employees (N_employees), and for its age (years since date of incorporation, Firm age) and patent intensity (number of patents per employee, Patents per employee).

A firm's sector of operation also matters. Empirical studies show that firms collaborate more frequently on applied science projects, especially materials and computer science (Levin et al., 1987; Meyer-Krahmer and Schmoch, 1998; Cohen et al., 2002). This is not to say, however, that firms working in other areas do not interact with universities: it has been shown that knowledge-intensive business service providers also engage strongly with universities (Amara et al., 2004). Since the sector of operation affects firms' likelihood to interact with universities (Schartinger et al., 2001), it may also influence their propensity to achieve knowledge access and co-creation objectives. We control for sector of economic activity considering five comprehensive sectors⁷.

In the selection equation, we include two exclusion restriction variables that influence the probability of selection but not the outcome: whether the firm used research-based interaction channels such as joint research projects with universities, organization of joint conferences, development of joint publications, setting up of joint labs (D_Research); and whether the

⁷ The five sectors considered are: 1) Agriculture and mining (includes Sections A Agriculture, Forestry and Fishing and B Mining and Quarrying), 2) Manufacturing, utilities and construction (includes Sections C Manufacturing, D Electricity, gas, steam and air conditioning supply, E Water supply, sewerage, waste management and remediation activities and F Construction), 3) KIBS (includes Sections K Financial and insurance activities, J Information and communication, L Real estate activities, M Professional, scientific and technical activities and N Administrative and support service activities), 4) public sector (includes Sections O Public administration and defence; compulsory social security, P Education and Q Human health and social work activities) and 5) other services (includes Sections G Wholesale and retail trade; repair of motor vehicles and motorcycles, H Transportation and storage, I Accommodation and food service activities, R Arts, entertainment and recreation, S Other service activities).

firm engaged in education-based interaction channels such as joint supervision of graduates, staff undertaking placements at universities and/or attending university training, hosting university staff at the company, hosting graduates as trainees (D_Education). The reasoning behind the use of these variables is that firms that engage in such knowledge-intensive interactions with universities are more likely to pursue knowledge acquisition and knowledge co-creation objectives (D'Este & Patel 2007; Perkmann & Walsh 2007). These variables should influence the likelihood to pursue such objectives, but not their achievement. Indeed, we have found that these variables are significant in the selection equation but they are not significant predictors of success in knowledge acquisition and knowledge co-creation if they are included in the outcome equation. This suggests that they are appropriate variables to use as exclusion restrictions.⁸ The selection equations also include the same independent variables as in the outcome equations.

FINDINGS

Of the 190 firms whose responses were usable for the analysis, 168 (88.4 per cent) reported that they had had some interactions with universities in the previous year. The empirical analysis in the rest of this paper will focus on those 168 firms. The following Table 6 shows the distribution of the main demographic variables for the 190 respondents, for the subset of 168 respondents that interacted with universities in the previous year and for the subset of 22 respondents that did not interact with universities in the previous year. The table also shows that there are no significant differences in the distributions of these variables for firms that did and did not interact with universities.

⁸ Moreover, if we try to include among the exclusion restrictions another dummy variable equal to 1 if the firm has used any of the other less knowledge-intensive channels listed in Table 4 (under “other channels”), this variable is never significant in the selection or outcome equation. This further confirms that engaging in more knowledge-intensive channels of interaction is a predictor of the firm’s likelihood to pursue knowledge acquisition and/or co-creation objectives when interacting with university, while engaging in less knowledge-intensive channels does not have this effect.

INSERT TABLE 6 HERE

Of the respondents, 42.3 per cent of respondents (71 firms) had interacted with between two and ten universities, 14.9 per cent (25 firms) had interacted with only one university and 18.5 per cent (31 firms) with more than ten universities. When firms were asked to mention the main university with which they interacted, they mentioned more than fifty universities based in the UK, including teaching and research intensive as well as old and new universities. Among them, 41.7 per cent (71) reported having had on average between two and ten interactions with each of the universities they worked with during the previous twelve months and 20.2 per cent (34 firms) had one interaction on average, and 9.5 per cent (16 firms) had more than 10 interactions on average.

Almost half of the firms that had collaborated with universities in the previous year (79 firms, 47 per cent) reported that more than three quarters of their relationships were with universities in the UK. On the other hand, 9.5 per cent (16 firms) had approximately half of their relationships with UK universities and for 14.3 per cent (24 firms) this proportion was less than a quarter, indicating a very global engagement profile.

Firms' achievement of knowledge acquisition and knowledge co-creation objectives

Of the 168 firms that stated that they had some interactions with universities in the previous 12 months, 113 pursued both knowledge acquisition and knowledge co-creation objectives, 17 pursued only knowledge acquisition but not knowledge co-creation objectives, eight pursued only knowledge co-creation but not knowledge acquisition objectives, and 52 pursued neither. As shown in Table 7 below, firms pursued knowledge acquisition and co-creation objectives to different extents: while more than 60 percent pursued knowledge acquisition objectives (with the exception of 'acquiring the technology the company needs',

pursued by 41.7 percent), less than 60 percent of firms pursued knowledge co-creation objectives.

INSERT TABLE 7 HERE

Firms were heterogeneous in relation to their achievement of knowledge acquisition and co-creation objectives. While some successfully achieved both knowledge acquisition and knowledge co-creation objectives, others were struggling. In general, more firms were able to achieve knowledge acquisition objectives than co-creation ones; almost 48 percent achieved at least two thirds of their knowledge acquisition objectives, while just under 30 percent achieved at least two thirds of their knowledge co-creation objectives; conversely, 36.9 percent of firms achieved less than one third of their knowledge acquisition objectives, while the share of firms that achieved less than one third of their knowledge co-creation objectives was 56 percent.

There is also a significant correlation between the achievement of knowledge acquisition and co-creation objectives. Of those who achieved all of their knowledge co-creation objectives, 69 per cent also achieved all of their knowledge acquisition objectives. This suggests that a group of sophisticated collaborators are able to successfully pursue all these objectives when interacting with universities. On the other hand, it is interesting to find that only 50 per cent of those who achieved all of their knowledge acquisition objectives were successful at achieving knowledge co-creation objectives to a similar extent. This confirms that a group of firms are able to acquire university knowledge, but are finding co-creation with universities more difficult. For these firms, there is scope for learning how to better engage in knowledge co-creation in order to address their more complex business challenges. Finally, 81 percent of firms that did not do well in knowledge acquisition also tended to be unable to engage in knowledge co-creation. These patterns may indicate that the ability to benefit from

interactions with universities to achieve one's strategic objectives depends on having the appropriate relational competences, whatever the objective pursued.

The effect of relational competences on the achievement of knowledge acquisition and knowledge co-creation objectives

We implemented two econometric models that analyzed the extent to which firms' success in achieving knowledge acquisition or knowledge co-creation objectives is influenced by the firms' relational competences, as well as by several firm characteristics including their patterns of interactions with universities.

First, we checked whether our data suffers from common method bias, which may occur when both dependent and independent variables are derived from the same respondents, particularly when the variables are perceptual measures (Podsakoff and Organ, 1986). Following Chang, Witteloostuijn and Eden (2010) a factor analysis of all 20 dependent and independent variables used for the analysis was conducted. This resulted in 9 highly significant components, which assured that data does not have common method bias.

Table 8 reports the main descriptive statistics on the variables included in the regressions.

INSERT TABLE 8 HERE

First, using the Heckman two step estimation procedure, we have carried out a regression analysis on the share of successfully achieved knowledge-acquisition objectives (second stage), given that the firm pursues knowledge acquisition objectives (first stage, which is a probit on the probability to pursue knowledge access objectives) (Table 9). The rho in this model is not statistically significant, which indicates that there is no significant selection bias in the second-stage estimations. Therefore, we also present the results of the OLS regression on the truncated sample of 130 companies that pursue knowledge acquisition objectives.

The propensity to successfully achieve knowledge acquisition objectives increased with stronger relational communication competences. The factor defining relational competences related to structuring the interaction is not significant. This is consistent with H2, while H3 is not supported. We hypothesized that relational closeness competences may be unimportant for knowledge acquisition and in fact that attempts to develop these competences may increase transaction costs, but it appears that instead they are somewhat important too, although with lower significance (10 percent), and the coefficient is smaller than for relational communication competences.

Compared with firms that had more than ten interactions with each university, those that had fewer were less likely to achieve success. This suggests that more frequent interactions are likely to enable firms to achieve knowledge acquisition objectives. The number of universities with which the firm interacted is not significant. Compared with firms that had a small share of UK collaborations, those that had a larger share of UK collaborations were less successful. Since knowledge acquisition does not necessarily require close interactions with universities, particularly when knowledge is codified, businesses might be able to easily acquire knowledge produced by international universities. The number of employees had a positive effect on the ability to successfully achieve knowledge acquisition objectives. It is notable from the selection equation that being engaged in education-based interaction channels and having relational communication competences increase the likelihood to seek knowledge acquisition objectives.

INSERT TABLE 9 HERE

Secondly, a regression analysis using the Heckman two-step estimation procedure was carried out on the share of successfully achieved knowledge co-creation objectives (second stage), given that the firm pursued knowledge co-creation objectives (first stage, which is a

probit on the probability to pursue knowledge co-creation objectives), (Table 10). The rho in this model is not statistically significant, which indicates that there is no significant selection bias in the second-stage estimations. Therefore, we also present the results of the OLS regression on the truncated sample of 119 companies that pursue knowledge co-creation objectives.

The propensity to successfully achieve knowledge co-creation objectives increased with relational closeness competences, whereas relational communication and structuring competences are not significant. This is consistent with H1, while H3 is not supported.

The variables measuring the number of universities with which the firm interacted, the number of relationships with each university, and the share of national collaborations, are not significant, and neither are the other controls. The selection equation shows that the probability to seek knowledge co-creation objectives is positively related to the use of both research-based and education-based interaction channels and to the use of relational communication competences.

INSERT TABLE 10 HERE

DISCUSSION AND RECOMMENDATIONS

While university–business interactions are a key knowledge-based interdependence in innovation ecosystems, evidence suggests that businesses are often unable to achieve the objectives which these interactions were designed to address. In our study we investigated how firms’ relational competences influence their ability to achieve two main innovation objectives, namely, knowledge acquisition and knowledge co-creation (Carmeli et al., 2009; Lee et al., 2003; Dyer and Singh, 1998). To our knowledge this is the first study that

distinguishes between these two types of objectives in the context of university-business interactions.

We find that while most firms are able to successfully acquire university knowledge in the form of basic knowledge, technology or human talent, addressing complex business challenges through knowledge co-creation proves to be more difficult for a significant proportion of them. To some extent this result is understandable, since addressing complex business challenges by jointly building upon the knowledge bases of firms and universities is a difficult process, and many of these organizations' objectives and incentives may not be aligned (Barnes, Pashby and Gibbons, 2002; Ambos et al., 2008). However, the scale of the challenge here is matched by the opportunity (Al-Laham, Amburgey and Baden-Fuller, 2010). It is encouraging to find that firms that are successful at knowledge co-creation are also successful at acquiring university knowledge, suggesting that there is no opposition between collaborating with universities in order to address more direct business challenges and engaging in more traditional knowledge transfer processes: rather, a group of sophisticated collaborators are able to successfully pursue all these objectives, indicating that their success is at least in part owed to their relational competences.

Our findings suggest that two kinds of relational competences are important in supporting the successful achievement of knowledge-based objectives: relational communication competences, firms' ability to communicate in an open, transparent and trustworthy manner and excluding hierarchical authority (Paulraj et al., 2008; Kale et al., 2000; Anderson and Weitz, 1992; Dyer and Singh, 1998; Kotabe et al., 2003; Takeishi, 2001; Chen and Paulraj, 2004); and relational closeness competences that help to reduce the cognitive distance between the parties' values and approaches towards the relationship (Carmeli and Azeroual, 2009; Carmeli et al., 2009; Lee et al., 2003; von Krogh, 1998). Since interactions between

universities and firms are not static but evolve over time, these competences—which increase transparency, ensure effective communication, set matching routines and practices and build shared values, by taking into account the changing circumstances of two parties as well as of the collaboration—enable firms to successfully manage dynamic interactions.

Nevertheless, the importance of these competences varies depending on the firms' innovation objectives. The analysis of marginal effects suggests that relational communication competences are particularly important for the achievement of knowledge acquisition objectives, while relational closeness competences are particularly important for the achievement of knowledge co-creation objectives. One reason for the latter finding may be that knowledge co-creation entails universities and businesses working together by integrating their complementary knowledge bases (Grant and Baden-Fuller, 2004; Lui, 2009), whereas in the case of knowledge acquisition the firm is independent in deciding how to utilize academic knowledge once it has been acquired (Siegel et al., 2003; Yli-Renko, Autio and Sapienza, 2001). Therefore, the parties involved in the knowledge co-creation process should align their value propositions (Steen et al., 2014; Wallin et al., 2014), which ensures that they are able to share resources, risks and decisions jointly (Curley and Salmelin, 2013). On the contrary, communication might not be so key for co-creation since the interaction is not necessarily aimed at transferring knowledge.

Relational structuring competences do not play a significant role in the interaction's success, suggesting that the ability to set out terms, conditions and programmes, mainly at the start of the relationship is not crucial for success; instead, it is those competences that support the ongoing relationship between the parties which are more suitable to the changing dynamics of the interactions. The negative (but insignificant) coefficients in of the relational structuring

competence variable in Models 1 and 2 may even suggest that greater focus on static terms and programmes could be detrimental to success in dynamic knowledge-based interactions.

The difficulties faced by firms when co-creating knowledge with universities—despite the clearly evident need for and benefits from knowledge co-creation—highlight the importance of universities, firms and policy makers placing greater emphasis on supporting knowledge co-creation initiatives. In general firms should strengthen their relational communication and relational closeness competences aimed at supporting the parties' collaboration as the relationship unfolds, by promoting ongoing communication and transparency, shared vision shared ways of working between the parties.

This study suffers from several limitations, in particular the relatively small number of observations and the focused nature of the sample. At the same time, the choice to focus on a subset of firms that interact frequently with universities is justified in light of the need to investigate behaviors such as knowledge co-creation, which are not yet widely diffused.

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INSERT APPENDIX HERE

Table 1. The distinction between knowledge acquisition and co-creation

Dimension	Knowledge access	Knowledge co-creation
1. Process	Acquire knowledge, which is then exploited in-house to achieve firm-specific objectives	Combine firm and university knowledge to achieve specific outcomes that each party cannot achieve independently
2. Knowledge relatedness	The firm gains knowledge of a related domain from the university. This knowledge is transferred to, absorbed, internalised, and assimilated by the firm into its own knowledge base, to be later exploited by the firm	The firm combines its knowledge with complementary specialist knowledge from the university. These bits of knowledge are integrated into a new knowledge base, and utilized to achieve specific outcomes during the interaction
3. Knowledge type	Mostly explicit, but if tacit knowledge needs to be used this should be transferred to the firm.	Could be tacit or explicit. The parties exploit each other's tacit knowledge without its being transferred from one to the other
4. Outcome	Interaction might not generate immediate market outcomes.	Since the firm's market knowledge is integrated, the interaction generates immediate market outcomes.

Sources: This table builds on Grant and Baden-Fuller (2004); Tsang (1999); Inkpen and Currall (2004); Lui (2009); Levinthal and March (1993); Yli-Renko, Autio and Sapienza (2001)

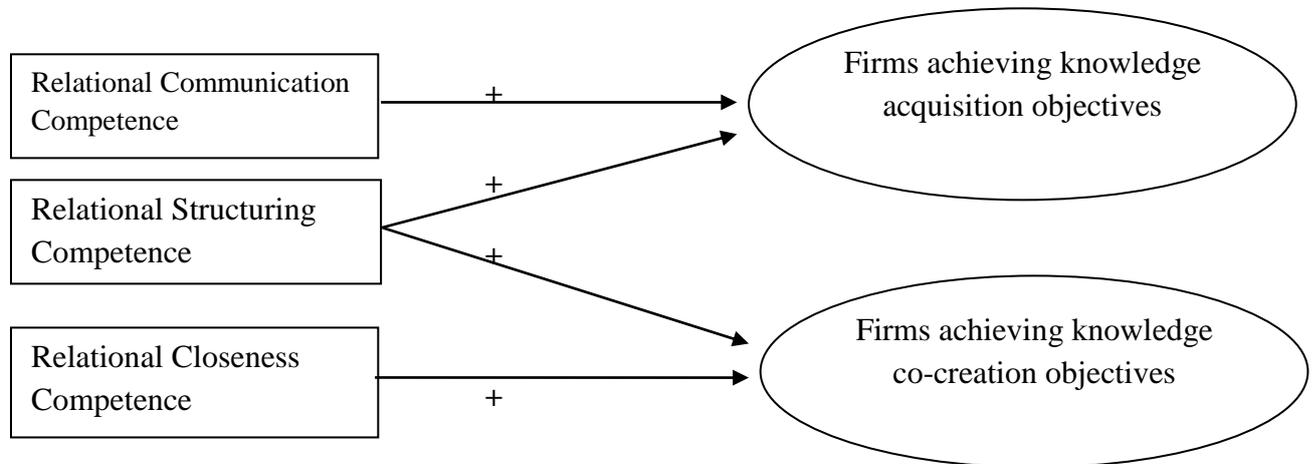


Figure 1. Relational competence and firms' innovation objectives

Table 2. Firms' innovation objectives when interacting with universities: questionnaire items

Strategic Objectives
1. Knowledge Acquisition Objectives
Acquiring new basic knowledge
Acquiring the technology the company needs
Acquiring university talent
2. Knowledge Co-creation Objectives
Developing new products and processes with university
Interactive learning and co-creation of knowledge with university
Gaining strategic market positioning through the integration of market knowledge and university knowledge

Table 3. Relational competences used when interacting with universities: questionnaire items

Relational competence
1. Relational Structuring Competence
Negotiating price or other terms of the contract
Negotiating with university technology support or business relations staff
Strong work programme structure with clear milestones
2. Relational Communication Competence
Increasing transparency
Reducing top-down approach with more team-level communications
Avoiding opportunistic behaviour or other trust issues
3. Relational Closeness Competence
Matching business routines to practices of academics or universities
Using institutions that link academics and companies
Attempt to reach a shared understanding with academics

Table 4. Interaction channels between universities and firms: questionnaire items

Interaction channels
1. Research-based channels
Participating in joint research projects
Arranging joint conferences or workshops
Joint publications
Forming joint research labs
2. Education-based channels
Company staff participating in higher education and training (e.g. MSc or PhD programme)
Company staff supervising university students (e.g. on MSc or PhD programme)
Company staff attending executive training offered by the university
Staff from a university undertaking a placement in a company
Company staff undertaking a placement in a university
University students working as trainees in a company
3. Other channels
University advice for applied problem-solving
Other services provided by the university (such as testing or prototyping)
Borrowing/lending equipment, sharing laboratories or other facilities
Contacts with university spinouts
Other interactions

Table 5. PCA on use of relational competences

	C1	C2	C3
Increasing transparency	0.593	-0.086	0.014
Reducing top-down approach with more team-level communications	0.521	0.077	-0.082
Avoiding opportunistic behaviour or other trust issues	0.427	-0.038	0.102
Negotiating price or other terms of the contract	-0.023	0.633	0.051
Negotiating with university technology support or business relations staff	-0.062	0.665	0.062
Strong work programme structure with clear milestones	0.323	0.341	-0.227
Matching business routines to practices of academics or universities	-0.035	-0.036	0.695
Using institutions that link academics and companies	-0.072	0.142	0.487
Attempt to reach a shared understanding with academics	0.284	-0.064	0.453

Table 6. Firm characteristics

Firm characteristics	All respondents (190)	Firms that had some interactions with universities in the previous year (168)	Firms that did not interact with universities in the previous year (22)		
	Number	Number	Number	t-statistic	p-value
Number of employees	9714.49	10927.38	452.18	-1.55	0.122
Firm age in years	22.58	21.98	27.23	0.905	0.367
Number of patents	2246.79	2363.79	1353.00	-0.359	0.720
	%	%	%	Chi-Square statistic	p-value
England	90.53	91.07	86.36	2.945	0.400
Scotland	6.32	5.36	13.64		
Wales	0.53	0.60	0		
Other region	2.63	2.98	0		
Agriculture and mining	1.58	1.79	0	5.571	0.350
Manufacturing, utilities and construction	12.11	12.50	9.09		
KIBS	62.111	63.10	54.55		
Public administration, health and education	4.21	4.76	0		
Other services	16.32	14.29	31.82		

Table 7. Firms' achievement of innovation objectives

Innovation objectives:	% firms that pursue each objective (out of 168 firms)	% firms that achieve each objective (as a share of firms that pursue that objective)
(1) Knowledge acquisition:		
Acquiring new basic knowledge	62.5	75.2
Acquiring the technology the company needs	41.7	24.3
Acquiring university talent	69.6	65.0
(2) Knowledge co-creation:		
Developing new products and processes with university	50.6	28.2
Interactive learning and co-creation of knowledge with university	58.3	54.1
Gaining strategic market positioning through the integration of market knowledge and university knowledge	53.0	43.8

Table 8. Descriptive statistics on variables used in the regressions (168 observations)

Variables	Mean	St. Dev.	Min	Max
Success_acquisition	0.49	0.43	0.00	1.00
Knowledge_acquisition	0.77	0.42	0.00	1.00
Success_cocreation	0.34	0.42	0.00	1.00
Knowledge_cocreation	0.71	0.46	0.00	1.00
Relational_communication	0.00	1.54	-1.52	3.91
Relational_structuring	0.00	1.39	-1.27	3.83
Relational_closeness	0.00	1.25	-1.55	3.34
Few UK collaborations	0.24	0.43	0.00	1.00
Many UK collaborations	0.47	0.50	0.00	1.00
One university	0.15	0.36	0.00	1.00
Two to ten universities	0.42	0.50	0.00	1.00
More than 10 universities	0.18	0.39	0.00	1.00
One relationship	0.20	0.40	0.00	1.00
Two to ten relationships	0.42	0.49	0.00	1.00
More than 10 relationships	0.10	0.29	0.00	1.00
N_employees	10927	31534	1.00	178792
Firm age	21.98	24.83	0.00	163.00
Patents per employee	1.29	7.14	0.00	56.70
Agriculture and mining	0.02	0.13	0.00	1.00
Manufacturing, utilities and construction	0.13	0.33	0.00	1.00
KIBS	0.64	0.48	0.00	1.00
Public sector	0.05	0.21	0.00	1.00
Other services	0.14	0.35	0.00	1.00

Table 9. The influence of relational competences on successful knowledge acquisition

Dependent variable	First stage (selection equation) knowledge_acquisition	Second stage (outcome equation) success_acquisition	OLS success_acquisition
D_Research	0.579 (0.359)		
D_Education	0.850** (0.337)		
Relational_communication	0.434*** (0.141)	0.040* (0.022)	0.041* (0.022)
Relational_structuring	0.227 (0.213)	-0.030 (0.023)	-0.030 (0.024)
Relational_closeness	0.074 (0.140)	0.065*** (0.024)	0.065** (0.025)
One_university	1.312** (0.617)	0.029 (0.114)	0.031 (0.121)
Two_ten_universities	0.139 (0.356)	0.080 (0.090)	0.081 (0.095)
Many_UK_Collaborations	0.414 (0.330)	-0.153** (0.069)	-0.152** (0.074)
One_relationship	0.772* (0.413)	-0.151 (0.103)	-0.148 (0.106)
Two_ten_relationships	0.567 (0.367)	-0.184** (0.091)	-0.182* (0.094)
N_employees	-0.000 (0.000)	0.000** (0.000)	0.000** (0.000)
Firm age	-0.011* (0.006)	-0.001 (0.001)	-0.001 (0.001)
Patents per employee	0.386* (0.223)	-0.004 (0.003)	-0.004 (0.003)
Manufacturing, utilities and construction	-0.327 (0.766)	-0.246** (0.104)	-0.246** (0.110)
KIBS	-0.392 (0.709)	-0.185** (0.087)	-0.185** (0.093)
Public sector	-0.719 (1.008)	-0.194 (0.187)	-0.197 (0.202)
Other services	-0.117 (0.736)	-0.170 (0.111)	-0.170 (0.118)
Constant	-0.193 (0.784)	0.975*** (0.117)	0.970*** (0.114)
Rho	-0.034 (0.252)		
Number of observations	168		130
Censored observations	38	R-squared	0.206
Uncensored observations	130		
Wald chi2(15)	59.29	F(15, 114)	3.51
Prob > chi2	0	Prob > F	0.0001

Robust standard errors in parentheses ; *** p<0.01, ** p<0.05, * p<0.1

Breusch-Pagan test: chi2(1): 6.85, Prob>Chi2: 0.0089

Wald Test of Independent equations (rho=0): chi2(1) = 0.02 Prob > chi2 = 0.8920

Table 10. The influence of relational competences on successful knowledge co-creation

Dependent variable	First stage (selection equation) knowledge_cocreation	Second stage (outcome equation) success_cocreation	OLS success_cocreation
D_Research	0.795*** (0.294)		
D_Education	0.616** (0.307)		
Relational_communication	0.335*** (0.091)	0.017 (0.031)	0.006 (0.029)
Relational_structuring	0.133 (0.136)	-0.024 (0.028)	-0.028 (0.031)
Relational_closeness	0.114 (0.120)	0.076*** (0.028)	0.073** (0.030)
One_university	1.326*** (0.451)	0.015 (0.138)	-0.018 (0.143)
Two_ten_universities	0.544* (0.321)	-0.092 (0.107)	-0.113 (0.111)
Many_UK_Collaborations	0.070 (0.266)	-0.034 (0.089)	-0.032 (0.096)
One_relationship	0.230 (0.355)	-0.042 (0.118)	-0.056 (0.125)
Two_ten_relationships	-0.004 (0.335)	0.103 (0.108)	0.096 (0.116)
N_employees	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
Firm age	-0.002 (0.005)	0.002 (0.002)	0.002 (0.002)
Patents per employee	-0.011 (0.014)	-0.004 (0.004)	-0.004 (0.004)
Manufacturing, utilities and construction	0.013 (0.579)	-0.127 (0.232)	-0.131 (0.247)
KIBS	0.265 (0.493)	0.085 (0.218)	0.077 (0.230)
Public sector	0.044 (0.793)	0.229 (0.283)	0.238 (0.303)
Other services	0.222 (0.549)	-0.013 (0.234)	-0.015 (0.249)
Constant	-1.032* (0.598)	0.367 (0.248)	0.433* (0.241)
Rho	0.249 (0.324)		
Number of observations	168		119
Censored observations	49	R-squared	0.132
Uncensored observations	119		
Wald chi2(15)	34.15	F(15, 114)	1.96
Prob > chi2	0.0032	Prob > F	0.0256

Robust standard errors in parentheses ; *** p<0.01, ** p<0.05, * p<0.1

Breusch-Pagan test: chi2(1): 0.26, Prob>Chi2: 0.6081

Wald test of independent equations (rho=0): 0.59 Prob > chi2 = 0.4422

Appendix: Correlation matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
1	1.00																						
2	0.62	1.00																					
3	0.41	0.25	1.00																				
4	0.36	0.65	0.52	1.00																			
5	0.34	0.33	0.21	0.32	1.00																		
6	0.18	0.25	0.14	0.24	0.48	1.00																	
7	0.29	0.22	0.26	0.20	0.34	0.35	1.00																
8	0.11	0.19	0.10	0.26	0.14	0.17	0.01	1.00															
9	0.14	0.19	0.03	0.15	0.12	0.07	0.04	0.04	1.00														
10	-0.02	0.11	0.05	0.12	-0.06	-0.13	-0.06	-0.16	-0.24	1.00													
11	0.10	0.20	0.02	0.12	-0.01	-0.06	0.11	0.10	0.15	-0.36	1.00												
12	0.17	0.18	0.06	0.17	0.39	0.40	0.14	0.13	0.18	-0.20	-0.41	1.00											
13	0.26	0.24	0.03	0.24	0.12	0.25	0.13	0.07	0.19	0.00	0.00	0.20	1.00										
14	0.02	0.25	0.06	0.13	0.08	-0.02	0.13	0.03	-0.06	0.11	0.35	-0.02	-0.53	1.00									
15	0.03	0.17	-0.08	0.10	-0.10	-0.11	-0.09	0.00	-0.04	0.25	0.08	-0.13	0.14	0.12	1.00								
16	0.11	0.28	0.19	0.20	0.27	0.22	0.19	0.13	0.11	-0.05	0.43	0.03	0.01	0.36	-0.43	1.00							
17	0.14	0.08	-0.05	0.12	0.11	0.11	0.13	0.11	0.10	-0.14	-0.15	0.53	0.15	0.02	-0.16	-0.27	1.00						
18	0.15	0.03	0.06	0.03	0.23	0.18	0.06	0.04	0.16	-0.14	-0.10	0.34	0.02	0.03	-0.13	0.10	0.17	1.00					
19	-0.02	-0.08	0.10	0.02	0.15	0.15	0.09	0.02	0.05	0.07	-0.13	0.10	-0.05	-0.02	-0.08	-0.01	-0.04	0.40	1.00				
20	-0.03	0.10	-0.07	0.01	0.02	0.11	-0.02	0.08	0.08	0.06	0.03	0.03	0.13	-0.01	0.02	0.00	0.15	-0.05	0.07	1.00			
21	0.12	0.07	-0.04	0.09	0.24	0.06	0.05	0.07	-0.05	-0.06	-0.02	0.17	0.03	-0.04	-0.07	0.07	0.11	0.21	0.10	-0.02	1.00		
22	0.04	0.08	-0.08	0.04	0.21	0.17	0.12	-0.03	0.08	0.04	-0.18	0.24	0.21	-0.10	0.08	-0.10	0.12	0.13	0.07	0.16	-0.05	1.00	
23	-0.13	-0.11	0.02	-0.05	-0.27	-0.11	-0.17	0.05	-0.06	-0.10	0.04	-0.09	-0.01	-0.03	-0.02	-0.04	-0.01	-0.13	-0.20	-0.03	-0.18	-0.03	
24	-0.02	-0.08	0.05	-0.04	-0.05	-0.09	0.00	-0.03	0.03	0.06	0.04	-0.11	-0.06	-0.10	-0.11	-0.02	-0.07	-0.08	0.13	-0.03	-0.03	-0.03	
25	0.03	0.06	0.01	0.04	0.08	-0.01	0.10	-0.01	-0.03	0.12	0.00	-0.11	-0.11	0.16	0.01	0.07	-0.07	0.00	0.09	-0.06	-0.06	-0.06	

Key: variables

1	success_acquisition	11	Two to ten universities	21	Agriculture and mining
2	knowledge_acquisition	12	More than 10 universities	22	Manufacturing, utilities, construction
3	success_cocreation	13	Few UK collaborations	23	KIBS
4	knowledge_cocreation	14	Many UK collaborations	24	Public sector
5	Relational_communication	15	One relationship	25	Other services
6	Relational_structuring	16	Two to ten relationships		
7	Relational_closeness	17	More than 10 relationships		
8	D_Research	18	N_employees		
9	D_Education	19	Firm age s		
10	One university	20	Patents per employee		