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**The effect of firms' relational capabilities on knowledge acquisition and co-creation
with universities**

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Abstract

This study examines how firms' relational capabilities influence two main approaches to sourcing knowledge from universities, namely, acquiring and co-creating knowledge. By adopting a sequential mixed methods design to gather empirical evidence from firms that interact with universities, it contributes to unravelling the puzzle presented in the literature on the positive effects and drawbacks of relational capabilities. We find that the balance between the opposing effects of relational capabilities differs depending on the knowledge sourcing approach. While capabilities for aligning goals, objectives, and routines/practices between firms and academics are of significant importance only for knowledge co-creation, communication capabilities are important for both, with greater significance for knowledge acquisition. We highlight implications about what relational capabilities firms should nurture in order to best source knowledge from universities.

Key words: Interorganisational collaborations; knowledge acquisition; knowledge co-creation; knowledge sourcing; relational capabilities; university-firm interactions.

JEL codes: O32 - Management of Technological Innovation and R&D; O31 - Innovation and Invention: Processes and Incentives; L21 – Business Objectives of Firms; L23 – Organisation 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 modularisation of knowledge, have increased firms' reliance on external knowledge in their innovation processes. In the context of a widening range of channels through which firms accrue inbound knowledge, interactions with universities play a central role, mainly owing to the latter's unique ability to produce frontier scientific knowledge (Brusoni *et al.*, 2001; Etzkowitz 2016). Evidence suggests that, although universities do not generally constitute the most frequently used sources of external knowledge (Cohen *et al.*, 2002; Arundel and Geuna, 2004; Abreu *et al.*, 2008), firms, particularly those with high research and development (R&D) intensity, rate them as very valuable (Bishop *et al.*, 2011; Petruzzelli, 2011)¹. There is a growing literature about firms' knowledge sourcing from universities, which explores the characteristics of firms that are more likely to source university knowledge – focusing on variables such as size, R&D expenditure, financial slack, geographical and organisational proximity to the university, search strategies (Laursen and Salter, 2004; Bruneel *et al.*, 2015), as well as the channels that they use in order to do so (Perkmann and Walsh, 2007; D'Este and Patel, 2007; Boardman and Ponomariov, 2009). Nonetheless, the understanding of what internal capabilities help firms to draw on different approaches to knowledge sourcing from universities remains underdeveloped (Bruneel *et al.*, 2015; Appio *et al.*, 2017).

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

By addressing this knowledge gap, this study extends the current literature in several ways. First, it differentiates between two approaches to the process of sourcing knowledge from universities. Building on the literature on interfirm strategic alliances² – which has highlighted different processes through which firms source external knowledge – a distinction is made between: (i) knowledge acquisition, whereby firms receive knowledge from universities, which may be integrated within their own knowledge base independently of the interaction (Friedman and Silberman, 2003; Siegel *et al.*, 2007); and (ii) knowledge co-creation, whereby firms combine their market knowledge with the university’s advanced scientific and technological knowledge, in order to jointly solve specific challenges (Curley and Salmelin, 2013). 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 (Osei-Frimpong *et al.*, 2016; Taheri and van Geenhuizen 2016; Yip *et al.*, 2015).

Second, among the various capabilities that might explain firms’ heterogeneity in acquiring and co-creating knowledge (Lucena and Roper, 2016; Colombo *et al.*, 2011), the study focuses particularly on the role of firms’ capabilities to manage their relationship with universities. The interorganisational literature has investigated the influence of relational capabilities on the success of strategic alliances or supply chain interactions (Kale *et al.*, 2000; Yli-Renko *et al.*, 2001), showing that firms’ relational capabilities play a crucial role in supporting external knowledge sourcing (Dyer and Singh, 1998; Lee *et al.*, 2003; Carmeli and Azeroual, 2009). However, the influence of relational capabilities on knowledge sourcing has not been explored

² Such alliances are defined as “agreements characterised by the commitment of two or more firms to reach a common goal entailing the pooling of their resources and activities” (Teece, 1992: 19).

in connection with university-firm interactions (Appio *et al.*, 2017). It might not be possible to generalise the findings of this literature to university-firm interactions without empirical testing, due to inherent differences between universities and firms in terms of their knowledge bases (Bartunek, 2007; Mindruta, 2013; Petruzzelli and Rotolo, 2015), culture (Lockett and Wright, 2005; Sauermann and Stephan, 2013), motivation and reward systems for interaction (Bruneel *et al.*, 2015), approaches to innovation (Barnes *et al.*, 2002), research orientation (Petruzzelli and Rotolo, 2015), and acceptable time frame for addressing problems (Rynes *et al.*, 2001).

Third, in line with recent studies on relational capabilities our study assume that all types of relational capabilities are not equally important to support different approaches to knowledge sourcing (Zhang *et al.*, 2017). We explicitly investigate the relationship between different relational capabilities and the acquisition and co-creation of knowledge with universities. Since the literature has highlighted that relational capabilities may have drawbacks as well as advantages (Anderson and Jap, 2005; Spitzberg and Cupach, 2009), the appropriate balance between them may differ in the context of different approaches to knowledge sourcing. Hence, we develop theoretical hypotheses on the relationship between each type of relational capabilities and firms' acquisition and co-creation of knowledge with universities. These hypotheses are then tested empirically using a sample of 190 British firms.

The investigation of how different relational capabilities enable knowledge acquisition and co-creation is a highly original aspect of the present analysis. The findings have implications for firm and university management: better understanding of which relational capabilities best support firms in sourcing different types of knowledge can guide firms, and to some extent also universities, in assessing and further developing the relational capabilities they need. They also have implications for policy, since the findings can help policymakers to develop effective

measures to support firms' relational capabilities to foster knowledge acquisition and co-creation.

THEORETICAL FRAMEWORK

Knowledge acquisition and co-creation as different approaches to sourcing knowledge from universities

The study focuses on the factors that support two distinct approaches to sourcing knowledge from universities: knowledge acquisition and knowledge co-creation. This distinction builds on typologies of knowledge-based interactions developed in previous studies of university-industry interactions and interfirm strategic alliances. The literature, in fact, has proposed numerous knowledge sourcing typologies, including: knowledge transfer and knowledge creation (Agrawal and Henderson, 2002; Rynes *et al.*, 2001; Bartunek, 2007; Geuna and Muscio, 2009) or knowledge co-production (Orr and Bennett, 2009; Knights and Scarbrough, 2010); knowledge exploration and knowledge exploitation (March, 1991; Laursen and Salter, 2004; Bruneel *et al.*, 2015); and knowledge acquisition and knowledge access (Grant and Baden-Fuller, 2004; Lui, 2009). Studies of university-industry interactions often take the university's perspective, focusing either on knowledge transfer processes (e.g. investigating how universities transfer knowledge to stakeholders outside academia) or on knowledge co-production (sometimes called knowledge creation or knowledge exchange) processes (e.g. investigating how academic researchers' engagement with practitioners helps to shape both research and practice). The concept of knowledge co-production is deliberately vague with respect to the interactions through which such engagement occurs, ranging from very close collaborations to less close working relationships, e.g. knowledge creation during joint symposia (Amabile *et al.*, 2001; Rynes *et al.*, 2001), without consensus on their boundaries (Geuna and Muscio, 2009). Those studies that look at university-industry interactions from the

firm's perspective place greater emphasis on how (for what objectives) the sourced knowledge is used by the firm, often contrasting knowledge exploration with knowledge exploitation (Laursen and Salter, 2004; Bruneel *et al.*, 2015), rather than on the processes through which the sourcing occurs. Studies of interfirm strategic alliances (Grant and Baden-Fuller, 2004) investigate knowledge sourcing processes and their drivers, but they do not account for the participants' intrinsic diversity that is often observed in university-firm interactions.

Knowledge acquisition and knowledge co-creation identify two contrasting approaches to sourcing knowledge, characterised by different objectives and different sourcing processes. Knowledge acquisition involves the unilateral sourcing of knowledge from university on the part of the firm, whose objective is to internalise and absorb (Grant and Baden-Fuller, 2004) university knowledge in order to integrate it within its own knowledge base³. Once knowledge has been acquired, the firm can use it in order to create value, either for experimentation (March, 1991; Laursen and Salter, 2004), or exploitation, within the firm (Yli-Renko *et al.*, 2001) or collaboratively (Laursen and Salter, 2004). However, such exploration and/or exploitation processes occur separately from the acquisition process, which involves a unidirectional flow of knowledge from the university to the firm. Knowledge acquisition occurs when, for example, firms acquire basic scientific knowledge by reading scientific publications (Caloghirou *et al.*, 2001), or when they license university intellectual property and technology (Balconi and Laboranti, 2006; Geuna and Nesta, 2006).

³ While the term 'knowledge transfer' is often used to indicate the unidirectional transfer of knowledge from universities to firms (Agrawal and Henderson, 2002), knowledge acquisition emphasises the firm's perspective (Yli-Renko *et al.*, 2001; Grant and Baden-Fuller, 2004).

Knowledge co-creation⁴ refers to the joint generation of new knowledge by both the university and the firm (Garner and Ternouth, 2011; Perkmann and Salter, 2012), with the objective to combine their knowledge bases in order to jointly solve a specific challenge. The firm and the university would not be able to produce this new knowledge independently, because the challenge they are trying to address requires their knowledge bases to be innovatively combined. The process necessarily involves joint exploration in order to produce new knowledge (Laursen and Salter, 2004; March, 1991; Bruneel *et al.*, 2015). Very often, it also involves the subsequent joint exploitation of the newly created knowledge to address a specific challenge (Blumenthal *et al.*, 1996; Caloghirou *et al.*, 2001). For example, knowledge co-creation may involve the combination of firms' market knowledge and universities' advanced scientific and/or technical knowledge to develop technological, organisational, service, or marketing innovations (Etzkowitz and Leydesdorff, 2000; Perkmann and Salter, 2012). Hence, we expect knowledge co-creation processes to involve close interactions between firm and university personnel, usually with the objective to innovate jointly.

The two concepts of knowledge acquisition and co-creation highlight two extreme types in a continuum of possible forms of knowledge sourcing from universities. Moreover, a firm may use different knowledge sourcing approaches interdependently. For instance, a firm may acquire a university license but later pursue a strategy of engaging with the inventor during the exploitation phase (Agrawal, 2006) in order to develop innovative products building on that license, so that initial knowledge acquisition leads to some degree of co-creation. Indeed, search behaviour for acquisition might positively relate with the firm's ability to successfully engage in subsequent co-creation (Fontana *et al.*, 2006). Conversely, it is also possible for a

⁴ The term 'co-creation' was initially used in the marketing literature to highlight close interactions between producers and buyers, in which the customer becomes a co-innovator (Payne *et al.*, 2007). More recently the research focus has shifted from customer-business co-creation towards co-creation by a wide array of actors in an ecosystem (Perks *et al.*, 2012; Hienerth *et al.*, 2014; Gemser and Perks, 2015).

firm to engage in co-creation with the university with the intention to integrate the co-created knowledge into its knowledge base and unilaterally exploit it later on (Inkpen 2000). In this study we do not look into the interdependence between different knowledge sourcing processes, and the empirical approach that we use to model the influence of relational capabilities on knowledge acquisition and co-creation allows us to account for such potential unseen interactions.

Influence of relational capabilities on the firm's ability to acquire and co-create knowledge

The knowledge based view of the firm (Kogut and Zander, 1996; Yli-Renko *et al.*, 2001) describes firms as repositories of knowledge and capabilities. According to this view, building difficult to imitate capabilities, including relational capabilities to acquire and exploit external knowledge, garners an essential source of competitive advantage (Kanter, 1994; Lado *et al.*, 1997; Madhok and Tallman, 1998; Paulraj *et al.*, 2008; Yli-Renko *et al.*, 2001). By developing capabilities to leverage their relational resources in knowledge-based interactions with other parties, for example those along their supply chain, firms can yield productivity and reduce transaction costs (Dyer and Singh, 1998; Lane and Lubatkin, 1998; Yli-Renko *et al.*, 2001). Yli-Renko *et al.* (2001) argue that relational capabilities are important for firms to draw on knowledge vested in their network of interactions, by affecting conditions necessary for successful knowledge-based collaborations. Among varied sources of knowledge, firms can leverage the advanced and up-to-date knowledge possessed by universities for sustainable competitive advantage (Perkmann and Salter, 2012). Hence, firms' relational capabilities to manage interactions with universities may influence their likelihood to acquire and co-create knowledge. In the literature, relational capability 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 conceptualised the components of relational capability differently in order to suit the context and research objectives⁵ (Ulaga and Eggert, 2006), three facets of relational capability that may influence knowledge acquisition and co-creation are proposed here.

These three facets are: *structuring capability*, which refers to the firm's ability to devise ex ante contractual agreements and mutually agreeable frameworks as to how the relationship is expected to carry out; *alignment capability* which refers to the firm's ability to align their goals, objectives, and routines/practices with those of universities; *communication capability*, which denotes the firm's ability to maintain dialogue with the university by promoting effective and efficient communication. Since relational capabilities may have drawbacks as well as advantages, we expect that the balance between them may differ in the context of different approaches to knowledge sourcing. Hence, we develop hypotheses about how each of these facets of relational capability may differently influence firms' knowledge acquisition and co-creation with universities.

Structuring capability. While transaction cost economics argues in support of contractual agreements, the sociology literature places greater emphasis on the development of relationship management frameworks encouraging the development of trust and embeddedness, as a pathway for avoiding opportunistic behaviour in interorganisational interactions (Dyer and Singh, 1998; Gibbons and Henderson, 2012). What we call structuring capability is the

⁵ For instance, in the relationship marketing literature, Woo and Ennew (2002) identify cooperation, adaptation, and atmosphere as sub constructs. In the interorganisational 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 *et al.*, (2008) assert that relational capabilities 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 *et al.*, (2001) conceptualise a relational view comprised of social interactions, network ties and relationship quality.

capability of firms to develop upfront contractual agreements and relationship management frameworks (Ariño *et al.*, 2014) – termed as ‘learning to contract’ (Mayer and Argyres, 2004) – by engaging in a set of practices that supersede the ‘pure’ transactional nature of contracts, but are not completely informal safeguards.

Firms with structuring capability are able to agree on the price, and terms of the contract, to define a clear working plan and to set clear goals (Ternouth *et al.*, 2012) before entering the relationship. Having these elements in place before the start of the relationship can reduce uncertainty/causal ambiguity (Vlaar *et al.*, V 2007), protect proprietary assets (Kale *et al.*, 2000), discourage free riding (Dyer and Singh, 1998), promote norms of reciprocity (Larson, 1992), improve relational rents (Madhok and Tallman, 1998), and enable the parties to achieve targets smoothly (Srinivasan and Brush, 2006). Firms that are able to clearly define upfront the terms and the content of their collaborations are more likely to acquire the knowledge they need from universities: in fact, since firms’ knowledge bases tend to be inherently different from those of universities, firms would not acquire university knowledge unless they have some clarity about the specific knowledge they are going to source (Fink and Kessler, 2010).

On the contrary, the importance of structuring capability might be lower for knowledge co-creation processes, which involve very close interactions between parties to develop new knowledge, the nature of which is relatively less clear upfront when compared to knowledge acquisition. In this context, learning and adaptation by partners during the collaboration may be more important than having a well defined collaboration structure (Gulati, 2007; Faems *et al.*, 2008; Gulati *et al.*, 2012). As the collaboration evolves dynamically, environmental conditions and partners’ needs may change, requiring them to change the direction of the project. This involves on-going and dynamic maintenance of the relationship (Vargo and Lusch, 2008) rather than rigid upfront specification of its terms and contents. Indeed, recent

studies on inter-organisational relationships have found that low specificity of contractual terms – which includes not stipulating how the focal firm’s partner should deliver the performance and what resources it should use – enhances the partner’s autonomy and therefore fosters innovation (Sumo *et al.*, 2016). Hence, we hypothesise that structuring capability may be more important for knowledge acquisition than knowledge co-creation:

Hypothesis 1: A firm’s relational structuring capability has greater positive influence on its likelihood to acquire knowledge from universities, than on its likelihood to co-create knowledge with universities.

Alignment capability. Reaching alignment between collaborators around co-operative norms, routines, and goals has been recognised as important for the success of interorganisational relationships, as these practices can help to build trust, increase co-operation, reduce transaction costs and improve relationship stability (Caloghirou *et al.*, 2004; Dyer and Chu, 2003; Zollo *et al.*, 2002). Nevertheless, achieving alignment might be time consuming and costly, and once achieved this could cause lock-in and restrict innovativeness, creativity and the breadth of knowledge sourcing (Ernst and Bamford, 2005; Goerzen, 2007). Also, as alignment promotes greater mutual understanding, it could cause each side to be less objective and dependable (Inkpen and Beamish, 1997), and even increase opportunistic behaviour (Anderson and Jap, 2005). This contradiction makes it interesting to investigate how firms’ capability to achieve alignment with universities influences knowledge acquisition and co-creation.

The organisational distance between universities and firms is very large due to inherently different operational practices, attitudes (Rynes *et al.*, 2001; Bonaccorsi and Thoma, 2007; Mindruta, 2013; Petruzzelli and Rotolo, 2015), rules, cultural habits (Lockett and Wright, 2005), and values (Zukin and DiMaggio, 1990; Boschma, 2005; Bruneel *et al.*, 2015;

Petruzzelli and Rotolo, 2015;). Academics' research agenda, which might be curiosity driven, costly and with relatively long-term pay-offs, may not be aligned with business objectives (Haeussler and Colyvas, 2011; Bruneel *et al.*, 2015). Also, since universities and firms have different operational practices (Petruzzelli and Rotolo, 2015), academics might be unaccustomed or unwilling to respond to commercial pressures (Tartari and Breschi, 2012).

By increasing uncertainty and transaction costs (Zukin and DiMaggio, 1990; Boschma, 2005; Petruzzelli and Rotolo, 2015), such large distance could inhibit the interactive learning and joint innovation processes that underpin knowledge co-creation (Capaldo and Petruzzelli, 2014). Relational alignment – which implies aligning the firms' goals, objectives (Perkmann and Walsh, 2009; Bruneel *et al.*, 2015) routines (Tsai, 2000; Carmeli and Azeroual, 2009; Bruneel *et al.*, 2015) and practices (Lorenzoni and Lipparini, 1999; Deken and Lauche, 2014) with those of academics – can help firms to engage in knowledge co-creation with universities in several ways (Taheri and van Geenhuizen 2016). First, it allows firm personnel to reduce their distance from academics with respect to objectives, attitudes, systems and cultures (Bruneel *et al.*, D 2010; Muscio and Pozzali, 2013), leaving them free to engage in specific knowledge based tasks instead of focusing on overcoming their differences (Yli-Renko *et al.*, 2001). Second, alignment can help firms to produce some form of shared mental analogy, mutual empathy and a common framework, essential prerequisites for close working relationships to achieve a common goal (Nonaka and Konno, 1998; Amabile *et al.*, 2001; Rynes *et al.*, 2001) and, hence, to produce results of interest to both the business and the academic communities (Perkmann and Salter, 2012). This suggests that firms' alignment capability is particularly important for knowledge co-creation, outweighing the potential negative influence of the 'dark side' of alignment.

In the case of knowledge acquisition, as firm personnel and academics do not attempt to combine two knowledge bases to reach common objectives through very close interactions, achieving alignment may be less important than in the case of knowledge co-creation. For acquisition, having the appropriate collaboration structure and clear and appropriate goals in place may matter more (Szulanski *et al.*, 2004; Perkmann and Salter, 2012; Bruneel *et al.*, 2015). Attempting to achieve alignment may even increase transaction costs (Szulanski *et al.*, 2004) and reduce the breadth of knowledge being acquired, so that the benefits of alignment may be outweighed by its drawbacks (Anderson and Jap, 2005). Hence, we hypothesise:

Hypothesis 2: A firm's relational alignment capability has greater positive influence on its likelihood to co-create knowledge with universities, than on its likelihood to acquire knowledge from universities.

Communication capability. In the context of relationship management, communication practices that involve sharing knowledge and information, including monitoring the fulfilment of commitments and obligations, between team members in an open (Kale *et al.*, 2000) and transparent (Chakrabarti and Santoro, 2004) manner, avoiding hierarchical authority (Zaheer and Bell, 2005), are considered of paramount importance for the achievement of the collaboration's objectives⁶ (Albino *et al.*, 1998; Arino *et al.*, 2001; Poppo and Zenger, 2002; Ramasamy *et al.*, 2006). Nevertheless, open and transparent communication might result in divulging information that can damage the firm's competitive advantage. For instance, difficult to protect knowledge being transferred from one party to other could expose the firm to the

⁶ Communication capability emphasises socially embedded, on-going and operational communication practices, and therefore it differs from structuring capability which emphasises upfront formal contractual designs. Moreover, it differs from alignment capability due to its emphasis on practices that affect how knowledge/information is shared, rather than on changing operational practices or goals to match with those of the collaborators. The distinction between alignment and communication capabilities mirrors similar distinctions presented in the relational capabilities literature, as reviewed in Bercovitz and Tyler (2014).

external world unnecessarily, allowing collaborators to exploit knowledge unilaterally (Capaldo, 2014), encouraging opportunistic behaviour and relationship failure (Anderson and Jap, 2005; Spitzberg and Cupach, 2009). Two major aspects differentiate university-firm interactions from interfirm alliances, which should be considered when adapting these arguments to the context of firms sourcing knowledge from universities: first, there are substantial communication barriers between universities and firms, which boost the importance of relational communication capabilities, and second, universities and firms can hardly be considered as competitors (Howells *et al.*, 2012; Decter *et al.*, B 2007), which suggests that there is relatively low risk of opportunistic behaviour by universities. Hence, the benefits of communication should outweigh its potential risks, facilitating both knowledge acquisition and knowledge co-creation.

We expect communication capability to be important for both knowledge acquisition and knowledge co-creation. In regards to knowledge acquisition, since the acquired knowledge is exploited outside the relationship (Lane and Lubatkin, 1998), effective communication is vital to ensure that valuable knowledge is appropriately transferred to the firm by reducing potential loss of knowledge during the acquisition process. Hence, knowledge acquisition is essentially a communication process (Albino *et al.*, 1998). Chen and Paulraj (2004) found that communication within strategic alliances is key for the exchange of timely, accurate, and relevant knowledge. Effective communication enhances firms' ability to recognise and assess the value of external knowledge, to acquire relevant knowledge (Yli-Renko *et al.*, 2002), to process and use acquired knowledge (Zahra *et al.*, 2000) and the willingness of external parties to share information with the firm. Effective communication reflects an enhanced absorptive capacity of firms (Cohen and Levinthal, 1990), and therefore it facilitates the transfer of both codified and tacit knowledge (Kogut and Zander, 1996); it helps to build trust and co-operation,

lowering transaction costs and enabling firms to generate relational rents, referring to the values gained through relationship-specific assets (Dyer and Chu, 2003; Paulraj *et al.*, 2008).

Similarly, communication capability is crucial for co-creation. Effective communication enables firms to avoid potential conflicts that may arise with universities owing to their diverse background (Amabile *et al.*, 2001). Open communication is essential for knowledge development (Takeishi, 2001; Kotabe *et al.*, 2003) in high value relationships (Paulraj *et al.*, 2008). Open and transparent firms are more likely to use university knowledge intensively (Laursen and Salter, 2004). Transparency speeds up the pace of innovation facilitating generation, use and distribution of knowledge (Caloghirou *et al.*, 2004) and increasing the access to heterogeneous sources of information, avoiding lock-in (Saviotti, 1996). Effective communication, a key for monitoring the fulfilment of commitments and obligations, also helps to avoid opportunistic behaviour and other lack of trust issues, facilitates trust building (Paulraj *et al.*, 2008) and creates a conducive environment to engage in collaborative projects (Antonelli, 2000; Paulraj *et al.*, 2008). Hence, we hypothesise:

Hypothesis 3: A firm's relational communication capability positively influences its likelihood to acquire knowledge from universities and its likelihood to co-create knowledge with universities.

DATA AND METHODOLOGY

The empirical analysis follows a sequential mixed methods design in three stages; namely, (1) an initial data gathering stage, (2) an on-line survey, and (3) post-survey in-depth interviews. This mixed method approach was used as a way to improve the validity of the overall study (Tashakkori and Teddlie, 1998; Bisbe *et al.*, 2007). In the initial data gathering stage, eight

interviews were conducted with R&D managers/ product managers of firms, who are responsible for managing interactions with universities (see Appendix A for more details). The findings of the initial interviews were used to (1) check the theoretical explanations of the main variables relating to knowledge acquisition and co-creation and relational capabilities against business practices and (2) design the survey questionnaire with the aim of improving construct validity (Tashakkori and Teddlie, 1998; Bisbe *et al.*, 2007). The results of the initial interviews clearly validated our theoretical constructs. Additionally, the survey was piloted with the initial interviewees to improve its reliability.

The online survey, which constitutes the main data source for our analysis, was aimed at gathering quantitative evidence on firms' experience of university interactions. This survey was sent (during March to April 2013) to 903 firms based in the United Kingdom (UK), drawn from a database of companies maintained by the Work Foundation, a not for profit research organisation owned by the University of Lancaster. Since the purpose of the study is to investigate the influence of firms' relational capabilities on knowledge acquisition and co-creation with universities, the sample is appropriate as it includes firms that, being in close contact with a university-owned research organisation, are particularly likely to source university knowledge. The respondents of the survey were mainly CEOs / directors / R&D or product managers of their organisations; people in these roles are usually believed to have an overall understanding of firm's capabilities and processes, as they have influence or what is commonly referred to as 'processing power' to decide the strategic direction of the organisation (Dexter, 1970; Fenno, 1978).

The survey received 190 complete responses (21% response rate). The respondents do not significantly differ from the overall sample 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 services⁷ sector are overrepresented). Furthermore, the distribution of the respondents in terms of size and sector is not significantly different from that of the approximately 800 British firms that interact with universities according to the UK Innovation Survey (Department for Business, Innovation and Skills 2010)⁸.

Several of the survey questions – particularly those related to the firms’ approaches to knowledge sourcing from universities, and to the firms’ management of their relationships with universities – had not been previously covered in any national survey, or in any other study, to our knowledge. As such, this research setting provides a unique opportunity to investigate how different relational capabilities underpin knowledge acquisition and co-creation with universities.

After the online survey, in-depth interviews were conducted with seven respondents (see Appendix A for more details) to further understand context-specific causal mechanisms, a practice which is believed to improve internal validity (Downward and Mearman, 2007). None of these respondents had been interviewed in the initial data gathering stage. Some qualitative findings from these in-depth interviews are presented in the ‘findings’ section, in order to provide contextual grounding for the interpretations of the quantitative analysis’ results, and to

⁷ 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.

⁸ 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 29,000 and the response rate was 49 percent.

illustrate the possible direction of underlying causal mechanisms (Kim and Miner, 2007; Autio *et al.*, 2013).

Variables construction

The main source of data for our variables was the online survey, while evidence from the seven post-survey in-depth interviews was used to validate our findings (Kim and Miner, 2007; Autio *et al.*, 2013).

Dependent variables

In the survey, respondents were asked to consider 5 different ways to source knowledge (related to knowledge acquisition and knowledge co-creation), listed in Table I, and for each one of these to tick whether, in the previous 12 months, knowledge had been sourced, not sourced, or whether that way to source knowledge had not been used. Building on these responses, we then developed two dependent variables that reflect whether firms had acquired or co-created knowledge respectively. Of the five questionnaire items indicating different approaches to knowledge sourcing, those aligned with the definition of knowledge acquisition presented in this study are: (i) acquiring the technology the company needs; (ii) acquiring basic knowledge; (iii) acquiring intellectual property. The dependent variable *Knowledge Acquisition* is a binary variable equal to 1 if the firm ticked that it had sourced knowledge using at least one of these approaches in the previous 12 months, and zero otherwise (i.e. the variable indicates whether the firm acquired knowledge from universities or not). The questionnaire items aligned with the definition of knowledge co-creation are: (i) engaging in interactive learning and co-creation of knowledge with universities and (ii) developing new products and processes together with universities. The dependent variable *Knowledge Co-creation* is a binary variable equal to 1 if the firm ticked that it had sourced knowledge using at least one of

these approaches in the previous 12 months, and zero otherwise (i.e. the variable indicates whether the firm co-created knowledge with universities or not).

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 INSERT TABLE I ABOUT HERE

Independent variables

One of the survey questions mentioned nine practices (listed in Table II) indicating relational capabilities of firms; in relation to each practice, respondents were asked to tick whether, in the previous 12 months, they had used that practice successfully, less successfully, or had not used it. Responses to this question were used to construct three variables capturing firms' relational capabilities, in the following way. For each of the nine practices, a binary variable was constructed measuring whether a firm had relied on the practice in the management of university interactions (the variable takes value 1 if the firm stated that they had used that practice successfully in the previous 12 months, and zero otherwise). A PCA routine was then performed on these nine binary variables, in order to highlight the sets of practices that firms tend to adopt together, denoting the possession of certain relational capabilities.

As shown in Table II, there are 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). Cronbach's Alpha being more than 0.6 indicates the reliability of the constructs (Price and Mueller, 1986). Furthermore, the Composite Reliability (CR) (Chin 1988) and Average Variance Extracted (AVE) (Fornell and Larcker, 1981) indices being more than 0.5 further

confirms the reliability of the measures and AVE also confirms the convergent validity. All these results indicate that the components derived are appropriate for this analysis.⁹

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 INSERT TABLE II ABOUT HERE

The factors that load highly on each component were grouped, and we checked these against our conceptual constructs, in order to come up with a qualitative description of the three main components. The first component is aligned with what has been defined as communication capability: it loads highly on the variables that measure firms' commitment to be transparent, to flatten hierarchical communication structures by introducing team-level communications, and to monitor the fulfilment of commitments and obligations in the course of the collaboration. The second component is aligned with what has been defined as structuring capability: it loads highly on variables that measure capabilities to decide the price and other terms of the contract, to devise agreements with university technology support or business relations staff and to develop a strong programme with clear milestones. The third component is aligned with what has been defined as alignment capability: it loads highly on variables that measure strengthening the company's institutional links with academics, reaching shared understanding with academics, matching the company's routines to academic practices. Hence, this approach allows us to validate our theoretically-informed categorisation of relational capabilities using our empirical dataset: the PCA supports the identification of some meaningful categories of relational capabilities that, while strongly rooted in the empirical data, also reflect the conceptual categories emerging from an analysis of the university-firm interactions and interorganisational collaborations literature.

⁹ The PCA results reported rely upon a Pearson correlation matrix, but similar results have been obtained when using a tetrachoric correlation matrix.

Factor scores for each observation, called, Communication (C1), Structuring (C2) and Alignment (C3) are used as data points for these three variables measuring relational capabilities. Factor scores could be interpreted as the projections of the observations onto the principal components (Basilevsky, 1983).¹⁰

Control variables

Responses to several survey questions about the nature of firms' interactions with universities in the previous 12 months (number of universities the firm had collaborated with, number of relationships per university, and share of collaborations with UK-based universities) were used in order to develop control variables.

Firms that have experience of collaborating with many different universities (Subramaniam and Venkatraman, 2001), and firms that frequently interact with universities (Gustafsson *et al.*, 2012), may enjoy greater ability to deal with academics and with university institutions. For example, having gained better understanding of academic culture and university practices and having adapted their processes to better work with universities, they may overcome cultural barriers. Their organisational, cognitive and cultural proximity to universities may be high, and this in turn facilitates the transmission of knowledge (Javidan *et al.*, 2005; D'Este and Iammarino, 2010; Bruneel *et al.*, 2015). Therefore, two control variables aimed at capturing firms' breadth of experience in interacting with university institutions are included in the empirical model: a dummy variable (*Broad experience*) equal to 1 if the firm interacted with many university institutions (more than two) and had many relationships with each university

¹⁰ As a robustness check, we also developed an alternative version of the three variables measuring relational capabilities, with each variable counting the number of different practices used successfully (each variable therefore could take on values from 0 to 3). Using these variables instead of the factor scores in our statistical model produces very similar results (available from the authors upon request).

(more than ten) in the previous 12 months, and the number of different channels ($N_channels$) that the firm used to interact with universities in the previous 12 months.

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 source knowledge, particularly where tacit knowledge is important, although this may not be crucial for firms that are involved in collaborations around mainly codified knowledge (Caloghirou *et al.*, 2001; Bodas Freitas *et al.*, 2014). Therefore the model also includes a variable capturing whether firms are particularly oriented to foreign collaborations (*Foreign collaborations*) that takes value 1 when the firm interacted with a few universities (less than ten) and most of its interactions (more than three quarters) were with foreign universities.

Some controls relating to firm demographic and innovation characteristics are also included. In order to mitigate *common method bias* (Podsakoff *et al.*, 2003), this information was drawn from public databases,; the FAME database (UK SIC 2007 sector, postcode, date of incorporation, number of employees and turnover) and the Espacenet database (number of patents assigned to the firm).

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). In the empirical model, firm size is measured as the number of employees ($N_employees$). Similarly, firms with greater absorptive capacity (Cohen and Levinthal, 1990), that is firms that are better able to absorb external knowledge and to integrate it in their innovation processes (Tsai, 2001), may be more likely to both acquire and co-create knowledge. Absorptive capacity is usually proxied

by variables capturing a firms' research or patent intensity or the skill profile of its workforce (Zahra and George, 2002). To proxy for absorptive capacity, the model includes variables measuring the firms' 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) and the value they attribute to university knowledge (Arundel and Geuna, 2004), it may also influence their acquisition and co-creation of knowledge. The sector of economic activity is therefore controlled for, considering five comprehensive sectors.¹¹

Estimation strategy

Based on the previous theoretical discussion, the empirical analysis explores how firms' likelihood to acquire and co-create knowledge is influenced by their relational capabilities, while controlling for several factors. As expected, the two dependent variables are correlated ($X^2(1, N=190) = 20.11, p=0.000$). As Figure 1 illustrates, knowledge co-creation is more likely

¹¹ 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).

among firms that also acquired knowledge from universities. But we do not treat knowledge acquisition as a necessary condition for knowledge co-creation, or vice versa: our theoretical model does not imply that these two approaches to knowledge sourcing operate in a mediation relationship. Therefore, we employ an analytical approach that considers knowledge acquisition and co-creation jointly. To accommodate for the different pathways, a bivariate probit model is used to estimate knowledge acquisition and knowledge co-creation as a pair of seemingly unrelated regressions. Such a model allows for two binary independent variables that vary jointly. For example, it has been used to study the choice to use personal and institutional channels of university-industry interaction (Bodas Freitas *et al.*, 2014). This specification allows for the coefficients to be estimated, while adjusting for correlation between the two equations (Greene, 1996). Indeed, knowledge acquisition and knowledge co-creation are correlated, and the seemingly unrelated bivariate probit regression fits the data better than two separate probit equations.

Throughout the research process, we took several measures to address *endogeneity* (Shadish *et al.*, 2002). First, our adoption of carefully crafted sequential mixed method design improves internal and construct validity. Second, we statistically checked the highest correlation among the constructs. The highest value was 0.540 (with a majority less than 0.3), which is lower than Bagozzi *et al.*'s (1991) cutoff of 0.8, as shown in Appendix B. Third, we tried to include as many theoretically justified controls as possible to avoid variable omission (Rubin, 2008; Shadish *et al.*, 2002). Fourth, we took measures to mitigate *common method bias* (Podsakoff *et al.*, 2003), which may occur when both dependent and independent variables are perceptual measures (Podsakoff and Organ, 1986). Not only we included data on respondents' demographic and innovation characteristics gathered from public databases, but the

questionnaire was purposefully long and complex¹², reducing respondent's ability to guess the model. To test for any remaining common method bias, following Chang *et al.*, (2010) we conducted a factor analysis of all 15 dependent and independent variables. This results in 7 highly significant components capturing 76% of the variance, with the first component accounting for only 21% of the variance, which assures us that the data does not suffer from common method bias.

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 INSERT FIGURE 1 ABOUT HERE

FINDINGS

The descriptive statistics indicate the nature of firms' interactions with universities. 42.3 per cent of respondents (71 firms) interacted with between two and ten universities, 14.9 per cent (25 firms) 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 had interacted in the previous 12 months, 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 had worked with during the previous 12 months, 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.

¹² In addition to the questions used to construct dependent and independent variables, the questionnaire also included questions on: how interactions with the university were usually initiated; what IP protection mechanisms were used when interacting with universities; what channels of interaction with universities had been used in the previous 12 months.

42 per cent of respondents (79 firms) reported that more than three quarters of their relationships involved universities in the UK. On the other hand, 8.4 per cent (16 firms) had approximately half of their relationships with UK universities, and for 12.6 per cent (24 firms) this proportion was less than a quarter, indicating a very global engagement profile.

Table III reports the main descriptive statistics on the variables included in the regression, while table IV reports the results of the seemingly unrelated bivariate probit regression^{13, 14}.

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 INSERT TABLE III ABOUT HERE

 INSERT TABLE IV ABOUT HERE

The factor capturing relational structuring capabilities is not significant in relation to either dependent variable, so our H1 is not supported: we have hypothesised that structuring capabilities would have a greater positive influence on knowledge acquisition compared to co-creation, but it appears that structuring capabilities are not significant in relation to either.

Knowledge acquisition is greater for firms with stronger communication capabilities, as shown by the positive and significant coefficient of *Communication* in relation to the dependent variable *Knowledge Acquisition*. The coefficient of the *Communication* variable is also positive, although marginally non-significant (with $p=0.107$), in relation to the dependent variable *Knowledge Co-creation*. This is consistent with hypothesis H3.

¹³ The same findings as those emerging from the seemingly unrelated bivariate probit model hold when running two separate probit regressions, with dependent variables Knowledge Acquisition and Knowledge co-creation respectively. However the seemingly univariate probit model is preferable due to having better fit (higher pseudo R2 and higher F-statistic) and the hypothesis of independence of the two equations being rejected ($\chi^2(1) = 8.31832$ Prob > $\chi^2 = 0.0039$).

¹⁴ As a robustness check, we have run the same models (seemingly unrelated bivariate probit, and individual probit models) on the subset of firms that have explicitly stated that they have engaged in knowledge acquisition (114 firms), knowledge co-creation (113 firms), or both (98 firms), with our dependent variables indicating whether they have acquired or co-created knowledge. The regressions return similar results to those that we have run on the entire sample of 190 respondents. Results are available from the authors upon request.

The importance of relational communication capabilities for knowledge acquisition is clearly highlighted in our in-depth interviews. For instance, a director of open innovation at a consumer goods company mentioned:

“Top-down relationships have been less successful. Communication is key to identify the type of knowledge to be acquired for the benefit of the company and to make sure that the specific knowledge is transferred. Even if one member of team involved in this process is not on board this can adversely affect the relationship”.

Another director in a manufacturing company, who mentioned his organisation having acquired university knowledge, explained how they had used communication to overcome barriers caused by distance between universities and firms. This further supports our expectation that firms use effective communication to manage knowledge acquisition processes:

“We always select a team who could communicate well with university academics since sometimes we do not speak the same language and have many differences between us [academics and firms]. Communication between those who do the ‘deal’ and understanding of deal terms by the team to ensure expectations are clear is critical”

The importance of transparent communication over structuring the relationship has been highlighted too: for instance, the head of business development of a consultancy group said:

“We are transparent with academics and try to build a good relationship. This is important to access and select the type of knowledge that we really want from a portfolio of knowledge and skills possessed by academics. Relationship building through open innovation is a much better strategy than trying to engage in never ending negotiations with them to design contracts upfront”

The greater importance of communication capability, as opposed to structuring capability, for knowledge co-creation with universities is also evident from the in-depth interviews. For instance, the head of partnerships of a pharmaceutical company mentioned:

“Open and transparent communication enables us to understand the skills, strengths and needs of universities, which was important when engaging in joint research. It was very difficult to devise contracts upfront due to the nature of our research: it is very difficult to predict the outcome ex-ante. We need to engage in on-going discussion with academics, for which effective communication was crucially important”

In-depth interviews also highlight the lack of importance of structuring capability for knowledge co-creation. A director of partnership in a drug discovery company mentioned:

“Initially we were too much bothered about coming up with a very well defined plan. So we spent so much time for negotiations and contract development. But it never worked well. It was not possible come up with detailed planning at the beginning. Just a waste of time”.

Alignment capabilities have a positive and significant influence on knowledge co-creation, whereas the variable *Alignment* has a positive but not significant influence on knowledge acquisition. This is consistent with H2.

The in-depth interviews confirm the importance of alignment capabilities for knowledge co-creation. For instance, the head of partnership of a pharmaceutical company highlighted how they tried to reach a shared understanding with academics as a strategy to reduce distance between them:

“Universities and we are different in several ways. When we have collaborative projects, we try to minimise this gap, otherwise it is very difficult to work with them (academics).....We have understood the tension between academia [need for publication] and us [lack of need to

publish] on publication. Our ability to have ‘sensible’ discussions in partnerships about publication and patent strategy that benefits both parties have meant that potential downstream issues are avoided”.

The importance of strengthening the firm’s institutional links with academics is clearly evident from the interviews. An R&D manager of an energy company mentioned:

“Working together with academics is not easy. We have different goals, innovation approaches and knowledge. Our secret for success is our ability to work with universities through company X (an intermediary). They (company X) help us to decide strategies to work with university team, work with us very closely, coordinate our work, help us with legal and administrative tasks. I could not imagine successfully completing the project without them.....I know many firms are not impressed with these offices (i.e. intermediaries), but if you could work with them successfully, you could get the best. I think that we know the art of working with universities through these offices (intermediaries)”

Firms that engage in many channels of interaction and firms that engage mainly in foreign collaborations are more likely to acquire and co-create knowledge (although in the latter case the marginal effects are smaller). Having many channels of interaction could suggest higher cultural and organisational proximity to universities. Firms that mainly interact with foreign universities may also be particularly able to engage in knowledge sourcing, particularly in knowledge acquisition, which does not necessarily require close interactions with universities. At the same time, since those that are able to co-create knowledge are capable of aligning goals, practices and routines, geographical distance might not restrict them from interacting with foreign universities. This supports past research that has found that geographical proximity can be substituted by other types of proximities (D’Este and Iammarino, 2010; Bruneel *et al.*, 2015).

DISCUSSION AND RECOMMENDATIONS

This study offers a theoretical and empirical framework for understanding how firms should strategically hone their relational capabilities to source knowledge from universities. Compared to previous literature on university-industry interactions, the study refines the understanding of the factors that support firms' knowledge sourcing from universities, by differentiating between two approaches to knowledge sourcing, namely, knowledge acquisition and knowledge co-creation. Compared to previous literature on interfirm collaborations, the study extends the understanding of the role of relational capabilities in supporting the success of interactions, by distinguishing between different types of relational capabilities, and by providing a more integrated and balanced approach that considers both advantages and drawbacks of such capabilities.

First, our findings support the argument presented in the literature (Gibbons and Henderson, 2012) that collaboration success depends more on communication capabilities encouraging the development of trust and embeddedness (Dyer and Singh, 1998; Gibbons and Henderson, 2012) than firms' ability to design formal upfront contracts. Relational communication and alignment capabilities provide firms with competitive advantage when sourcing knowledge from universities as these are difficult to imitate by competitors. Hence, the capability to devise upfront contract or agreements seem to be less important in dynamically evolving knowledge-based interactions, regardless of which knowledge sourcing approach they use, than those relational capabilities that help organisations to develop trust and shared values.

Secondly, the findings contribute to unravelling the puzzle presented in the literature on the positive (Poppo *et al.*, 2008) and negative (Anderson and Jap, 2005) effects of relational capabilities. Our results suggest that the balance between the positive and negative effects of relational capabilities depends on the type of knowledge sourcing approaches they support.

Alignment capability positively influences knowledge co-creation, while it is not significant for knowledge acquisition. The former can occur because the alignment of firms' practices, routines and values with those of academics enables them to develop conditions conducive for close interactions – such as trust, cohesion, flexibility, mutuality (Paulraj *et al.*, 2008) and a shared mental analogy (Nonaka and Konno, 1998; Amabile *et al.*, 2001; Rynes *et al.*, 2001) – that allow them to invest more on specific knowledge based tasks (Yli-Renko *et al.*, 2001). As a consequence, the drawbacks of alignment are outweighed by benefits. Instead, in the context of knowledge acquisition, the drawbacks of alignment outweigh benefits (Anderson and Jap, 2005) since making deliberate efforts to align firms with academics unnecessarily increases transaction costs (Szulanski *et al.*, 2004).

Communication capability positively influences both knowledge acquisition and co-creation, but it is particularly important for the former. Indeed, from the operational point of view knowledge acquisition could be perceived as a form of communication process.

Better understanding of which relational capabilities best support firms in sourcing different types of knowledge can help firms, and to some extent universities, to assess and further develop the relational capabilities they need. When firms are engaged in acquisition it is important to focus on improving communication, or to use a team who is good at communicating with academics. However, it would be unnecessary to make deliberate efforts to reach alignment with academics if the firm is mainly interested in acquiring knowledge. On the contrary, if a firm engages in co-creation, they should make efforts to achieve alignment with academics in terms of goals, routines and practices. Also, firms should priorities developing informal, productive and dynamic relationships with universities over reaching upfront formal agreements.

The findings can help policymakers to develop effective measures to support firms' relational capabilities to foster knowledge acquisition and co-creation. If policies intend to support firms' acquisition of academic knowledge, measures should be taken to facilitate communication processes between academics and firm personnel. If policies intend to support knowledge co-creation between universities and firms, they need to be accompanied by measures aimed at facilitating both communication and alignment processes.

This study suffers from some 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 behaviours such as knowledge co-creation, which are not yet widely diffused. As there is no consensus around the effects of relational capabilities, a similar study could be conducted in relation to general interorganisational interactions to test whether our findings – on the dependence of the influence of relational capabilities on the approach for knowledge sourcing – could be generalised.

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Appendix A: Initial case studies and in-depth interviews

Eight case studies – in four different sectors, namely, life sciences (medical and pharmaceutical), information and communications technology and digital technologies, creative industries and the third sector (e.g. charities) – were conducted, using secondary data and, 9 in-depth interviews with R&D / product managers of firms who interact directly with universities:

| Case study description | The title of respondents |
|---|---|
| A pharmaceutical company engages in discovery, development, and commercialization of Drugs | Head of Academic Discovery Performance Unit and Director Academic Liaison |
| A pharmaceutical company engages in discovery, development, and commercialisation of Drugs | Chief Science Officer |
| A company providing online tools and processing services to enable the collection of charitable donations | Head of Product and CTO |
| A Drug discovery company | Head of Business Development |
| An international consultancy working in the cultural and creative economy | Senior Consultant |
| A finance company providing alternative finance options | Chief Scientist |
| A provider of platforms and digital services to public sector | Manager |
| Multinational consumer goods company | Vice President Open Innovation |

Seven in-depth interviews were conducted with selected respondents of the on-line survey:

| Case study | The title of respondents |
|--|----------------------------------|
| A consumer goods company | Director of Open Innovation |
| A manufacturing organisation | Director |
| A Pharmaceutical company engages in discovery, development, and commercialisation of Drugs | Head of Partnership |
| A business consultancy company | Head of Business Development |
| Energy company | R&D Manager |
| A drug discovery company | Director of Partnership |
| A finance company | Chief Design and Digital Officer |

Appendix B: Correlation matrix between dependent and independent variables

| | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | 13. | 14. | 15. |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|
| 1. Knowledge co-creation | 1.00 | | | | | | | | | | | | | | |
| 2. Knowledge Acquisition | 0.33 | 1.00 | | | | | | | | | | | | | |
| 3. Communication | 0.26 | 0.44 | 1.00 | | | | | | | | | | | | |
| 4. Structuring | 0.22 | 0.33 | 0.50 | 1.00 | | | | | | | | | | | |
| 5. Alignment | 0.28 | 0.25 | 0.37 | 0.37 | 1.00 | | | | | | | | | | |
| 6. Broad experience | -0.05 | 0.14 | 0.13 | 0.13 | 0.15 | 1.00 | | | | | | | | | |
| 7. Foreign collaborations | 0.15 | 0.18 | -0.05 | 0.05 | 0.02 | -0.05 | 1.00 | | | | | | | | |
| 8. N_channels | 0.24 | 0.50 | 0.47 | 0.47 | 0.30 | 0.36 | 0.05 | 1.00 | | | | | | | |
| 9. N_employees | 0.07 | 0.13 | 0.25 | 0.19 | 0.07 | 0.18 | -0.12 | 0.25 | 1.00 | | | | | | |
| 10. Firm age | 0.06 | -0.06 | 0.11 | 0.11 | 0.04 | -0.04 | -0.10 | -0.01 | 0.36 | 1.00 | | | | | |
| 1. Patents per employee | -0.05 | -0.06 | -0.05 | -0.03 | -0.05 | -0.02 | -0.02 | -0.09 | -0.03 | -0.06 | 1.00 | | | | |
| 12. Manufacturing, utilities and construction | 0.05 | 0.05 | 0.20 | 0.16 | 0.11 | 0.12 | 0.06 | 0.23 | 0.13 | 0.07 | -0.02 | 1.00 | | | |
| 13. KIBS | -0.01 | -0.11 | -0.23 | -0.10 | -0.15 | 0.00 | 0.09 | -0.04 | -0.11 | -0.20 | 0.05 | -0.48 | 1.00 | | |
| 14. Public sector | 0.02 | -0.09 | -0.03 | -0.08 | 0.02 | -0.06 | 0.00 | -0.03 | -0.07 | 0.12 | -0.02 | -0.08 | -0.27 | 1.00 | |
| 15. Other services | -0.04 | 0.03 | 0.04 | -0.01 | 0.06 | -0.08 | -0.12 | -0.17 | -0.01 | 0.10 | -0.03 | -0.16 | -0.54 | -0.09 | 1.00 |

Figure 1. The relation between knowledge acquisition and knowledge co-creation: distribution of 190 observations across different approaches to knowledge sourcing

| | | Knowledge Acquisition | | |
|-----------------------|-----|-----------------------|-----|-----|
| | | No | Yes | |
| Knowledge Co-creation | No | 84 | 43 | 127 |
| | Yes | 20 | 43 | 63 |
| | | 104 | 86 | 190 |

Table I. Firms' approaches to knowledge sourcing from universities: questionnaire items

| Knowledge sourcing approaches |
|---|
| 1. Knowledge Acquisition |
| Acquiring new basic knowledge |
| Acquiring the technology the company needs |
| Acquiring intellectual property |
| 2. Knowledge Co-creation |
| Developing new products and processes with university |
| Interactive learning and co-creation of knowledge with university |

Table II. PCA on use of relational capabilities

| | C1 | C2 | C3 |
|---|--------------|--------------|--------------|
| Communication (<i>Cronbach's Alpha= 0.757; CR=0.514 ; AVE=0.606</i>) | | | |
| Engaging in transparent communication | 0.593 | -0.086 | 0.014 |
| Engaging in team-level communications | 0.521 | 0.077 | -0.082 |
| Communicating ongoing commitments and obligations | 0.427 | -0.038 | 0.102 |
| Structuring (<i>Cronbach's Alpha= 0.745; CR=0.546 ; AVE=0.621</i>) | | | |
| Deciding price or other terms of the contract | -0.023 | 0.633 | 0.051 |
| Devising agreements with technology support or business relation staff | -0.062 | 0.665 | 0.062 |
| Devising a strong work programme structure with clear milestones | 0.323 | 0.341 | -0.227 |
| Alignment (<i>Cronbach's Alpha= 0.615; CR=0.545 ; AVE=0.620</i>) | | | |
| Matching company routines to practices of academics or universities | -0.035 | -0.036 | 0.695 |
| Strengthening the company's institutional links with academics | -0.072 | 0.142 | 0.487 |
| Reaching shared understanding with academics | 0.284 | -0.064 | 0.453 |

Table III. Descriptive statistics on variables used in regressions (n = 190)

| Variable | Mean | Std. Dev. | Min | Max |
|--|-------------|------------------|------------|------------|
| Knowledge co-creation | 0.33 | 0.47 | 0.00 | 1.00 |
| Knowledge Acquisition | 0.45 | 0.50 | 0.00 | 1.00 |
| Communication | -0.12 | 1.49 | -1.52 | 3.91 |
| Structuring | -0.08 | 1.34 | -1.27 | 3.83 |
| Alignment | -0.07 | 1.22 | -1.55 | 3.34 |
| Broad_experience | 0.08 | 0.28 | 0.00 | 1.00 |
| Foreign_collaborations | 0.12 | 0.33 | 0.00 | 1.00 |
| N_channels | 4.84 | 3.67 | 0.00 | 14.00 |
| N_employees | 9714 | 29834 | 1.00 | 178792 |
| Firm age | 22.58 | 25.58 | 0.00 | 163.00 |
| Patents per employee | 15.80 | 199.75 | 0.00 | 2753.00 |
| Manufacturing, utilities and construction | 0.12 | 0.33 | 0.00 | 1.00 |
| KIBS | 0.63 | 0.49 | 0.00 | 1.00 |
| Public sector | 0.04 | 0.20 | 0.00 | 1.00 |
| Other services | 0.16 | 0.37 | 0.00 | 1.00 |

Table IV. Seemingly unrelated bivariate probit regression

| Model | (1) | (2) |
|---|-------------------------------|------------------------------|
| VARIABLES | sur Knowledge Co-creation | sur Knowledge Acquisition |
| Communication | 0.131 ⁺ (0.081) | 0.273*** (0.094) |
| Structuring | 0.026 (0.089) | 0.012 (0.101) |
| Alignment | 0.210** (0.087) | 0.055 (0.095) |
| Broad_experience | -0.645 (0.417) | -0.095 (0.432) |
| Foreign_collaborations | 0.636** (0.303) | 0.955*** (0.323) |
| N_channels | 0.062* (0.036) | 0.182*** (0.040) |
| N_employees | 0.000 (0.000) | 0.000 (0.000) |
| Firm age | 0.003 (0.004) | -0.010* (0.006) |
| Patents per employee | -0.026 (0.021) | -0.000 (0.002) |
| Manufacturing, utilities and construction | 0.154 (0.511) | -1.701** (0.671) |
| KIBS | 0.259 (0.453) | -1.404** (0.597) |
| Public sector | 0.252 (0.674) | -2.001** (0.895) |
| Other services | 0.081 (0.488) | -0.814 (0.630) |
| Constant | -1.041** (0.476) | 0.387 (0.626) |
| Athrho | 0.426*** (0.153) | |
| Observations | 190 | 190 |
| R-squared | | |
| Log-likelihood | -186.984 | |
| Wald Chi2(26) | 80.52 | |
| Prob > Chi2 | 0.000 | |

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1, + p<0.15

Likelihood-ratio test of rho=0: chi2(1) = 8.31832 Prob > chi2 = 0.0039

McFadden's pseudo R2 adjusted = 0.174