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THE IMPACT OF FINANCIAL SLACK ON EXPLORATIVE AND EXPLOITATIVE KNOWLEDGE SOURCING FROM UNIVERSITIES: EVIDENCE FROM THE UK

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ABSTRACT

Some organizations use universities to explore new areas, whereas others turn to universities to exploit knowledge for immediate and practical gain. Drawing on the behavioral theory of the firm and the literature on university-industry collaboration, we examine how the level of financial slack available to a firm influences their level of explorative and exploitative knowledge sourcing from universities. We suggest that two types of proximity moderate this relationship: organizational and geographical. Using on a rich sample of university collaborators, we find - consistent with our expectations - that high levels of financial slack are associated with explorative knowledge sourcing, whereas low levels of slack are associated with exploitative knowledge sourcing. Our results also point out that organizational proximity can complement for the lack of financial slack in shaping explorative knowledge sourcing, while it can heightens the effects of low levels of financial slack on exploitative knowledge sourcing. In contrast, we find that geographical proximity plays a weaker moderating role compared to organizational proximity. We explore the implications of these findings for our understanding of university-industry collaboration.

Keywords: explorative knowledge sourcing, exploitative knowledge sourcing, financial slack, university-industry collaboration

INTRODUCTION

Working with universities is one of the central mechanisms that organizations can draw upon to absorb new knowledge from outside their firm (Cohen and Levinthal, 1990, Cockburn and Henderson, 1998). Universities provide organizations with a source of new ideas, access to rich networks and the opportunity to recruit trained and skilled problem-solvers (Salter and Martin, 2001, Cohen et al., 2002, Bishop et al., 2011). Research has shown that firms that can successfully build links with universities may have higher stock market value during their Initial Public Offering (Zucker et al., 2002, Zucker et al., 1998), supplying broader and richer patterns of technological search (Fleming and Sorenson, 2004) and have higher innovative performance than those firms that choose to eschew collaborations with universities (Cassiman et al., 2008, George et al., 2002, Grimpe and Hussinger, 2008, Arvanitis and Woerter, 2009).

Although the literature in university-industry collaboration has supported a greater understanding of the decision to collaborate with universities or the economic consequences of doing so (Mansfield, 1991; Rosenberg and Nelson, 1994), the factors that led firms to draw different types of knowledge from universities remain underdeveloped. This has three important consequences for our understanding of the role of universities in shaping industrial innovation. First, since the early generation of research on this topic has been largely policy-driven, there has been little attempt to connect this question with established theories in management about the drivers of organizational search and collaboration, leaving this work somewhat marginalized from more mainstream debates in the wider literature. Second, the current literature on firms' use of universities tends to privilege structural explanations of firm's engagement with universities – their size, sector, geographical proximity and R&D expenditures - and therefore it may discount other more managerial-oriented explanations. Third, prior research often tends to assume that drawing

from university knowledge involves a specific type of knowledge exchange, largely related to creation of new knowledge. Yet, it is clear that firms do not draw knowledge from universities in homogenous ways, and that understanding the drivers of these different forms of collaboration might help to enrich our understanding of the role of universities in the wider economic system (Cohen et al., 2002).

To help meet these challenges, we draw from the behavioral theory of the firm (Cyert and March, 1963, Argote and Greve, 2007, Greve, 1998) to propose a connection between firms' availability of resources, especially financial slack, and firms' decisions to engage in different forms of search. We suggest that high financial slack will lead firms to engage in distant search efforts with universities - what we term *explorative knowledge sourcing* - whereas highly financially resource constrained firms will turn to universities for near-term support and problem-solving - what we term *exploitative knowledge sourcing* (Bercovitz and Feldman, 2007, March, 1991, Bierly et al., 2009). In addition, we explore how different forms of proximity - *organizational and geographical* - moderate the effect of financial slack on knowledge sourcing, providing insights on whether these different forms of proximity act as substitutes for slack resources. We focus on these two forms of proximity as they are often seen to facilitate knowledge exchange and learning processes between organizations, especially universities and firms (Boschma, 2005).

To explore these relationships, we employ a novel combination of data sources, including a large-scale postal survey, the complete project records of the UK largest research council (i.e. Engineering and Physical Sciences Research Council, EPSRC), the records of the technology transfer activities of universities and companies' financial accounts. We test our hypotheses on a sample of 341 companies and examine the extent to which these firms engage in explorative and exploitative knowledge sourcing from universities in the period 2002-2006.

THEORY AND HYPOTHESES DEVELOPMENT

The behavioral theory of the firm links the availability of resources to the firm's decision to engage in different forms of search (Cyert and March, 1963, Argote and Greve, 2007, Greve, 2003, Greve, 1998). In the case of abundant resources, firms will engage in more explorative search efforts, leading to the acceptance of higher risk and favorable disposition to greater experimentation. This is what Cyert and March (1963) refer to as 'slack search', which they see as organizational efforts that would not be approved under conditions of scarcity (Levinthal and March, 1981). In contrast, firms with limited available resources are more likely to engage in exploitative search efforts to achieve immediate gain. For example, Baum and Dahlin (2007) found that when free resources of companies had been used up, these companies were more likely to exploit more aggressively their own prior experiences.

In this literature, one of the key types of slack available to managers are financial reserves, what is often called 'unabsorbed slack' or 'financial slack' (Greve, 1998, Greve, 2003, Greve, 2007). As Greve (2007) suggests, these resources not only help organizations to develop innovations; they also shape the type and direction of an organization's innovative efforts. Along these lines, Kim and Lee (2008: 405) suggest that financial slack provides "decision-agents with the greatest degree of freedom in allocating it to alternate uses and is more easily deployable than other types of slack in support of R&D investments." Financial slack is a 'fungible' resource and thus represents an area of high managerial discretion (Singh, 1986, Nohria and Gulati, 1996, George, 2005). In this sense, financial slack provides an opportunity for organizations to place a wider set of bets on the future of different technologies, taking options in a range of technological areas in order to enable future exploitation (Greve, 2003, Kim and Lee, 2008).

Although the literature above has identified financial slack as a driver of innovative efforts of firms, there has been little attempt to link this discussion to the way organizations source knowledge from outside their organization, including the use of university knowledge. Drawing this link may provide a greater appreciation of how the presence of financial slack shapes managers' attitudes to the exploration and exploitation of university knowledge. Accordingly, building on the behavioral theory of the firm, we suggest two reasons why one might expect the level of financial slack available to the firm to shape its level of explorative and exploitative knowledge sourcing from universities.

First, engaging in exploration activities with universities can be a challenging process for many organizations, often requiring the development of new operating routines to align the distinct ways of working of collaborating partners. Exploration activities often involve the establishment of long-term R&D partnerships, where conflicts of interest between the parties are likely to emerge, since academic researchers guard their autonomy and freedom, and are often unwilling to respond to commercial pressures (Merton, 1973, Dasgupta and David, 1994, Tartari and Breschi, 2012). Although some academics are experienced collaborators with industry, from whom they draw resources to further their own research agendas (Colyvas and Powell, 2007, Haeussler and Colyvas, 2012), working successfully with academics on explorative activities often requires the willingness on the part of the firm to allow academic partners the freedom to pursue their research questions, even if the value of such investigations is not immediately clear to the industrial partner at the beginning of the project (Murray, 2004). In this sense, a firm needs to be willing to bear the costs of a relationship with uncertain payoffs, allowing their academic partners with some opportunities to shape their own research agendas (Perkmann and Walsh, 2009).

Since financial slack enables firms to undertake a wide range of high risk projects, high financial slack can help managers to put aside immediate commercial pressures, allowing them to launch projects outside formal management accounting systems (Voss et al., 2008) and break away from conventional categories and well-established operating routines (Greve, 2007). In doing so, it can enable the formation of common explorative research efforts between the firm and its academic partners, as these collaboration efforts may not be subject to narrow availability of financial resources or process management tools that may constrain exploration (Benner and Tushman, 2002). In contrast, firms that are financially constrained will be looking to develop a relatively narrow portfolio of university engagement activities, undertaking proximate search efforts, generally oriented to get assistance in problem-solving and focused on downstream stages of product development. Accordingly, they will be looking to external relationships that require little managerial resources to be activated, and that can be delivered and assessed according to normal accounting requirements (Cohen et al., 2002).

Second, working with universities on explorative activities requires a time horizon that is consistent with academic norms, which are long-term in orientation (Dasgupta and David, 1994). Such time frames include the ability to participate in a project that lasts the length of a doctoral student project (which in the UK is normally three years), a common currency of research collaboration. Moreover, the benefits of explorative knowledge sourcing from universities often take a long time to be realized. For instance, Mansfield (1991) estimated the length of time from academic research to industrial practice was on average seven years. Of course, the outcomes of any research project will also require considerable follow-on work to be made useful in an industrial situation (Pavitt, 1991, Jensen and Thursby, 2001).

If a firm has high financial slack, it will be able to sustain and support long-term relationships with universities and be willing to bear the follow-on costs of honing and grafting ideas developed in the university system to supplement its own knowledge base. Indeed, one of the advantages of financial slack is that it allows organizations to pursue "continuous, uninterrupted investments in R&D" (O'Brien, 2003: 416). Financial slack may also ensure that the organization has a greater tolerance for projects whose outcomes may be uncertain at early stages or whose expected results may be discordant with convention (March, 2006). In doing so, financial slack can allow managers to engage in long-term, uncertain activities with its university partners that organizations with less financial slack would be liable to shy away from. In contrast, exploitative knowledge sourcing involves drawing knowledge and ideas from universities that can be used in a short span of time. Firms with limited financial slack resources will be under pressure to search for near-term or immediate solutions. Consequently, these firms are liable to be highly attracted to universities as a means of augmenting or complementing internal projects to accelerate development of existing innovation projects. In addition, exploitative knowledge sourcing involves working with universities in areas where the industrial partner can relatively easily and immediately assess the tangible benefits of collaboration. Thus, we put forward the following two hypotheses:

> *H1a. The higher the level of financial slack available to the firm, the greater the degree to which a firm will use university knowledge for exploration.*
>
> *H1b. The lower the level of financial slack available to the firm, the higher the degree to which a firm will use university knowledge for exploitation.*

The moderating effect of organizational proximity

While collaborations between firms and universities entail the potential of innovation-related performance, these collaborations are also subject to important challenges. Firms

and universities respond to different set of incentives, reward systems and research orientation priorities, all of which raise a number of significant challenges for the successful governance of partnerships between firms and universities (Bruneel et al., 2010). In this context, organizational proximity between partnering organizations may help attenuate the potential conflicts due to a clash of cultures, incentives and priorities. Organizational proximity refers to the set of formal and informal interdependencies between organizations that contribute to the coordination and governance of strategic resource sharing and joint learning processes, while minimizing the risks of short-sightedness, lack of reciprocity and opportunistic behavior among partners (Torre & Gilly, 2000; Boschma, 2005).

As pointed out by Rosenberg (1990) and Bouty (2000), the formation of long-term and trusting relationships in scientific-related endeavors, are built on the two-way flow of resource exchange between partners and the capacity, and willingness, to share common and strategic resources. Resources can be both tangible, such as equipment or funding, or intangible, such as the exchange of scientific or technical information, technical advice or ideas for new projects or work-in-progress. The more varied the range of resources exchanged, the higher the degree of interpersonal acquaintance between the partnering organizations, and the stronger the basis for the formation of informal routines and inter-organizational proximity (Tsai, 2000).

Drawing on the above discussion, we suggest that the exchange of tangible and intangible resources with universities, insofar as it contributes to build organizational proximity among collaborating partners, is likely to moderate the effects of financial slack on explorative and exploitative knowledge sourcing. That is, firms may be willing to engage in explorative knowledge sourcing from universities in the absence, or at low levels, of financial slack provided that they encounter a favorable climate for the sharing

and exchange of intangible and tangible resources. Accordingly, the disposition to exchange strategic resources with university partners would reflect the presence of well-honed governance structures and trusting relationships between partners, facilitating the engagement in exploration search activities even in the absence, or at low levels, of financial slack.

Similarly, in the case of exploitative knowledge sourcing, the disposition to share and commit a wider range of resources with university partners should further enhance exploitation search strategies under a situation of low financial slack. A strong organizational proximity between the firm and its university partners, as reflected by the degree of commitment of tangible and intangible resources with university partners, should facilitate and encourage the pursuit of short-term results and near-term gains in downstream stages of innovation processes out of these relationships, in a context of low financial slack. Thus, we put forward the following two complementary hypotheses:

H2a: The effect of a firm's financial slack on explorative knowledge sourcing will be moderated by the degree of organizational proximity with its university partners, so that for higher levels of organizational proximity the effect of higher slack on exploration will be lessened.

H2b: The effect of a firm's financial slack on exploitative knowledge sourcing will be moderated by the degree of organizational proximity with its university partners, so that for higher levels of organizational proximity the effect of lower slack on exploitation will be enhanced.

The moderating effect of geographical proximity

There is abundant evidence showing that geographical proximity plays an important role in shaping university-industry collaborations. Researchers have found strong localized spillovers between universities and firms and have provided systematic evidence showing

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that firms are more likely to work with university partners located nearby to their organization (Arundel and Geuna, 2004, Abramovsky et al., 2007, Henderson et al., 1998, Jaffe, 1989, Laursen et al., 2011). Decisions to locate nearby universities are particularly noticeable in the case of academic spin-offs (Kolympiris et al., 2014). One reason why geographic proximity is important in university-industry exchanges is that to work productively together firms and academics need to build mutual understanding, enabling them to share complex and uncertain information. Face-to-face communication, which is facilitated by geographic proximity, helps to build on this mutual understanding (Storper and Venables, 2004; ter Wal and Boschma, 2011). Moreover, when firms and their universities partners are located in the same area, there will be pressure on both parties to treat each other well by developing outputs from collaborations that enable both parties to achieve their respective goals. These pressures arise because information about non-delivery or poor treatment in the exchange may spillover to other members of the local area, lowering the reputation of either party as an attractive partner for future exchanges (Bathelt et al., 2004: ter Wal, 2014).

Given this context, we expect geographic proximity to moderate the effect of financial slack on university knowledge sourcing. On the one hand, geographic proximity can contribute to enhance explorative search strategies by enabling more frequent and close personal exchanges between the firm and its university partners, potentially compensating for the shortening or absence of financial slack. Frequent face-to-face interactions should allow both parties to work more effectively on explorative efforts in the design and development of research projects, according to evidence pointing out that geographical proximity is particularly important for university-business interactions involving basic research (Abramovsky et al., 2007) and R&D partnerships in engineering-related projects (D'Este and Iamarino, 2010).

On the other hand, geographic proximity may also moderate the effect of low slack on exploitation of university knowledge. In particular, we suggest that geographic proximity is liable to enhance the orientation towards exploitable outcomes from university knowledge, among organizations with low financial slack. Since geographic proximity lowers the costs of interacting with university partners, it will further facilitate the focus on short-term goals among financially constrained firms. Thus,

> *H3a: The effect of a firm's financial slack on explorative knowledge sourcing will be moderated by geographical proximity with its university partners, so that for closer geographical proximity the effect of higher slack on exploration will be lessened.*

> *H3b: The effect of a firm's financial slack on exploitative knowledge sourcing will be moderated by geographical proximity with its university partners, so that for closer geographical proximity the effect of a lower slack on exploitation will be enhanced.*

SETTING, DATA AND MEASURES

Research setting

The UK constitutes the background context for this study. The UK is an important example in terms of government policy initiatives to promote university-business interactions. Since the early 1990s, the UK government has introduced a wide range of support mechanisms for university-business knowledge exchange, including initiatives to support joint research collaborations (e.g. Link, Faraday Partnerships, and Knowledge Transfer Partnerships programmes) and initiatives to support capacity building of commercialization activities at universities (e.g. University Challenge Funds and Higher Education Innovation Fund programmes) (BIS, 2007, BIS, 2008, BIS, 2011) . These initiatives have been successful in contributing to the establishment of business incubators, improving the intellectual property infrastructure and facilitate the interface between the science base and industry. However, there is an increasing emphasis from government

towards more demand-oriented initiatives that try to increase university responsiveness to industry needs (Wilson, 2012). In that respect, it is crucial to get a better understanding of the type of knowledge that business search for in their interactions with universities. This should help shifting the focus from supply to demand-oriented policy initiatives, and would contribute to better understand the capacities required at universities to meet business needs. This study moves in this direction by investigating the firms' modes of knowledge sourcing from universities.

Data

In order to explore these questions, this study draws on three rich sources of information: (i) the project records of a large UK research council; (ii) a survey of companies involved in collaborations with universities; and (iii) firms' financial records. First, we drew upon the records of the UK's largest research council, the Engineering and Physical Sciences Research Council (EPSRC). The EPSRC provides £700 million per year to university researchers to conduct new research in fields such as civil, mechanical and electrical engineering as well as mathematics, chemistry and physics. We focused on collaborative grants funded between 1999-2006 as all of these projects involved industrial collaborators. The EPSRC project records list the name of all organizations collaborating on each project, allowing us to construct measures of the number and duration of the research projects for each collaborator. In addition, contact details of individuals from the collaborating organization are named on the grant. After cleaning these records, we found that there were some 3,088 unique industrial collaborating firms based in the UK between 1999-2006. To be clear, our approach does not attempt to explain why firms work with universities, but we are concerned with the *nature* of collaboration rather than the decision to collaborate.

Our second source of data comes a survey of the industrial collaborators named in the EPSRC project records (see also Bruneel et al., 2010).[1] To develop the survey, we interviewed seven individuals within industry with responsibility for working with universities. In addition, we tried to ensure that the questionnaire was designed based on past research about the nature of interaction with universities (Cohen et al., 2002). All factual questions of the survey referred to the period 2005-2006. On the questionnaire itself, we tried to blend factual questions with attitudinal measures, using a mixture of scales and anchors to help avoid habituation by respondents. In addition, we included a range of variables to capture structural features of the organizations: size, sector, R&D expenditure and share of staff with higher education degrees.

The unit of analysis for the survey was the business unit, which we defined as an organizational unit producing goods or services, which benefits from a degree of autonomy in decision making, especially for the allocation of its resources. We decided to focus on the business unit because some of the firms in our sample are large, multi-site organizations. To account for differences in ownership structure, we also asked information about whether businesses were independent organizations or whether they belonged to larger groups – in this latter case, we also asked information about the country where headquarters are located

The use of the EPSRC records allowed us to target the survey at the individuals responsible for the university collaboration – i.e. the contact persons named in project data. We choose this strategy to ensure that our respondents were well informed about the relationship between the firm and its university partners. Furthermore, to ensure that the respondents were representative of wider views of their organization, we included a top up

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[1] A full copy of the survey can be found at
http://www.aimresearch.org/uploads/File/pdf/Academic%20Publications/AIM%20Search%20Talent_2009.pdf, accessed July 2015

sample of 343 individuals that were listed as the second most frequent contact name on the collaborations. In total, this strategy led to the creation of a sample of 3,431 individuals.

The survey data collection was done in several stages. First, in November 2007, we sent an invitation letter, which included a letter of endorsement for the study from the Chief Executive of the EPSRC. At this stage, only electronic responses were allowed. This approach generated 276 responses. A telephone chase of non-responders yielded another 176 responses. In a later stage, we conducted a postal wave of the survey (February 2008). The postal wave yielded another 188 responses. Finally, we sent a final mail reminder to non-respondents, yielded another 13 responses. The approach gave us 646 usable responses, covering 602 different organizations.[2] Based on a total survey population of 3,088, the response rate was just under 20 per cent. This response rate is comparable to that of other studies based on survey data to university or industry scientists for which participation is voluntary (Bekkers and Bodas-Freitas, 2008; Fini et al., 2010; Lee et al., 2001). The sample is diverse, covering manufacturing and professional service firms from all parts of the UK.

The third source of data corresponds to the firms' financial records. These records were drawn from Financial Accounts Made Easy (FAME), a database provided by Bureau van Dijk that contains financial information of around seven million companies in the UK and Ireland. We looked up each company of our sample in FAME based on the company's location and the sector in which it operates. We crosschecked the resulting companies listed in FAME using the company's website. We retained 341 firms, where we had full financial information and complete survey data.

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[2] There are 42 organizations with two respondents and 2 organizations with three respondents. This means that our sample covers 602 organizations. The results reported in the paper are based on the average score of the multiple respondents. The analyses with the scores of each respondent yielded results that are consistent to those reported in the paper.

We undertook a number of tests to ensure the reliability of the final sample. First, we explored whether the responses to the survey were consistent with the overall pattern of population within the EPSRC records by comparing the responses by industry in our sample against the sectoral breakdown of the total population: overall the two distributions were consistent. Second, we tested for differences between responses made in electronic vs. paper-based media to our survey and found no significant differences in terms of size, age, and ownership structure. Third, following Armstrong and Overton (1977), we compared early and late respondents to the survey and again found no significant differences in the former dimensions. Fourth, we checked the responses we received from 44 organizations where we have two or more responses and found no significant differences between the respondents from the same organization in dimensions such as knowledge sourcing from universities and R&D intensity. Fifth, we checked for response bias by the reduction in the sample to firms through the match with FAME and found no statistical difference in terms of size and ownership structure between matched and unmatched firms.

MEASURES

Dependent and Independent Variables

The dependent variables in this study are *exploitative* and *explorative knowledge sourcing*. To capture the extent to which firms sourced exploitative or explorative knowledge from their university partners, we drew on survey responses to a question about the benefits that the organization received as a result of the interactions with universities over the last five years. Although we propose two new scales, the items were developed based on the literature on the types of benefits firms gain from university engagement (Bercovitz and Feldman, 2007, Cohen et al., 2002). We used three items to create the variable *explorative knowledge sourcing*: 'creation of long term links with university

researchers', 'improved understanding of foundations of particular phenomena' and 'source of information suggesting new projects and identifying future trends'. We considered four items to create the variable *exploitative knowledge sourcing*: 'assistance in problem solving (e.g. support during the development process)', 'contribution to the successful market introduction of new products/processes', 'cost reduction in the product or process development (e.g. new prototypes)', and 'reducing the time required for the completion of the company's R&D'.

Respondents were asked to score each item on a five-point likert scale ranging from 1=not at all important to 5=crucial. We created composites to construct the dependent variables by calculating the average across the items. The scales for both variables appear to be reliable (explorative knowledge sourcing, α=62 and exploitative knowledge sourcing, α=.77) (Nunnally, 1967).

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For our measure of slack, we use a measure of *financial slack*, i.e. the level of cash and deposits (measured in pounds) of the firm in the period 2003-2006[3]. We use this measure of financial slack for several reasons. First, cash provides greatest options to organizations in terms of allocating resources to alternative uses as it is more easily re-deployable than other types of slack and therefore provides an area of high managerial discretion (Nohria and Gulati, 1996, Singh, 1986). Excess cash represents unabsorbed slack, which emphasizes uncommitted resources compared to absorbed slack, that are tied up with ongoing operations (George, 2005). Second, since financial slack has been the focus in prior other studies (e.g. Greve, 2003, Kim and Lee, 2008), it provides a degree of theoretical and empirical consistency between our research and prior studies of slack.

Moderating variables

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[3] We also ran the models with the average annual level of slack – the results from these analyses are consistent to those reported in the paper.

Organizational proximity is a measure of the degree of formal and informal interdependencies between a firm and its university partners that captures the extent to which a firm shares and commits tangible and intangible resources with its university partners. The measure is taken from a survey question about the importance attributed by firms to the different tangible and intangible resources they provide or share with their university partners. The question asks firms to 'assess the importance of the resources provided to university partners', and it included five items: 'ideas for research projects'; 'materials or equipment'; 'specialized software'; 'consultancy services'; and 'funding for research'. Respondents were asked to rate the importance of each of these resources on 1-5 likert scale from 'not at all important' to 'crucial'. The Cronbach alpha for this measure is .70, demonstrating reasonable reliability (Nunnally, 1967).

The *geographical proximity* between the organization and its most important university partner is measured as the spatial distance expressed in miles. Information about the most important university partner of the firm was taken from the survey, where respondents were asked to name the university partner they collaborate most frequently with.. We then calculated the distance between the two sets of organizations using postcode information and Google Maps.[4] We measured geographical proximity as the inverse of the spatial distance ($1/d_{ij}$) between each firm in our sample (*i*) and its most frequent university partner (*j*), where d_{ij} is the spatial distance between them in miles[5].

Control variables

We first controlled for some structural features of the organizations. This includes organizational *age*, as the number of years since the company was founded (taken from FAME), and *firm size*, by taking the log of its number of full-time employees (for this measure, we use the survey data) (Mishina et al., 2004). We also control for the ownership

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[4] We also tried using travel times between the two locations and the results were unchanged.
[5] We used a minimal distance of 0,1 miles when the firm and university partner have the same postal code.

structure of the firm, using a dummy to measure whether the firm is *independent* or part of a larger group (Kim and Lee, 2008). To account for domestic versus foreign ownership, we use a categorical variable to identify if the firm's owners are domestic (1), European (2), North American (3) or in the Rest of the World (4). Information on ownership structure is taken from the survey data.

We also control for a set of characteristics about the firms' collaborations with universities. First, the organization's *prior collaboration experience*, calculated as the total length in months (log scale) of working on research projects with universities (Bruneel et al, 2010). We control for the breadth of a firm's university-industry interactions to account for the types of informal and formal exchanges that were present between the firm and its university partners (Arvanitis and Woerter, 2009). To capture this effect, we created a variable measuring the extent to which organizations use the following types of interactions with universities during the period 2005–2006: 'joint research projects', 'contract research', "consultancy', 'training of firm employees'; 'postgraduate training in the company'; 'recruitment of recent graduates or postgraduates'; and 'student placements'. Each channel of interaction was coded 1 if the firm reports having used a given interaction channel and zero otherwise. We then added up the seven interaction channels to represent the *breadth of interaction*. To account for the effect of interaction with one single university partner, as compared to collaborating with many university partners, we computed the organization's number of university partners during the period 2005 – 2006 (*Number of university partners*). This information is taken from the EPSRC project records and the survey responses.

We introduce a control variable *human capital* for the percentage of staff in the firm with higher education degrees as this may shape the firm's use of universities as a source of knowledge (Mohnen and Hoareau, 2003). The measure is constructed from a categorical

question on the survey that ranges from 1 to 5: 1 = percentage of higher education staff equal to or less than 10%; 2 = percentage of higher education staff between 11% and 20%; 3 = percentage of higher education staff between 21% and 40%; 4 = percentage of higher education staff between 41% and 60%; and 5 = percentage of higher education staff between 61% and 100%. We used a categorical approach because we wanted to reduce the burden for respondents.[6]

Building on Bercovitz and Feldman (2007), we control for the *importance of patents* as a protection mechanism. It uses responses to the UK Innovation Survey data for the corresponding period of our survey. Like the Carnegie Mellon Survey (Cohen et al., 2000), the UK Innovation Survey asks firms about their use of different protection methods for innovation (DTI, 2005). For this measure, we took the average scores for all firms in 28 different industries (based on 3-digit SIC codes).

Since the *nature of knowledge* (tacit vs. codified knowledge) may shape the effectiveness of knowledge exchange across organizational boundaries (Bierly et al., 2009, Winter, 1987, Kogut and Zander, 1992), we control for the degree of codified knowledge in the organization's exchanges with universities. The operationalization of this variable is based on a survey question of Hansen's (1999) and consists of two items measured on a five-point likert scale: 'it was already well documented, contained in reports, documents, and self-explanatory software' and 'it could be easily explained to others in my organization in writing (in emails, software code, written reports, manuals, scientific papers etc.)' (α=.66).

Finally, we include a control variable to capture the level of university *technology transfer activity* at the most important university partner listed by the firm on the survey. This variable is measured as the number of full-time equivalent staff supporting university-

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[6] We also conducted an additional analysis where we substituted percentage of staff with higher education degrees for R&D intensity. Overall, the results were consistent with those reported here.

industry collaboration at the university and is taken from the HE-BCI survey[7] for 2005. A variable that captures the *level of resources of the principal investigators (PIs)* who were active collaborators with the sample firm, as this may influence the nature of knowledge sourcing. This variable is operationalized as the total amount of research funds granted from the EPSRC, over the five years prior to the survey, to the individual academic partners of each firm. Although academics may receive funding from other sources, EPSRC is considered to be the most important source of research funds in the fields of research covered by our survey. And inter-industry differences in the use of university knowledge by including eight industry dummy variables. A summary table of all the measures used in included in an Appendix.

Econometric approach

We performed a confirmatory factor analysis to test whether the items are consistent with the nature of the underlying constructs explorative/exploitative knowledge sourcing from universities, organizational proximity, and nature of knowledge using LISREL. The result of this analysis is reported in Table 1. This analysis shows that the overall fit of the four-construct model is good (GFI = .93, NFI = .91, RMSEA = .067, SRMR = .056) and all loadings of the statement items are positive and significant. Table 2 reports the summary statistics and correlations between the variables. To minimize multicollinearity, we mean-centered the independent and moderator variables before entering the interaction term (Aiken and West, 1991). All variance inflation factors are below the accepted cut-off level of 10 (Neter et al, 1990), so multicollinearity between the variables should not pose a problem.

<center>---INSERT TABLE 2 HERE---</center>

RESULTS

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[7] Further information about this survey can be found at www.hefce.ac.uk, accessed July 2015.

Table 3 represents the results regarding explorative and exploitative knowledge sourcing, respectively. Since our dependent variables are continuous, we use Ordinary Least Squares regressions that allows for clustering at the sector level. Models 1a and 1b show the impact of the control variables on the extent to which firms use university knowledge for exploration and exploitation. Results show that independent firms are less engaged in explorative and exploitative knowledge sourcing from universities. Further, the nature of knowledge and the breadth of interaction are positively associated with explorative knowledge sourcing. The importance of patents reduces the extent to which firms use university knowledge for exploitation.

---INSERT TABLE 3 HERE---

In Models 2a and 2b, the key independent variables are introduced. Hypothesis 1a predicted a positive relationship between the level of slack available to the firm and its levels of explorative knowledge sourcing. The coefficient for this variable is positive and significant, providing support for this hypothesis (0.02, $p \leq .05$). We also find support for Hypothesis 1b, since the level of slack available to the firm has a negative and significant effect on the extent to which firms use university knowledge for exploitation (-0.02, $p \leq .05$).

The interaction effect between the level of slack and the moderating variables organizational and geographical proximity are examined in Models 3a and 3b. In Hypothesis 2a, we proposed that organizational proximity would lessen the positive effect of slack on explorative knowledge sourcing. This hypothesis is supported (coefficient -0.02, $p \leq .05$). Simple slope results indicated that for organizations with a low organizational proximity (one s.d. below the mean), slack resources was positively and significantly related to explorative knowledge sourcing ($\beta = .04$, $p \leq .05$), but for organizations with a high organizational proximity to their university partners (one s.d.

above the mean), financial slack was not significantly related to explorative knowledge sourcing (β = .01, n.s.). Figure 1a shows a plot of this interaction effect.

Hypothesis 2b predicted a negative interaction effect between organizational proximity and slack on exploitative knowledge sourcing from universities. The coefficient is negative and significant (-0.02, p ≤ .05), indicating that Hypothesis 2b is supported. Simple slope results indicated that for organizations with a low organizational proximity (one s.d. below the mean), slack resources was not related to exploitative knowledge sourcing (β = -.004, n.s.), but for organizations with a high organizational proximity with regards to their university partners (one s.d. above the mean), slack resources was negatively and significantly related to exploitative knowledge sourcing (β = -.04, p ≤ .05). Figure 1b shows a plot of this interaction effect.

Hypothesis 3a predicted a negative interaction effect between geographical proximity and slack on explorative knowledge sourcing from universities. The coefficient is positive and significant (.09, p ≤ .001), indicating that Hypothesis 3a is not supported. Simple slope results indicated that for organizations with a high geographical proximity (one s.d. above the mean), slack resources was positively and significantly related to explorative knowledge sourcing (β = .12, p ≤ .001), but for organizations high in geographical proximity (one s.d. below the mean), slack resources were negatively and significant related to explorative knowledge sourcing (β = -.07, p ≤ .05). Figure 1c shows a plot of this interaction effect. Finally, we hypothesized that geographical proximity would enhance the effect of lower slack on exploitative knowledge. However, this Hypothesis (3b) was not supported (.02, n.s.).

---INSERT FIGURES 1a, 1b AND 1c HERE---

DISCUSSION

The main purpose of this paper is to examine the impact of financial slack on the way firms draw knowledge from universities. The results suggest that drawing external knowledge from universities into the firm can involve either explorative or exploitative relationships (Rothaermel and Deeds, 2004) and the extent to which firms engage in these two approaches is profoundly shaped by the financial reserves available to the firm. We found high financial slack is positively associated with firm engagement in explorative knowledge sourcing while low financial slack results in higher engagement in exploitative knowledge sourcing. Further, results indicate that organizational and geographical proximity moderate the influence of financial slack in shaping firms' knowledge sourcing strategies.

This study contributes to the literature on university-industry collaboration and behavioral theory of the firm in several ways. First, most research on university-industry collaboration is policy-driven with limited theoretical underpinning (Perkmann et al, 2013). By drawing on the behavioral theory of the firm (Cyert and March, 1963), this paper introduces slack resources as an important mechanism to explain firm knowledge sourcing behavior from universities. The results of this study suggest that high financial slack appears to enhance the ability of firms to explore jointly with their university partners. Of course, the costs and challenges of engaging in explorative search efforts with universities are high and therefore the availability of slack may be a critical issue in enabling firms to 'fish upstream' in their knowledge sourcing strategy (Bercovitz and Feldman, 2007). Explorative search with universities is fundamentally a costly activity that requires managerial resources and attention to be directed away from the short-term to more distant and uncertain outcomes. Without the cushion of surplus cash on the books, firms may turn away from such efforts, looking inward and to more short-term and tangible outcomes through exploitative knowledge sourcing from universities.

Second, this study further suggests that we need to give greater attention to the role of universities as vehicles of exploitation as well as exploration. Often in the literature on university-industry collaboration, engagement with universities is considered by definition to be explorative. Yet, as this study shows, there are complex mechanisms of exchange between universities and firms. As Cohen et al. (2002) suggested, many firms search for university knowledge as a vehicle for exploitation rather than exploration.

Third, the evidential basis for the behavioral theory is broad, but has tended to focus on the impact of past and relative performance on patterns of organizational change (Argote and Greve, 2007). For instance, Greve (2003) found that levels of R&D spending by Japanese shipbuilders was driven by past performance, indicating that as firms' relative and historical performance declined firms were more likely to increase their R&D spending to catch up to other firms. This theoretical approach has been increasingly applied to explain direction and type of innovative effort undertaken by firms. A seminal paper in this area was Nohria and Gulati (1996), that demonstrated the availability of slack can help firms to innovate, especially if this slack is allocated efficiently. This paper extends prior research on the link between slack and innovation by empirically examining how financial slack influences the extent to which firms engage in explorative and exploitative knowledge sourcing from universities. In doing so, it helps to enrich our understanding of how behavioral pressures related to performance shape managerial decision-making with respect the use of external knowledge.

Fourth, the study also brings to the surface how organizational and geographical proximity influence the financial slack – knowledge sourcing relationship. We found that the business' organizational proximity to universities lessens the effect of financial slack on exploration and heightens its effects on exploitation. On the one hand, this suggests that firms with little slack can compensate the lack of financial available resources by

strengthening inter-organizational proximities through the sharing and exchange of tangible and intangible strategic resources. This is particularly the case for explorative knowledge sourcing, since our findings point out that firms can compensate financial slack constrains by benefiting from a strong organizational proximity with their university partners. On the other hand, our results point out that when financial constraints are high, a strong organizational proximity with university partners may facilitate the focus on short term, immediate outcomes in their university relations, and thus, to enhance exploitative search.

Further, we explored the effect of geographic proximity on patterns of university knowledge sourcing. In general and contrary to prior research, our results find that geographic proximity plays a modest role in shaping the orientation of the firm towards university knowledge, as this variable is only weakly significant in explaining exploration and not statistically significant for exploitation. In terms of the first case, we found some evidence that close proximity between universities and their main university partners enhances exploration in the case of high slack firms. However, geographic proximity appears to play a little role in shaping the explorative efforts of firms with low financial slack. In the second case, we found little evidence that geographic proximity moderates the tendency of low slack firms to engage in exploitation of university knowledge. This suggests that the geographic proximity advantages associated with the exploitation of university knowledge may be lower than is commonly presumed and the geographic proximity effects may fundamentally apply to exploration knowledge sourcing from universities, where face-to-face communication is required for sustained periods of time (Abramovsky et al., 2007).

By exploring university knowledge sourcing, this paper has also contributed to broaden the range of organizational practices considered by the behavioral theory. At its

core, the behavioral theory focuses on the search behavior of organizations. However, it is have given relatively little attention to the mechanisms of search itself. Therefore, by examining the context of university knowledge sourcing, this paper has helped to reveal how elements of the behavioral theory can explain firm's engagement patterns with universities, suggesting that search in the domain of university knowledge is partly driven by similar features of search in other areas of organizational life. In turn, it suggests that behavioral theory can be broadened to look beyond simply focusing the levels and direction of R&D expenditures to incorporate a richer menu of firm's search behavior.

POLICY IMPLICATIONS, LIMITATIONS AND FUTURE RESEARCH

Over the past 30 years, considerable government effort in the UK and elsewhere has been focused on enhancing university-industry collaboration (Mowery et al., 2001). These attempts are premised that that there is an interaction deficit between firms and universities and that often the results of research are not translated into commercial applications. These policy measures have sought to change incentives and support mechanisms available to academic researchers, universities and firms in order to aid the formation of new and more substantial links between universities and industry. Although this study does not explore the decision of a firm to engage in collaboration with universities, it does offer some insights into what firms gain from collaborating from universities. It is clear, for example, that many firms turn to universities not to explore the knowledge frontier, but to receive help and support on their more pressing concerns. This suggests that universities can often act as a key external resource to enable more incremental and cumulative learning within firms. In turn, this finding indicates that policies to support university engagement need to focus on short-term mechanisms of industrial support, as well as long-term explorative efforts. Our study also suggests that engaging in exploration with universities often requires that firms themselves have excess financial resources. It is clear form our study

that cash constrained firms turn to universities for short-term, near-market help. The policy implication of this finding is that the nature of the benefits that firms gain from universities is contingent on the financial resources that these organizations have available. Interestingly, our research suggests that organizational interdependencies with university partners can mitigate the cash constraint, helping firms with low financial slack to set up more explorative knowledge strategies with universities and to look beyond short-term exploitation. This suggests that policy-makers should highlight the potential for financially constrained firms to develop a rich and mutual exchange of resources with their university partners, as bi-directional flows of ideas, materials and expertise should allow these firms to engage in more fundamental, long-term oriented benefits from their university engagement.

Although we have combined a number of different and unique datasets, this study is subject to a number of limitations that provide avenues for future research. First, we do not explore the performance implications of the different knowledge sourcing approaches, and therefore it is unclear whether explorative or explorative knowledge sourcing from universities is associated with greater levels of innovative or business performance. Second, since we rely on only one-wave survey, we are unable to explore changes in firms' knowledge sourcing strategies. Although this approach is consistent with prior research, there is little reason to assume such knowledge sourcing strategies are stable over time. Longitudinal research designs could track the changes in knowledge sourcing strategies, generating findings on the dynamics of the relationship between knowledge sourcing strategy and financial slack. Third, like other studies invoking financial measures to capture the concept of slack, we lack information on how firms actually allocate their slack resources. Studies that focus on the allocation of slack resources to different knowledge sourcing activities could provide insights complementary to our study. Fourth,

since our study only focuses on collaborators, we do not explore the behavior of non-collaborators that - by definition - do not engage in explorative or exploitative knowledge sourcing from universities. It must be said that the number of firms that engage directly with universities in collaborative arrangements in the UK is fairly low (Tether, 2002) and therefore our sample, although not large in general terms, accounts for many of the most frequent collaborators on university projects. Finally, our study includes only information on firms and universities located in the UK. Therefore, we are unable to comment on whether the patterns we observe would be consistent for other countries, which operate under a different institutional set-up to support university-industry collaboration.

In terms of future research, it would be useful to explore how the aspiration levels of the firms shape their knowledge sourcing behavior, i.e. whether firms that perform below the industry average are more likely to exploit rather than explore university knowledge. There remains much to be learnt about the knowledge sourcing strategies of firms and how the availability of resources in turn shapes these strategies with different types of external partners. This work could help to extend both the behavioral theory of the firm as well as the literature on the nature and consequences of university-industry collaboration.

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TABLES AND FIGURES

Table 1: Descriptive analysis and confirmatory factor analysis (N = 341)

Item	Mean	Standard deviation	Loading	Loading	Loading	Loading
Creation of long term links	3.56	.76	.62			
Improved understanding of foundations	2.92	.94	.52			
Sources of information for new projects	2.84	.92	.68			
Assistance in problem solving	2.86	.86		.58		
Contribution to successful market introduction	2.34	.97		.73		
Cost reduction in product/process development	2.16	.94		.70		
Reducing time for completion of R&D projects	2.48	.98		.69		
Ideas for research projects	3.39	.91			.57	
Materials or equipment	2.95	1.01			.60	
Specialized software	2.39	1.11			.44	
Consultancy services	2.57	1.02			.54	
Funding for research	2.81	1.05			.60	
It was already well documented, contained in report, documents, and self-explanatory software	3.13	.89				.73
It could be easily explained to others in my organization in writing (in emails, software code, written reports, manuals, scientific papers, etc.)	3.39	.81				.65
$X^2 =179.96*$, d.f. = 71						
GFI = .93, NFI = .91, RMSEA = .067, SRMR = .056						

$^*p < .05$

Table 2 Summary Statistics and Correlation Matrix (N = 341)

Variable	Mean	St.dev.	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]
									Correlation matrix									
[1] *Explorative knowledge sourcing*	3.11	.66	1															
[2] *Exploitative knowledge sourcing*	2.46	.72	.48	1														
[3] *Financial slack[a]*	7.39	2.98	.13	-.02	1													
[4] *Organizational proximity*	.02	.98	.47	.34	.01													
[5] *Geographical proximity*	3.69	1.91	.04	-.01	.05	.10												
[6] *Age[a]*	2.74	.89	-.03	.11	.24	-.07	.18											
[7] *Size[a]*	1.90	.95	.15	.10	.60	.09	.17	.28										
[8] *Independent*	.57	.50	-.19	-.09	-.33	-.12	-.10	-.27	-.40									
[9] *International*	1.53	.90	.07	.03	.19	.05	.07	.23	.23	-.67								
[10] *Prior collaboration experience[a]*	.81	5.49	.06	-.003	.21	.01	.11	.24	.26	-.21	.11							
[11] *Human capital*	3.37	1.52	-.05	-.18	-.15	.09	-.15	-.26	-.34	.13	-.08	-.06						
[12] *Importance of patents*	.82	.39	.03	-.06	-.004	-.02	.01	.09	-.04	-.08	.12	.04	.10					
[13] *Nature of knowledge*	3.26	.73	.09	.08	.03	.02	.09	.01	.03	-.02	.05	-.02	.03	-.02				
[14] *Breadth of interaction*	3.57	2.02	.24	.06	.36	.24	.002	-.02	.50	-.21	.06	.16	.10	.09	.06			
[15] *Number of university partners*	.91	1.62	.11	.03	.15	.06	-.02	-.07	.18	-.05	-.03	-.001	.09	.07	.06	.26		
[16] *Technology transfer activity[a]*	3.06	.77	.01	-.06	.17	.04	-.03	.01	.10	-.09	.12	.08	-.05	.05	-.02	.06	.01	
[17] *PI level of resources[a]*	10.24	6.84	.02	.05	.13	.03	-.05	.04	.10	-.11	.08	.21	.03	-.002	.02	.10	.24	.06

Notes: Coefficients with an absolute value above .11 are significant at the .05 level, two-tailed. Industry dummies are not reported.

[a] Logarithm

Table 3 OLS regression estimates of exploitative knowledge sourcing and explorative knowledge sourcing

	Explorative knowledge sourcing			Exploitative knowledge sourcing		
	(1a)	(2a)	(3a)	(1b)	(2b)	(3b)
Constant	3.19***	3.31***	3.09***	2.71***	2.71***	2.61***
	[.17]	[.22]	[.23]	[.26]	[.28]	[.27]
Age	-.05	-.03	-.05	.06	.09+	.09+
	[.04]	[.04]	[.03]	[.04]	[.05]	[.04]
Size	-.04	-.03	-.02	-.06	.0004	.004
	[.04]	[.02]	[.02]	[.04]	[.02]	[.02]
Independent	-.28+	-.21	-.18	-.13+	-.07	-.07
	[.15]	[.13]	[.11]	[.06]	[.07]	[.07]
International	-.05	-.05	-.05	-.04	-.05	-.05
	[.04]	[.03]	[.04]	[.04]	[.03]	[.03]
Prior collaboration experience	.002	.008	.009	-.007	-.005	-.005
	[.01]	[.01]	[.01]	[.006]	[.004]	[.004]
Human capital	-.04	-.05*	-.05*	-.08	-.09*	-.09*
	[.04]	[.02]	[.02]	[.05]	[.03]	[.03]
Importance of patents	-.01	-.06	.003	-.10+	-.07	-.07
	[.10]	[.07]	[.07]	[.05]	[.06]	[.06]
Nature of knowledge	.07**	.08**	.08***	.07	.09	.09
	[.02]	[.02]	[.01]	[.07]	[.06]	[.06]
Breadth of interaction	.07**	.02	.03	.03	.007	.007
	[.01]	[.02]	[.02]	[.02]	[.02]	[.02]
Number of university partners	.04	.02	.02+	.01	-.001	-.001
	[.02]	[.01]	[.01]	[.02]	[.01]	[.01]
Technology transfer activity	-.01	-.03	-.001	-.07	-.07	-.07
	[.05]	[.02]	[.03]	[.08]	[.05]	[.05]
PI level of resources	-.004	-.007	-.007	.006	.007	.007
	[.005]	[.006]	[.005]	[.005]	[.005]	[.005]
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Financial slack		.02*	.03*		-.02*	-.02*
		[.01]	[.01]		[.01]	[.01]
Organizational proximity		.31***	.44***		.27***	.43***
		[.03]	[.07]		[.04]	[.09]
Geographical proximity		.04**	.06**		.03**	.03*
		[.01]	[.01]		[.01]	[.01]
Financial slack * organizational proximity			-.02*			-.02*
			[.01]			[.01]
Financial slack * geographical proximity			.09***			.02
			[.01]			[.02]
R^2	.11	.30	.33	.08	.21	.22

Notes: This table represents the results of the OLS regressions in which exploitative and explorative knowledge sourcing are the dependent variables. Robust standard errors appear below the coefficients in brackets. + Significant at 10%. * Significant at 5%. ** Significant at 1%. *** Significant at 0.1%. One-tailed tests for hypotheses; two–tailed tests for control variables. Monetary values are logarithmic transformed

Figure 1a: Moderating effects of organizational proximity on the relationship between slack and explorative knowledge sourcing
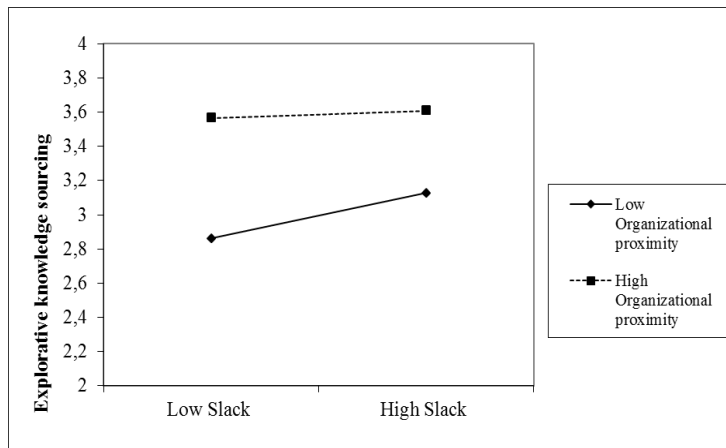

Figure 1b: Moderating effects of organizational proximity on the relationship between slack and exploitative knowledge sourcing
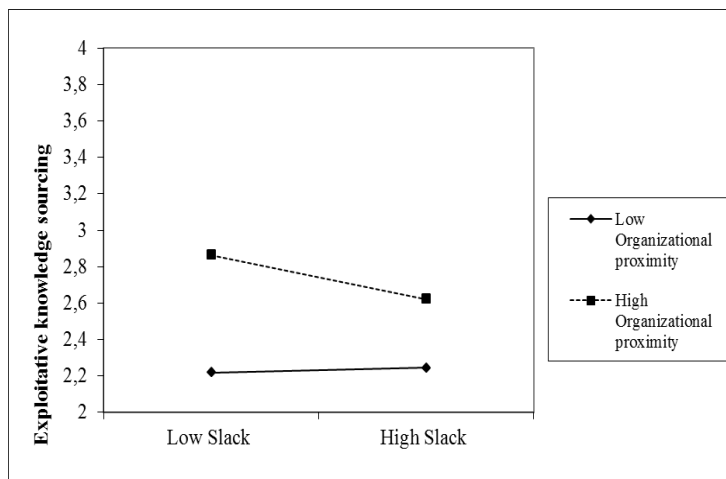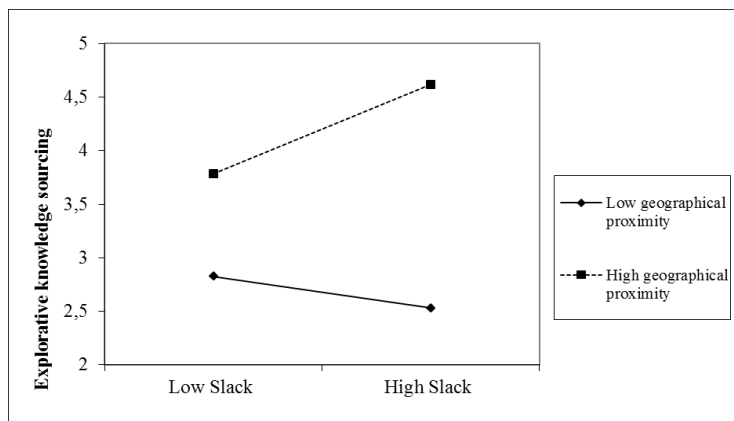

Figure 1c: Moderating effects of geographical proximity on the relationship between slack and explorative knowledge sourcing

Appendix: variables, measurement

Variable	Measurement	Corresponding time frame	Source	Reliability (alpha's)	Research reference
Explorative knowledge sourcing	3 items, likert-type response scales	2002 – 2006	Survey	.62	Cohen et al, 2002; Bercovitz and Feldman, 2007; Bishop et al, 2011
Exploitative knowledge sourcing	4 items, likert-type response scales	2002 – 2006	Survey	.77	
Financial slack	Amount in £	2003 – 2006	FAME		Greve, 2003; Kim and Lee, 2008
Organizational Proximity	5 items, likert-type response scales	2005-2006	Survey	.70	Cockburn and Henderson, 1998
Geographical proximity	1/Distance in miles	2005-2006	Survey		Laursen et al. 2011
Age	Number of years	2006	Survey		Mishina et al, 2004
Size	Full-time equivalents employees	2006	Survey		
Independent	Dummy	2006	Survey		Kim and Lee, 2008
International	Categorical variable	2006	Survey		Cantwell and Odile, 1999
Prior collaboration experience	Number in months	2002-2006	EPSRC		Bruneel et al. 2010
Human capital	Full time equivalents of staff with higher education degrees	2006	Survey		
Importance of patents	1 item, likert type response scale by industry 2 digit	2002 – 2004	UK Innovation Survey CIS 4		Bercovitz and Feldman, 2007
Nature of knowledge	2 items, likert-type response scales	2005 – 2006	Survey	.66	Winter, 1987; Kogut and Zander, 1992; Bierly et al, 2009
Breadth of interaction	7 items, likert-type response scales	2005 – 2006	Survey		Grimpe and Hussinger, 2008; Arvanitis and Woerter, 2009
Number of university partners	Number of partners	2005 – 2006	EPSRC		
Technology transfer activity	Full-time equivalents knowledge exchange staff employed by university	2005	HE-BCI		
PI level of resources	Amount in £	2002 – 2006	EPSRC		D'Este and Patel, 2007