Proximity across the distant worlds of university–industry collaborations

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Funding information
H2020 Marie Skłodowska-Curie Actions, Grant/Award Number: 722295

Abstract

This paper examines the extent to which firms perceive different dimensions of proximity to be important for the formation of their interactions with universities. Furthermore, it investigates whether the importance of the different types of proximities varies depending on the type of interaction—be it about knowledge exploration, knowledge exploitation, competence enhancement, advice-seeking or marketing. Using data from a survey of 1,200 Norwegian firms, we find that most managers believe cognitive, institutional, social and geographical proximity were important for their decision to collaborate with university partners and that the importance of proximity types varies depending on the contents of the interaction.

KEYWORDS
distance, Norway, proximity, survey, university-industry collaboration

JEL CLASSIFICATION
123; 125; O32

1 | INTRODUCTION

Universities and firms interact for multiple purposes, and their interactions therefore take many different forms. Firms collaborate with universities to explore new knowledge, for example, through contract research or joint research projects, and to exploit new knowledge through commercialization in the form of patents, licences or new spinoff firms. Firms also collaborate with universities to enhance their competence, for example, contributing to the

education of university students or participating in training for firm staff. They may consult academics to solve their technical problems or seek advice on their activities, often in informal ways. And they may simply want to brand or market themselves by, for example, sponsoring the university or organizing events.

However, university-industry interactions can be hard to realize. Universities and firms have been described as occupying different worlds (Bruneel, D'Este, & Salter, 2010), with differences in worldviews, organizational structures, values and cultures, goals and motivations acting as barriers to interaction. These distances are not the same across all university-firm relationships. Not all firms or all universities share the same values; have the same cognitive capacities; or operate under the same organizational principles (Sauermann & Stephan, 2013). They also do not matter equally for all types of collaboration but their importance will vary depending on the content and purpose of collaboration. Hence, university-industry interactions can play out differently in different cases, suggesting that different university–industry collaboration (UIC) types need to be tackled separately.

Proximity (in a geographical as well as non-geographical sense) is important for the formation of networks (Boschma, 2005). If firms and universities occupy different worlds, a pertinent question is which dimensions of proximity can enable UIC of different types. Nonetheless, the number of studies looking at the importance of proximity dimensions in UICs has been limited (Ponds, van Oort, & Frenken, 2007; Steinmo & Rasmussen, 2018) and these works have largely focused on specific UIC mechanisms, such as joint research, co-patenting and spin-offs (Hoekman, Frenken, & van Oort, 2009; Marek, Titze, Fuhrmeister, & Blum, 2017). More importantly, existing studies have seldom examined the relative importance of various proximity dimensions in facilitating different forms of UICs (D'Este, Guy, & Iammarino, 2013). However, the different characteristics of UICs depending on the purpose of interactions require a closer examination of the interplay between various proximity dimensions and various UIC channels. Furthermore, prior research has employed crude measures for proximity dimensions instead of collecting primary data on actors' perceptions of the importance of proximity for the formation of the relationships. This paper fills these gaps in the literature and provides a more comprehensive understanding of the significance of proximity dimensions for a wide set of UIC channels.

With the empirical analysis drawing on a customized survey of firms in Norway, conducted in 2018, this paper represents the first endeavour to analyze the role of various dimensions of proximity across different UIC channels. The results indicate that the majority of interactions occur with local and regional universities for all types of UICs. The analyses also indicate the importance of non-geographical proximity for UICs. However, the importance of proximity dimensions varies depending on the UIC type. We run a multinomial logit regression analysis to determine the relative significance of each proximity dimension for different UIC types. Compared to competence enhancement UICs, cognitive and institutional proximity matter more for knowledge exploration collaborations, while geographical proximity is less significant. Social proximity is perceived as more important by firms engaging in knowledge exploitation interactions. For advice-seeking interactions, organizational proximity is less important.

The remainder of the paper is structured as follows. First, we discuss previous literature on distance(s) in UICs and the role of proximity in bringing the "two worlds" closer, outlining how different dimensions of proximity matter for different UIC types (Section 2). Then, we describe the data and methodology in Section 3. In Section 4, we present the findings of the analysis. A discussion of the results concludes the paper (Section 5).

2 | THEORETICAL FRAMEWORK

2.1 | Proximity in UICs

The proximity framework provides a useful theoretical perspective on inter-organizational collaborations for knowledge exchange purposes (Nilsen & Lauvås, 2018). Proximity, defined as "being close to something measured on a certain dimension" (Knoben & Oerlemans, 2006, pp. 71–72), helps in overcoming co-ordination problems by facilitating communication and reducing uncertainty, and therefore, contributes to effective interaction in knowledge

transfer between the partners (Boschma, 2005). Some studies argue that geographical proximity, or the co-location of the partners, facilitates the interaction process by allowing face-to-face communication that enables thick knowledge exchange (Storper & Venables, 2004), making knowledge, especially tacit knowledge, easier to transfer (Maskell & Malmberg, 1999). However, co-location does not necessarily ensure the effectiveness of the knowledge exchange, as it does not in itself lead partners to interact (Broekel & Boschma, 2012). Moreover, actors who are not located in close proximity can still effectively exchange knowledge, in many cases building on non-geographical dimensions of proximity—including cognitive, organizational, institutional, and social proximity (Boschma, 2005).

Partners engaging in knowledge transfer need to be competent enough to understand each other—or in the proximity language, they must have cognitive proximity. Cognitive proximity depends on the similarity of the knowledge base of the agents (Boschma, 2005). For an effective knowledge transfer, the actors should be able to perceive, absorb, internalize and process the new knowledge coming from the other partner. This is easier if their knowledge base is similar. Organizational proximity denotes being subject to the same, or similar, control mechanisms and depends on the degree of formal arrangements governing the relationship between the actors (Fitjar, Huber, & Rodríguez-Pose, 2016). It reduces the chances for opportunistic behaviour of the partners in the knowledge exchange process by providing a control mechanism in the form of "checks-and-balances," especially when the arrangement is formalized. Institutional proximity facilitates knowledge transfer by ensuring that the interacting parties are governed by similar hard/formal (regulations, laws etc.) and soft/informal (values, culture, language etc.) institutions (Boschma, 2005). Social proximity captures the social relations mainly emanating from prior ties, repeated interactions, friendship or kinship between the individuals involved in the collaboration (Boschma, 2005). Social proximity provides a solid basis for trust (Fitjar et al., 2016; Innocenti, Capone, & Lazzeretti, 2020), which works as a safeguard against opportunistic behaviour and, thus, facilitates communication and knowledge sharing.

Notwithstanding the critical facilitative role of proximities in inter-organizational relationships, too much proximity can be detrimental to learning. Too much proximity may result in lock-in situations that can block the effectiveness of collaborations. If cognitive proximity is too high, the potential for learning becomes small. Excessive social proximity can be associated with nepotism, if actors choose to collaborate only with their personal friends. Too much organizational proximity can mean a highly bureaucratic framework with little room for maneouvre. Institutional proximity can work conservatively if established values and norms are not challenged. Hence, in innovation networks, the actors should be neither too close nor too far, but located at the right distance from each other to maximize the benefits from collaboration (Broekel & Boschma, 2012; Fitjar et al., 2016). While some distance is thus required for effective collaboration, several studies have shown that proximity increases the likelihood that a relationship is formed (Boschma & Frenken, 2010; Broekel & Boschma, 2012).

University-industry collaborations represent a puzzle from the proximity perspective. Following divergent institutional logics, academia and businesses are said to represent "two worlds" (Hall, 2003; Hewitt-Dundas, Gkypali, & Roper, 2019), suggesting irreconcilable distances between them. Universities and firms differ in their orientations—due to dissimilarities in worldviews and motivations—and encounter transactional difficulties, arising from the inflexibility of university administrations and conflicts regarding intellectual property (Bruneel et al., 2010). In this regard, UICs involve proximity structures that are characterized by distance rather than proximity.

Despite the distances, UICs are being formed between academic and industrial actors. This suggests that the distances can be bridged and barriers can be overcome in UICs. In order to achieve this, the social and relational characteristics of actors are of crucial importance in UICs (Al-Tabbaa & Ankrah, 2016, 2019). The proximity of the interacting partners presents pre-conditions that either hinder or facilitate the collaboration process in UICs (Rajalo & Vadi, 2017; Slavtchev, 2013; Steinmo & Rasmussen, 2018).

Against this backdrop, various studies have shown that individual dimensions of proximity affect the formation of UICs and the interaction process (Cao, Derudder, & Peng, 2019; Crescenzi, Filippetti, & Iammarino, 2017; D'Este et al., 2013). One strongly held argument in the literature is the prominence of geographical proximity in easing the collaborations, and thus the more prevalent realization of UICs between universities and firms located in close geographical proximity. Knowledge generated at universities spills over to geographically proximate industrial actors

more easily than to distant firms (Jaffe, Trajtenberg, & Henderson, 1993) and tends to remain in the localities where the universities are established (D'Este et al., 2013). Firms, especially in science-based sectors such as biotechnology and pharmaceuticals, tend to locate their R&D establishments in close vicinity of research universities. University spin-off firms primarily concentrate around universities and research institutes (Ponds, Oort, & Frenken, 2010). The firms around universities also benefit from access to graduates staying in the local area after their studies. Firms tend to initially approach nearby universities when looking for collaboration partners. The majority of UICs hence takes place in close geographic proximity (Fitjar & Gjelsvik, 2018).

Non-geographical dimensions of proximity further facilitate the formation and management of UICs. Cognitive proximity can make communication between universities and firms easier by building a shared understanding based on the similarities of knowledge bases of universities and firms. Organizational proximity in UICs can be achieved through common membership of the same organizational structures, such as research centres (Kuttim, 2016). Villani, Rasmussen, and Grimaldi (2017) argue that "intermediary organizations" such as technology transfer offices (TTOs) and collaborative research centres (CRCs) facilitate UICs by creating organizational proximity. Institutional proximity, conceptualized as the similarity of institutional arrangements (such as intellectual property rights regimes and common language) at the national level (Hoekman et al., 2009) or as the subordination of firms and universities to the same overarching institutional authorities (Hong & Su, 2013), has been found to facilitate UICs. Finally, social proximity in the form of having graduates from a specific university increases the likelihood of firms collaborating with that university in Denmark (Drejer & Østergaard, 2017), presumably in part due to their social connections to faculty. Crescenzi, Nathan, and Rodríguez-Pose (2016) show that social proximity plays a significant role in the co-patenting behaviour of researchers with firms in the UK. Previous collaborative experiences also positively influence the success of R&D-related UICs in Spain (Mora-Valentin, Montoro-Sanchez, & Guerras-Martin, 2004).

Even though the role of proximity dimensions in UICs has been examined, prior research lacks several perspectives that we attempt to address in this paper. First, existing studies often focus on a single proximity dimension, typically geographical proximity (D'Este & Iammarino, 2010; D'Este & Perkmann, 2011; Johnston & Huggins, 2017; Laursen, Reichstein, & Salter, 2011; Ponds et al., 2010; Tijssen, Klippe, & Yegros, 2020). Second, studies that include a broad proximity perspective typically use indirect measures of proximity, and rarely take the perspective of the firm. Finally, no previous studies have examined how important proximity is for different types of collaboration. Therefore, this paper asks: how important are the various dimensions of proximity in the emergence of UICs of different types?

2.2 | Which types of proximity for which types of interaction?

Firms establish collaborations with universities in various forms, ranging from formal R&D collaboration to graduate recruitment, from joint patenting to informal consultations (Fernández-Esquinas, Pinto, Yruela, & Pereira, 2016; Muscio, 2013). The organizational involvement of the actors, the degree of formalization of the relationship, the intensity and frequency of contact, and the thickness of knowledge exchange vary greatly across UIC types. The literature on UICs has developed different typologies for UIC channels. For instance, Ankrah and Al-Tabbaa's (2015) systematic review presents six categories for organizational forms of UICs, covering 41 distinct activities. Hughes and Kitson (2012) report four "pathways"—people-based activities, community-based activities, commercialization activities and problem-solving activities—through which academics and businesses interact. A report prepared for the European Commission identified 14 UIC activities in four different areas: education, research, valorization and management (Davey, Galan Muros, Meerman, Orazbayeva, & Baaken, 2018).

Many of these typologies classify UICs from the perspective of universities. In this study, we instead consider various rationales based on the needs and purposes of collaborations from the perspective of the firm. We distinguish between five broad categories of UICs: "knowledge exploration UICs" are mainly concerned with the generation of new knowledge that businesses lack internally. This can take the form of contract research or joint research

activities. The research activities may lead to commercial outputs such as new patents or the establishment of new ventures, which we refer to as "knowledge exploitation interactions." These interactions seek to commercially valorize the knowledge. "Competence enhancement interactions" address activities aiming to increase the internal capabilities of firms, such as education, training or the mobility of staff and students. Firms often seek out academics for advice on issues they face, resulting in UICs in the form of informal consultations, which we term "advice-seeking interactions." Finally, firms may collaborate with universities to gain public visibility and increase their image and reputation, for example, through sponsorships or the organization of events. We call these UICs "'marketing interactions."

The various channels of interaction between universities and firms have different characteristics (Gertner, Roberts, & Charles, 2011). The degree of actors' involvement, the type of knowledge concerned (tacit or codified) (Gertler, 2003), the intensity and frequency of contact (Storper & Venables, 2004), and the institutionalization of the interaction structure vary greatly by the type of UIC. In the light of these differences, we should not expect each and every UIC channel to follow the same interaction pattern (Ramos-Vielba, Fernández-Esquinas, & Espinosa-de-los-Monteros, 2010). Although various types of collaboration between universities and firms fall under the broad banner of UIC, the interaction channels require different types of proximity. This requires a closer examination of how proximities affect the UIC types individually. Therefore, this paper poses the following research question: does the importance of proximity depend on the type of UIC?

Based on the needs of each type of interaction, we expect the various proximity dimensions to be more or less important for the different types. For example, collaborative research activities can take place between actors situated far from each other, especially in science-based industries, due to the codified nature of the exchanged knowledge (Ponds et al., 2010). The need for face-to-face communication during the implementation of joint research projects may be satisfied through regular meetings. Therefore, for knowledge exploration interactions, geographical proximity is less important than for other types of interactions (Abramovsky & Simpson, 2011; Thune, 2011). Conversely, geographical proximity may be especially important for advice-seeking interactions, since these interactions often rely on face-to-face contact through purposeful or serendipitous encounters between academics and firm representatives (Azagra-Caro, Barberá-Tomás, Edwards-Schachter, & Tur, 2017). This has been highlighted as one of the reasons why firms in R&D-intensive industries often locate close to universities (Abramovsky & Simpson, 2011). For other types of UICs, geographical proximity also matters: UICs aimed at knowledge exploitation have been shown to occur in smaller geographical distances. Spin-offs or start-ups established from university research tend to locate close to the mother university (Breznitz & Feldman, 2012; Goldstein & Drucker, 2006). Patenting also represents a highly localized phenomenon despite its codified nature (Jaffe et al., 1993). Competence enhancement interactions rely on direct communication between the actors involved, such as students, graduates and businesses (Thune, 2011). For marketing interactions, geographical proximity is important, as philanthropy and other types of community initiatives are often oriented towards the local community (Fitjar & Gjelsvik, 2018; Glückler & Ries, 2012).

Cognitive proximity can play a decisive role particularly in research collaborations, since the partners must understand each other for the projects to succeed (Steinmo & Rasmussen, 2016). Therefore, cognitive proximity matters more for explorative UICs than any other type of interactions. Cognitive proximity is less important for marketing interactions as knowledge exchange is not the central aim of such collaborations. For other types of UICs, some cognitive proximity is also important: knowledge exploitation interactions can be claimed to represent later stages of innovation processes of which both sides are knowledgeable. Therefore, some cognitive proximity is required between partners in these interactions. In competence-enhancing interactions, the knowledge bases of firms and universities should be overlapping to meet the competence enhancement expectations of both sides properly. A certain level of cognitive proximity is also required for advice-seeking interactions, since a common understanding of the subject matter is necessary.

Without strong organizational commitments, knowledge exploitation interactions are hard to realize. Therefore, high organizational proximity is particularly important for the establishment of UICs aimed at

knowledge exploitation (Crescenzi et al., 2017). As advice-seeking interactions are mainly informal, organizational proximity is less relevant for this type of UICs. Organizational proximity is also typically not required for the formation of marketing type of links, but formal relationships such as strategic partnerships may provide the basis for marketing interactions. Organizational proximity may also help in the establishment of knowledge exploration interactions since new projects are often easier to generate in a shared organizational context. Organizational proximity is also fairly important for competence enhancement interactions since joint organizational structures will play the role of intermediaries.

The institutional flexibility of the university administration is especially important for knowledge exploitation interactions since it reduces the risk of transaction-oriented barriers, such as conflicts over intellectual property (Bruneel et al., 2010). Conversely, institutional proximity is less important for marketing interactions as these interactions can also take place at arm's length. Institutional proximity is somewhat important for knowledge exploration interactions, as universities need to be open for the involvement of firms in research projects for such interactions to materialize. Institutional proximity is salient with regards to the adoption of a business-friendly attitude by universities that can support the development of human capital in enterprises through competence enhancement interactions. Institutional proximity can also be influential in removing the barriers for the establishment of advice-seeking interactions between firms and universities, as they require a positive attitude by academics to spend their time providing advice to firms.

Social proximity in the form of prior linkages is less relevant for knowledge exploration interactions since research projects to explore new ground will often involve new partnerships. On the contrary, a high level of social proximity may facilitate knowledge exploitation activities. As this type of interactions requires a large element of trust given the intellectual property involved, personal contacts and previous collaboration experience plays a crucial role in the formation of such links. Social proximity can also play a role in initiating interactions with universities for competence enhancement purposes since they often emerge as a result of contacts between lecturers and firm staff. Personal and social networks also make it easier to reach out to academics for advice (Azagra-Caro et al., 2017). Social proximity is also important for marketing UICs, since it would be easier to establish this type of linkages when prior knowledge on the corresponding partner exists. For instance, prior studies on donations to universities have shown that personal contacts are important for this type of linkages (Glückler & Ries, 2012).

Table 1 summarizes the UIC categories for which we expect each dimension of proximity to be more and less important than for the other dimensions.

TABLE 1 Summary of the importance of proximity dimensions for UIC categories

UIC Type	Geographical proximity	Cognitive proximity	Organizational proximity	Institutional proximity	Social proximity
Knowledge exploration interactions	Less important	More important			Less important
Knowledge exploitation interactions			More important	More important	More important
Competence enhancement interactions					
Advice-seeking interactions	More important		Less important		
Marketing interactions		Less important		Less important	

3 | DATA & METHODOLOGY

3.1 | Description of data

In order to examine the role of proximity in UICs, we conducted a survey of 1,201 businesses in Norway. The survey covers firms located in regions that host universities: Oslo/Akershus, Agder, Hordaland, Nordland, Rogaland, Troms, and Trøndelag. These are all university regions that include the headquarters of a university. Furthermore, the distances between the regions, in particular their main cities and university campuses, are relatively large, which helps distinguish between regional and extra-regional interactions.

Norwegian firms attach more importance to innovation collaboration and interact more with external partners than firms in many other developed countries (Fagerberg, Mowery, & Verspagen, 2009). However, most of these interactions happen within supply-chain relationships, typically with suppliers and customers (Fitjar & Rodríguez-Pose, 2013). A small share of Norwegian firms (around 3%) value universities as the most critical source to obtain external knowledge for innovation (Fitjar & Rodríguez-Pose, 2017). Similarly, a report commissioned by OECD (2017) shows that the share of small and medium-sized enterprises (SMEs) collaborating with HEIs for innovation purposes is relatively low in Norway (around 16.7%), which is slightly above the OECD average of 13%.

Intensifying the interactions between universities and businesses has been a significant priority for Norwegian governments and various policies have been put into force, especially in the last 20 years (Gulbrandsen & Nerdrum, 2007). These policies have been geared towards increasing the contributions of Norwegian universities to regional development and national competitiveness by engaging with businesses in third mission activities, mainly through direct collaboration, commercialization of academic R&D results, and undertaking a more prominent role in the innovation system (Thune & Gulbrandsen, 2011). Firms also receive financial support for R&D projects in collaboration with universities and research institutes, from competitive programmes as well as rights-based schemes such as SkatteFUNN.

The survey was specifically designed to examine the interactions of Norwegian firms with universities. The sample of firms was compiled from the Norwegian Register of Business Enterprises (Brønnøysund Register Centre), which collects and stores information about all enterprises in Norway. The population comprised firms with more than five employees in mining, manufacturing, trade and knowledge-intensive service industries[1] in the aforementioned regions. In total, 10,117 companies were contacted, and 1,201 completed the survey, which corresponds to a response rate of 11.9%. A market research firm (Ipsos) carried out the survey through telephone interviews with firm representatives in December 2018. Table 2 presents the share of firms that were interviewed by county, sector and number of employees.

3.2 | University-industry collaborations

Firms were initially asked whether they had been involved in interactions with universities in the last three years. 232 firms stated that they had been involved in UICs (19.3%). This share is comparable to other studies from Norway (e.g., Fitjar & Rodríguez-Pose, 2013 with a share of 24.9%), and elsewhere, such as the UK (e.g., Laursen & Salter, 2004, 27% and Tether, 2002,16% of innovative firms). From then on, the survey continued separately for firms with and firms without UICs. The firms which had not interacted with universities (without UICs) received a shorter version of the questionnaire, while those who had interacted (with UICs) answered questions about the nature and content of these UICs. The longer version of the questionnaire was aimed at providing detailed accounts of UICs from the firms' perspective with a particular emphasis on the dimensions of proximity.

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[1]This includes the NACE codes B, C, G (excluding sub-section 47), J, K, M and N.

TABLE 2 Distribution of firms in the sample by region, sector and firm size

| Region | With UIC | | Without UIC | | All |
	Frequency	Share (%)	Frequency	Share (%)	Frequency
Oslo/Akershus	91	18.3	407	81.7	498
Hordaland	28	17.5	132	82.5	160
Rogaland	29	14.8	167	85.2	196
Agder	19	19.6	78	80.4	97
Trøndelag	40	30.3	92	69.7	132
Nordland/Troms	25	21.2	93	78.8	118
Sector					
(B) Mining and quarrying	6	42.9	8	57.1	14
(C) Manufacturing	58	22.1	204	77.9	262
(G) Wholesale and retail trade	35	11.0	284	89.0	319
(J) Information and communication	38	30.2	88	69.8	126
(K) Financial and insurance activities	2	7.7	24	92.3	26
(M) Professional, scientific and technical activities	72	23.0	241	77.0	313
(N) Administrative and support service activities	21	14.9	120	85.1	141
No. of employees					
5–9	72	14.4	429	85.6	501
10–49	40	37.0	68	63.0	108
50–99	97	18.3	432	81.7	529
100+	23	36.5	40	63.5	63
N	232	19.3	969	80.7	1,201

Respondents with UICs were asked to indicate what types of interactions (among 17 predefined types, with the additional option of entering other types if the predefined categories did not fit) they were involved in with universities. The UIC types considered in the study were selected from Ankrah and Al-Tabbaa's (2015) systematic literature review on UIC. The selection was based on the most prevalent interaction types. In this regard, the typology resembles that of Muscio (2013) and Fernández-Esquinas et al. (2016). These UIC types were, then, grouped into five exclusive categories according to the purpose of interaction from the perspective of the firm: *knowledge exploration*; *knowledge exploitation*; *competence enhancement*; *advice-seeking; and marketing interactions*. This classification covers three common purposes of university-industry collaborations from the perspective of firms: (i) the generation of new knowledge through research activities (knowledge exploration); (ii) the transfer of knowledge from universities to businesses via mobility of students and university staff and the provision of training (competence enhancement); and (iii) the absorption and use of knowledge in innovation processes through valorization by patents and spin-offs (knowledge exploitation) (Thune, 2009). In addition, we include two categories of interaction which are often overlooked, but which are nonetheless important and common channels of interaction: the more informal advice-seeking interactions, as well as marketing interactions where firms want to increase their visibility and prestige in the eyes of the public.

3.3 | Operationalizing proximities

The survey included various questions related to firms' interactions with the university with which they had the most extensive collaboration. They were asked about the dominant type of UIC with that university. Furthermore, they were asked how important various factors were in their decision to interact with that university. These factors reflect five dimensions of proximity (cognitive, organizational, institutional, social and geographical), following the typology of Boschma (2005). We operationalized proximity dimensions building on Fitjar et al. (2016), who provide more direct measures of proximity than earlier studies by asking the actors about the importance of various proximity dimensions in their choice of collaboration partners. Previous studies of proximity in UICs have mainly relied on rather indirect indicators of proximity dimensions—such as the matching of academic fields and industrial sectors for cognitive proximity (Garcia, Araujo, Mascarini, Gomes Dos Santos, & Costa, 2018). This makes it impossible to capture the dynamics of proximity dimensions, which are subject to change over time. Furthermore, they are often unable to detect variation across universities and across firms. In addition, existing studies have measured various dimensions of proximity by looking at established collaborations and trying to figure out possible proximities between the actual collaborators. However, they do not account for how proximities were perceived by the actors and how proximity to the university influenced the decision to interact in the first place. Therefore, we prefer the direct questioning of proximity dimensions based on the subjective assessment of firms. This is the first study of UICs that examine proximities using such a direct approach, rather than relying on indirect indicators of proximity. Respondents were requested to rate the importance of each factor on a four-point Likert scale with 4 as 'very important', 3 as 'fairly important', 2 as 'not very important' and 1 as 'not at all important'.

For the operationalization of cognitive proximity, we rely on the original definition provided by Boschma (2005, p. 63): "with the notion of cognitive proximity, it is meant that people sharing the same knowledge base and expertise may learn from each other." Therefore, we asked firms about the importance of "sharing a common knowledge base and expertise with this university" in their decision to interact. Boschma (2005, p. 65) defines organizational proximity as "the extent to which relations are shared in an organizational arrangement, either within or between operations." Accordingly, we operationalize organizational proximity in terms of common membership of organizational structures, such as research centres or science parks. Institutional proximity encompasses "formal rules and cultural values at a macro level (Boschma, 2005, p. 68). Adapting this to the context of UIC, we operationalize it in terms of the adoption of a business-like mindset and attitude by universities. This reflects the perception by firms of whether or not the values and norms of the university are similar to those of the firm's institutional sphere. Social proximity is operationalized as "having previous/ongoing interaction with that university," following the definition that "social proximity refers to the extent to which agents share prior mutual relationships" (Balland, De

TABLE 3 Operationalization of proximity dimensions

Dimension of proximity	How important have the following reasons been in your decision to interact with this university?
Cognitive proximity	Sharing a common knowledge base and expertise with this university.
Organizational proximity	Being members of the same organizational network/structure (research centre, research consortium, association, cluster, science park etc.).
Institutional proximity	Feeling that the university/faculty/unit has a business-friendly, entrepreneurial mindset.
Social proximity	Having previous/ongoing interaction with that university.
Geographical proximity	Being geographically close to our company.

Vaan, & Boschma, 2013, p. 756). For geographical proximity, we include an operationalization that captures firms' subjective perception of closeness, asking for the importance of the university "being geographically close to our company." Table 3 reports the operationalization of proximity dimensions used in the analysis.

The operationalization of proximity variables based on the perception of the actors comes with some drawbacks. The statements may have resonated differently in the minds of the respondents. Furthermore, we are not able to distinguish between whether proximity is absent, or whether it is present but the respondents consider it unimportant for the decision to interact. For instance, firms may not have organizational proximity since they are not part of any joint organizational structures with universities. Or, they might be part of such structures, but deem organizational proximity unimportant. Overall, we consider this to be a benefit, as studies relying on objective measures draw conclusions about the role of proximity without knowing whether the partners consider these aspects to be important or not.

In order to address this limitation, we assess the extent to which partners that are proximate using objective criteria also consider proximity to be important for the formation of the relationship. Table A3 in the Appendix compares—for each dimension on which objective data are available—the share of proximate and distant firms that consider proximity to be important. For cognitive proximity, we distinguish between firms with above (cognitively proximate) and below (cognitively distant) average shares of staff with tertiary education. Social proximity was measured as the length of interactions. Firms who have collaborated with universities longer than three years have been categorized to have high social proximity, whereas more recent collaborators have low social proximity. Finally, we distinguish between regional and extra-regional interactions in order to account for geographical proximity. For institutional and organizational proximity, no data was available to measure the proximity between partners using objective criteria. The results show that 83% of geographically proximate partners consider geographical proximity to be important for the decision to interact, compared to 27% of geographically distant partners. Similarly, 80% of socially proximate partners consider social proximity to be important, compared to 35% of socially distant partners. These differences are statistically significant. For cognitive proximity, 81% of proximate partners consider proximity to be important, compared to 72% of distant partners. This difference is not statistically significant.

4 | RESULTS

Table 4 describes the total number of interactions and the share of firms using each UIC type. Competence enhancement interactions are the most frequently used. More than 90% of firms that interact with universities use at least one type of competence enhancement interaction. Student projects are the most common interaction type in this category. Two of three firms (64.66%) have engaged with universities through student projects. As an individual channel, informal consultations are the most widely used channel between Norwegian firms and universities. Almost three out of four enterprises that interact with universities (72.84%) use informal consultations. Despite the focus on patents and spin-offs in UIC research and policy, these two channels are the least realized interactions, with 7.33% and 10.78% of firms involved, respectively.

If we look exclusively at the interaction considered most important by the firm, competence enhancement interactions remain the most frequent type. They are followed by knowledge exploration interactions (Table 4). However, when we look at individual channels within each type, joint research projects lead the list. They represent approximately 20% of the interactions considered most important. Knowledge exploitation interactions are rarely the most important type of UIC. Only nine firms have indicated that commercial exploitation of knowledge represents the core of their interaction with universities. Most of the interactions in this category occur via the use of university infrastructures.

Table 5 presents an overview of the universities with which firms interact. The Norwegian University of Science and Technology (NTNU) is, by far, the most frequent university partner for Norwegian firms. Almost 30% of firms

TABLE 4 Total number of interactions and percentage of firms using each UIC type

| Type of interaction	All interactions (multiple answers allowed)		Most important interaction (one answer only)	
	Number of firms	Share of firms (%)	Number of firms	Share of firms (%)
Knowledge exploration interactions	216	52.59	58	
Consultancy/Contract research	62	22.84	15	6.79
Joint research projects	154	46.55	43	19.46
Knowledge exploitation interactions	164	37.50	9	
Purchase of university patent, license or other IPR	18	7.33	1	0.45
Use of universities' facilities, laboratories, equipment etc.	82	28.88	6	2.71
Creation/funding of Research Centres/Incubators/ Research, Science and Technology Parks	33	13.36	1	0.45
Creation of new ventures/firms (Spin-offs, start-ups)	31	10.78	1	0.45
Competence enhancement interactions	741	90.52	105	
Joint PhD supervision/Industrial PhDs	62	25.00	4	1.81
Temporary staff exchanges for research purposes	30	12.50	1	0.45
Training of firm staff/employees	87	31.03	9	4.07
Student internships/apprenticeships	121	46.98	18	8.14
Student projects	174	64.66	39	17.65
Guest lecturing at universities	131	44.83	15	6.79
Recruitment of graduates based on a contract/referral	87	33.19	13	5.88
Co-development and co-delivery of curriculum	49	19.83	6	2.71
Advice-seeking interactions	215	71.55	17	
Informal consultations	215	72.84	17	7.69
Marketing interactions	176	59.05	32	
Sponsorship, scholarships, fellowships provided to university	55	20.69	2	0.90
Joint organization of events	92	33.19	4	1.81
Other interactions	29	34.91	26	11.76

have identified NTNU as their most significant university partner. The dominance of NTNU is not surprising when its position in the Norwegian university landscape is considered. The university has a long history of interaction with industry (Gulbrandsen & Langfeldt, 2004) given its leadership in technology-related fields (Gulbrandsen & Nerdrum, 2007). The majority of interactions with NTNU occur in the form of joint or contract research projects, while slightly fewer are related to competence enhancement. Norwegian firms collaborate heavily with NTNU for knowledge exploration, which illustrates that NTNU acts as a magnet that attracts the attention of Norwegian firms for research collaboration. More than 40% of knowledge exploration interactions of Norwegian firms happen with NTNU. The Norwegian University of Life Sciences (NMBU) in Akershus and the University of Agder follow NTNU in terms of the number of interactions. The other regional universities in Bergen, Stavanger, Tromsø, Bodø (Nord) and Oslo follow closely, along with BI and HVL, all with 10–15 interactions. Foreign universities are rarely the most crucial partners for Norwegian firms. Only six firms have identified their most significant university partner as located in another country.

**TABLE 5** The most interacted universities by UIC category

	Total	Knowledge exploration interactions	Knowledge exploitation interactions	Competence enhancement interactions	Advice-seeking interactions	Marketing interactions
Norw Univ of Science and Technology	64	41.4	44.4	21.9	29.4	25.0
Norwegian University of Life Sciences	18	8.6	22.2	6.7	17.6	3.1
University of Agder	18	1.7	22.2	8.6	11.8	12.5
University of Bergen	15	8.6	0.0	5.7	5.9	9.4
University of Stavanger	15	3.4	0.0	7.6	11.8	9.4
University of Tromsø	14	6.9	11.1	4.8	0.0	12.5
Nord University	13	6.9	0.0	5.7	0.0	9.4
BI Norwegian Business School	10	5.2	0.0	6.7	0.0	0.0
Western Norway Univ Applied Sciences	10	0.0	0.0	9.5	0.0	0.0
University of Oslo	10	5.2	0.0	2.9	11.8	6.3
Foreign universities	6	5.2	0.0	1.9	5.9	0.0
Other universities	28	6.9	0.0	18.1	5.9	12.5
Total	221	58	9	105	17	32

4.1 | Geographical distribution of UICs

In order to measure the spatial distribution of UICs in terms of the location of university partners, the firms were asked to list all the possible types of UICs they have utilized across four geographical scales, namely *regional*, *national*, *European* and *outside Europe*. As very few firms reported collaboration with universities outside Europe, we combined these answers with the *European* category and labelled them as *international* at the analysis stage. Figure 1 reports the university partners' location for all UICs. Most of the interactions, regardless of the UIC type, occur with universities in the region where the firm is located. Alongside the dominance of regional collaborations for all kinds of interaction types, the distribution across different geographical scales remains more or less the same for many of the interaction categories. The exception is knowledge exploration interactions, which have a different profile. The share of international collaborations for knowledge exploration purposes is much higher than for any other UIC category. Exploratory interactions with foreign universities account for more than 25% of the total interactions in this category, while the share is less than 10% for all other UIC types.
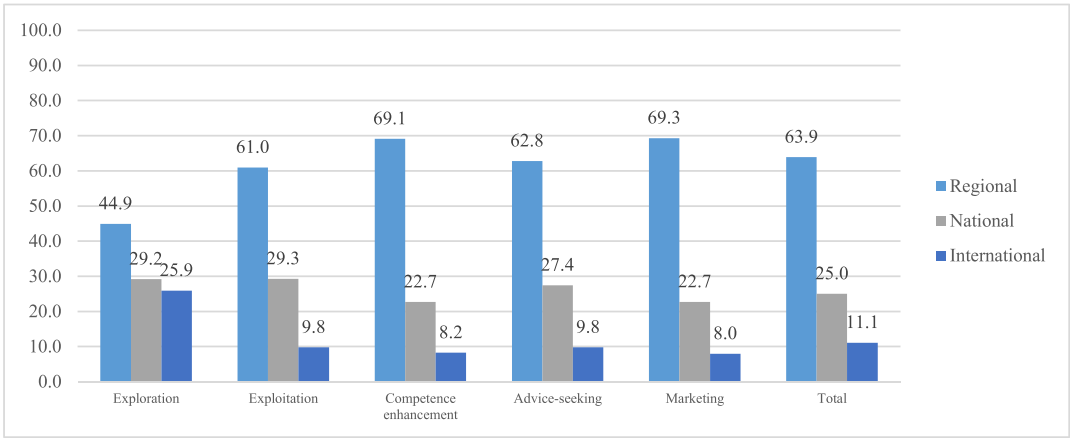
FIGURE 1 Distribution of all UICs across geographical scales
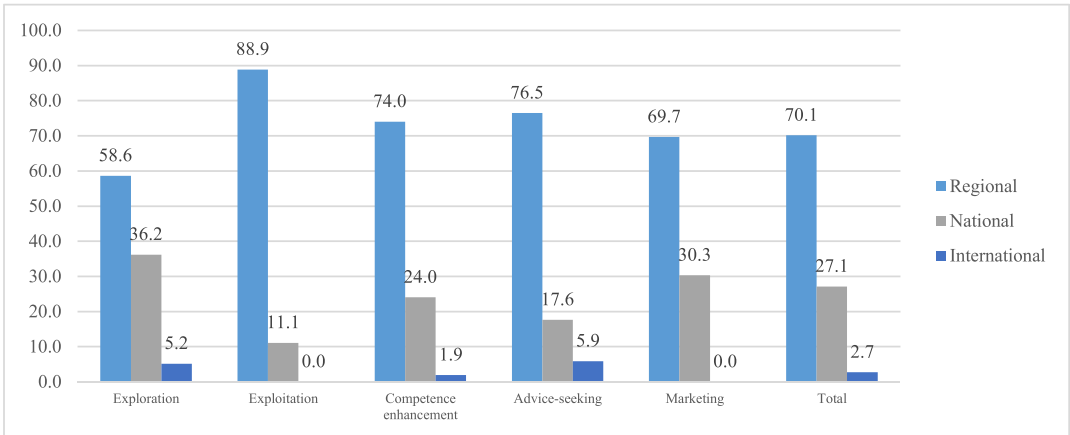
FIGURE 2 Distribution of most important UICs across geographical scales

In Figure 2, firms were asked which university they consider to be their most important partner, and what was the most important type of interaction with this university. The interactions with regional universities have the largest share once again. For all UIC categories, the regional level represents the modal scale. Seven out of ten interactions arise between universities and firms in the same region. Interactions at the international scale are less visible in this classification. None of the businesses that were dominantly involved in knowledge exploitation and marketing interactions indicated that their most significant university partner is foreign.

4.2 | Importance of proximity dimensions

As the previous section illustrates, most of the interactions between universities and firms occur in close geographical proximity. But how important do firms consider different dimensions of proximity to be when initiating interactions with universities? This question is addressed in Table 6, which shows the mean responses for each

TABLE 6 Mean values of proximity dimensions and share of firms by UIC categories

UIC Category		Cognitive proximity	Organizational proximity	Institutional proximity	Social proximity	Geographical proximity
All interactions	Mean	3.09	1.89	2.97	2.81	2.84
	Important (%)	77.3	27.6	73.8	67.0	66.8
Knowledge exploration interactions	Mean	3.32	2.00	3.20	2.93	2.72
	Important (%)	80.6	30.5	83.1	70.5	62.3
Knowledge exploitation interactions	Mean	2.89	2.11	2.75	3.33	3.33
	Important (%)	77.8	33.3	50.0	77.8	77.8
Competence enhancement interactions	Mean	3.00	1.95	2.91	2.77	2.90
	Important (%)	76.0	31.8	73.4	68.1	70.4
Advice-seeking interactions	Mean	3.07	1.21	2.40	2.33	3.07
	Important (%)	71.4	0.0	53.3	46.7	73.3
Marketing interactions	Mean	2.85	1.80	2.96	2.81	2.63
	Important (%)	73.1	24.0	73.1	65.4	59.3

Note: Important (%) denotes share of firms considering proximity to be very or fairly important in the decision to collaborate with this university.

proximity dimension by the UIC categories. Table 6 also includes the share of firms which indicated that these dimensions were either very or fairly important in their decision to interact with their most significant university partner.

In overall terms, proximity is considered to be important for UICs from the perspective of firms. For four of the five dimensions, more than two-thirds of the firms find proximity to be important for their decision to interact. The exception is organizational proximity. Only 27.6% of the firms report that organizational proximity was important in their choice of the most important university partner. This reflects that a low percentage of firms were collaborating with universities through formal organizational structures. Conversely, the highest share of firms (77.3%) report that cognitive proximity was important for their decision to interact with their most important university partner. Almost three out of four firms (73.8%) report that institutional proximity was influential in their decision. Social proximity and geographical proximity also play a decisive role in the UICs for two-thirds of the firms (67.0% and 66.8% respectively).

Despite the overall tendency to rate proximities important, some nuances can be found across the different UIC categories. The weight attached to proximity dimensions by firms varies by UIC types. Cognitive proximity is most important for knowledge exploration interactions (mean of 3.32) and least important for marketing interactions (2.85), in line with the predictions in Table 1. Organizational proximity is most important for knowledge exploitation (2.11) and least important for advice-seeking interactions (1.21), also in line with Table 1. However, even for knowledge exploitation, the share of firms reporting that organizational proximity is important is only 33.3%. Institutional proximity is considered most important by firms involved in knowledge exploration interactions (3.20), and least important for advice-seeking (2.40). Social proximity is most important for knowledge exploitation (3.33) and least important for advice-seeking (2.33). Geographical proximity is also most important for knowledge exploitation (3.33), and least important for marketing interactions (2.63).

TABLE 7 Multinomial logit model results for proximity

	Knowledge exploration	Knowledge exploitation	Advice-seeking	Marketing
Cognitive proximity	0.458** (0.221)	−0.393 (0.394)	0.185 (0.322)	−0.104 (0.243)
Organizational proximity	−0.104 (0.176)	0.387 (0.398)	−0.915** (0.441)	−0.134 (0.239)
Institutional proximity	0.359* (0.191)	−0.220 (0.368)	−0.351 (0.259)	0.224 (0.237)
Social proximity	0.188 (0.180)	0.780* (0.461)	−0.422 (0.282)	0.308 (0.231)
Geographical proximity	−0.269* (0.159)	0.297 (0.399)	0.367 (0.277)	−0.314 (0.205)
Log of no. of employees	0.049 (0.135)	−1.033** (0.433)	−0.068 (0.242)	−0.217 (0.179)
Log % of tertiary education	−0.190 (0.172)	−0.142 (0.330)	−0.150 (0.244)	−0.492*** (0.182)
Constant	−2.072* (1.165)	−1.649 (2.168)	0.811 (1.728)	1.079 (1.249)
Pseudo R2	0.0899			
Log likelihood	−262.55456			
Observations (N)	220			

Notes:
*p < 0.10, **p < 0.05, ***p < 0.01; Standard errors in parentheses.

We further test more formally whether the perceived significance of proximity dimensions for the decision to interact varies across UIC types using a multinomial logit regression model. The model takes the following form:

$$\Pr(UIC_i = k) = \alpha_k + \beta_{1,k}\textbf{\textit{Proximity}}_i + \beta_{2,k}\textbf{\textit{Controls}}_i + \varepsilon_i. \tag{1}$$

In the model, *k* refers to the different types of UIC: *knowledge exploration*; *knowledge exploitation*; *competence enhancement*; *advice-seeking*; and *marketing*. The reference category for the model is *competence enhancement* interactions.

The independent variables of interest are the five dimensions of proximity, that is, cognitive, organizational, institutional, social and geographical proximity. We used mean substitution for missing values and don't knows in order to avoid bias from listwise deletion. As a robustness check, we have also estimated the models using multiple imputation, and with listwise deletion (see Appendix, Tables A1 and A2). Both approaches give results consistent with those reported here.

We also include a vector of control variables. These include the log number of full-time employees and the log share of employees holding a university degree.[2]

Table 7 shows the results for the estimation. While the explained variance of the model is relatively low, there are some notable differences in the importance of proximities across UIC types. Firms that engage in knowledge exploration interactions attribute more importance to cognitive proximity than firms interacting for competence enhancement or for knowledge exploitation purposes. This is the only category with a significant positive coefficient for cognitive proximity, although the coefficient is also positive, but not significant for advice-seeking interactions. Firms asking for informal advice from universities rely less on organizational proximity compared to firms with competence enhancement or knowledge exploitation interactions. Institutional proximity is more important for

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[2]We have tried introducing additional control variables, such as industry and regional fixed effects, and R&D expenditure. However, the limited degrees of freedom reduce the number of additional variables that can be introduced without rendering the model subject to multicollinearity. We therefore prefer to keep the model simple with a few key control variables. For R&D expenditure, several units have missing values and the correlation with the two other control variables is fairly high. However, we ran the multiple imputation model with R&D expenditures as an additional control and the results were consistent with the main findings.

TABLE 8 Confirmation of relative importance of proximity dimensions for UIC categories

UIC Type	Geographical proximity	Cognitive proximity	Organizational proximity	Institutional proximity	Social proximity
Knowledge exploration interactions	Less important CONFIRMED	More important CONFIRMED		POSITIVE	Less important
Knowledge exploitation interactions			More important	More important	More important CONFIRMED
Competence enhancement interactions	BASELINE	BASELINE	BASELINE	BASELINE	BASELINE
Advice-seeking interactions	More important		Less important CONFIRMED		
Marketing interactions		Less important		Less important	

knowledge exploration interactions than for any other types of UIC (except for marketing interactions, where the difference is not significant). Social proximity is more important for knowledge exploitation than for competence enhancement or advice-seeking UICs. The only statistically significant coefficient for geographical proximity is for knowledge exploration interactions. Firms engaging in joint knowledge exploration collaborations attribute less importance to geographical proximity than firms in any other category (except for marketing interactions). For the control variables, firm size has a significant and negative coefficient for knowledge exploitation interactions, implying that firms engaged in this category of UICs tend to be smaller than firms with competence enhancement interactions. The other control variable—the share of employees with a higher education degree—has a negative and significant coefficient for marketing interactions, meaning that in comparison to firms with competence enhancement interactions, these firms tend to have a lower share of university graduates in their workforce.

These results indicate that proximity dimensions matter differently for various types of UICs. In Table 8, we compare these results to predictions derived from Table 1, where we indicated the expected importance of proximity dimensions for each UIC category. The results confirm the lower importance of geographical proximity and the higher importance of cognitive proximity for knowledge exploration interactions. Institutional proximity is also more important for knowledge exploration interactions. The results also confirm that organizational proximity is less important for advice-seeking interactions compared to knowledge exploitation interactions. In addition, the results confirm that social proximity is more important for knowledge exploitation interactions than for competence enhancement interactions.

5 | DISCUSSION AND CONCLUSIONS

This paper has examined the geographical distribution of the interactions between firms and universities and the influence of five proximity dimensions in shaping the decisions of firms to collaborate with universities in different types of UICs. The empirical data was gathered through a survey of firms' interaction with universities with a focus on their perception of the importance of proximity for the decision to interact with their most important university partner. The study examines how the importance of different types of proximity varies across UIC categories.

The contributions of the study are threefold. The first contribution is to provide large-scale empirical evidence on the use of a multitude of UIC types. The findings indicate that around 20% of the surveyed Norwegian firms interact with universities across different UIC types. Competence enhancement, knowledge exploration and advice-seeking interactions constitute the most prevalent channels of UICs in Norway. Conversely, knowledge exploitation

UICs are not very common among Norwegian firms and universities. The paper also considers the geography of different types of UICs. Regional interactions outweigh interactions at other geographical scales for all UICs, although their share fluctuates by UIC categories. Hence, geographical proximity is important for UIC formation.

However, non-geographical dimensions of proximity also matter. The second contribution of the paper is therefore to assess the importance of proximity for UICs from the perspective of industrial actors by directly asking how important proximity to their university partners was for the decision to interact. While previous studies have used remote proxies to account for proximity dimensions (Garcia et al., 2018; Petruzzelli, 2011), this study considers that how proximity is perceived and handled by the actors themselves is important for the decision-making process (Fitjar et al., 2016). With this approach, we assess the importance of proximity dimensions for the decision to interact with the most important university partner from the firms' perspective. The results illustrate the importance of several proximity dimensions for UICs. A large share of firms considers cognitive, institutional, social and geographical proximity as important for their decisions to interact with a university. However, organizational proximity, that is being part of the same organizational arrangements with universities, is considered less important. This does not mean that the influence of proximity is pre-determined, static and fixed. On the contrary, several studies have begun to assert that the actors may become more proximate in various dimensions in the course of interactions suggesting that proximities involve dynamic and evolutionary characteristics (Balland, Boschma, & Frenken, 2015; Broekel, 2015; Menzel, 2015). Specifically, the collaboration process can help in the development of proximity dimensions. For instance, UICs may lead to higher social proximity indicated by increased trust between collaborating partners (Hewitt-Dundas et al., 2019). This dynamic relationship between proximity dimensions and interaction processes creates possible endogeneity or circularity issues that need to be considered in future studies.

The third and most important contribution of the study is to extend the understanding of proximity dimensions for UICs by comparing their importance for different types of UICs. Although earlier studies have pointed out that proximity facilitates interactions between firms and universities (D'Este et al., 2013; Ponds et al., 2010), they have treated UICs as a homogenous group of activities, largely ignoring their different targets and characteristics (Gertner et al., 2011; Ramos-Vielba et al., 2010). This study, however, shows that the importance of proximity dimensions varies across different UIC channels. Although proximity facilitates UICs in overall terms, the impact of proximity dimensions differs by the type of interaction. Knowledge exploration collaborations tend to occur with universities at further spatial distances. Conversely, cognitive and institutional proximity are more important in these types of interactions. Social proximity—that is having previous interactions with a particular university—is particularly important when forming knowledge exploitation interactions. This finding reflects the ease of co-ordination between partners who know and trust each other, which is particularly important for the commercial exploitation of knowledge. Finally, firms consider organizational proximity less important when they seek informal advice from universities.

Several policy and managerial implications can be derived from this study. First, we show that UICs comprise a large range of activities. The majority of interactions occurs in the form of competence enhancement interactions, whereas knowledge exploitation is less prevalent. Therefore, policy-makers aiming to increase the levels of interaction between firms and universities should develop overarching and inclusive policies that take into account the variety of UIC channels. Second, the results illustrate the dominance of regional UICs. In this regard, universities, especially university managers and individual academics, should be aware of the breadth of ways in which they can contribute to the growth and development of firms in their regions and attempt to deepen their expertise aligned with the priorities of the industries around them. Third, we show that several distances exist between firms and universities. Policies for the mitigation of these distances should be developed that can support effective knowledge transfer in UICs. For example, firms need absorptive capacity to understand and utilize knowledge stemming from universities, which would increase cognitive proximity. This can be achieved by more effective mobility schemes that would allow short term staff exchanges between organizations. Institutional proximity may be increased by taking policy measures that would allow some flexibility in the regulations and norms that govern the institutional spheres of universities and firms. Social proximity can be enhanced by programmes and schemes for small-scale projects that would create the initial contact and provide the impetus for the initiation of interactions between firms and universities.

Finally, the findings indicate that various dimensions of proximity affect UICs differently depending on the purpose of the interactions. Thus, universities need to prioritize the development of proximities that are important for the type of UICs that they want to develop. Similarly, firms that would like to engage in UICs need to develop specific capabilities with regards to proximity dimensions. For instance, firms that are eager to collaborate with universities for knowledge exploration purposes can invest in increasing their cognitive capacities. The need for higher social proximity, proxied by previous collaborations, for knowledge exploitation UICs means that firms need to be patient to invest in their relationships and have longer time horizons when forming this type of relationships. The firms that seek informal advice from universities do not need to invest in developing their organizational proximity to universities by creating joint organizational structures, but can deploy their resources elsewhere such as creating linkages at the personal level.

The findings carry some limitations that need to be acknowledged. First, we only have data on objective proximity for some dimensions. Thus, we do not know whether negative answers mean that the collaboration involves distant partners or whether this reflects a proximate relationship for which proximity is not perceived as important. Future studies could combine objective measures for proximity with perceptional measures to address this. The second limitation of the study is the potential for non-response. Since the analysis uses data of firms who collaborated with universities, we furthermore do not have data on non-collaborators. Therefore, a study that includes the perception of firms that do not have any collaborations with universities can provide valuable insights about the importance of proximity in eliminating distance barriers in UICs. Third, since various dimensions of proximity are interdependent and interrelated, geographical and non-geographical dimensions of proximity may either overlap or substitute each other (Hansen, 2015; Huber, 2012). Hence, future studies may want to look at the interrelationship between different types of proximity. Finally, we investigated the role of proximity for the formation of UICs rather than for the functioning of UICs. However, proximity not only facilitates the establishment of linkages between actors in the first place, but also contributes to effective interactions. Further research on the significance of proximity dimensions in overcoming operational problems in UICs would enlighten the discussions on this topic.

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APPENDIX: ROBUSTNESS CHECK RESULTS A

TABLE A1 Multinomial logit results without mean replacement

	Knowledge exploration	Knowledge exploitation	Advice-seeking	Marketing
Cognitive proximity	0.536** (0.232)	−0.342 (0.413)	0.508 (0.375)	−0.016 (0.271)
Organizational proximity	−0.130 (0.186)	0.572 (0.423)	−0.991** (0.550)	−0.011 (0.250)
Institutional proximity	0.282* (0.202)	−0.232 (0.386)	−0.644** (0.302)	0.057 (0.253)
Social proximity	0.050 (0.192)	1.378** (0.689)	−0.546 (0.338)	0.183 (0.256)
Geographical proximity	−0.286* (0.170)	0.043 (0.397)	0.307 (0.310)	−0.353 (0.223)
Log of no. of employees	0.073 (0.151)	−1.033** (0.498)	0.071 (0.290)	−0.157 (0.200)
Log % of tertiary education	−0.026 (0.184)	−0.272 (0.378)	−0.005 (0.282)	−0.239 (0.204)
Constant	−2.175* (1.219)	−2.920 (2.470)	0.116 (1.994)	0.390 (1.319)

Pseudo R2	0.1014
Log likelihood	−211.2423
Observations (N)	179

Notes:
*p < 0.10, **p < 0.05, ***p < 0.01; Standard errors in parentheses.

TABLE A2 Multinomial logit results with multiple imputation method (proximities are imputed)

	Knowledge exploration	Knowledge exploitation	Advice-seeking	Marketing
Cognitive proximity	0.431** (0.218)	−0.406 (0.388)	0.139 (0.361)	−0.106 (0.248)
Organizational proximity	−0.100 (0.174)	0.363 (0.389)	−0.696 (0.430)	−0.176 (0.244)
Institutional proximity	0.369* (0.192)	−0.155 (0.386)	−0.308 (0.274)	0.178 (0.230)
Social proximity	0.159 (0.179)	0.703 (0.439)	−0.423 (0.302)	0.188 (0.240)
Geographical proximity	−0.272* (0.157)	0.261 (0.386)	0.369 (0.311)	−0.283 (0.203)
Log of no. of employees	0.044 (0.139)	−1.023** (0.429)	−0.093 (0.247)	−0.202 (0.182)
Log % of tertiary education	−0.185 (0.174)	−0.147 (0.331)	−0.126 (0.249)	−0.466** (0.183)
Constant	−1.955* (1.166)	−1.403 (2.116)	0.430 (1.810)	1.397 (1.243)

Imputations	20
Observations (N)	220

Notes:
*p < 0.10, **p < 0.05, ***p < 0.01; Standard errors in parentheses.

TABLE A3 Share of firms that find different dimensions of proximity important based on objective measurement of proximities

	Firms with high human capital	Firms with low human capital	All firms
Cognitive proximity	81.4%	72.4%	77.3%
	Previous collaborators	New collaborators	All firms
Social proximity***	80.0%	34.8%	73.8%
	Regional collaborators	Extra-regional collaborators	All firms
Geographical proximity***	83.1%	26.7%	66.8%

Note:

***Significant at 1%.