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Proximity and Performance in University-Industry Research Collaboration Projects: Evidence from Thailand

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Abstract. This study investigates the impact of geographical, cognitive, and social proximities on the success of university-industry research collaboration (UIRC) projects. The success of UIRC projects is evaluated by firms' innovative performance regarding whether UIRC leads to innovations that firms can effectively utilize for commercial purposes. The empirical analysis is based on data collected from 153 firms engaged in research collaborations with universities and receiving financial support through the Research and Researchers for Industry (RRI) program, a public research granting initiative in Thailand aimed at enhancing firms' innovativeness through collaborations with universities. The results from ordinal regression analysis reveal that geographical and cognitive proximities improve firms' innovation performance, suggesting that physical proximity and shared knowledge and expertise contribute to the favorable outcomes of UIRC projects. However, our findings do not indicate a significant impact of social proximity on firms' innovations, suggesting that relational aspects alone may not be sufficient for driving successful collaborations. These findings shed light on the importance of geographical and cognitive proximities in fostering successful UIRC projects and their subsequent impact on firm innovation. The outcomes provide valuable insights for policymakers, industry practitioners, and researchers seeking to optimize university-industry collaborations and leverage the benefits of geographical and cognitive proximity. Future studies could further explore additional factors that may mediate or moderate the relationship between proximities and UIRC project success, enhancing our understanding of effective collaboration strategies in the context of university-industry research partnerships.

Keywords: University-industry research collaboration; Geographical proximity; Cognitive proximity; Social proximity; Innovation

1. Introduction

University-industry linkages (UILs) are an essential component of innovation systems from academic and policy perspectives. UILs can take many forms and have different institutional arrangements. University-industry research collaboration (hereafter, UIRC) is a formal UIL arrangement between firms and universities aiming to cooperate on research and development (R&D) activities. It is expected to facilitate knowledge exchange and interactive learning between the two organizations (Perkmann & West, 2014). Arguably, UIRC can benefit both firms and universities. For firms, establishing research collaboration with universities is the way to access basic scientific knowledge and highly advanced technologies, enabling firms to introduce radically new products or novel technologies that are more efficient than the existing ones. For universities, collaborative research with industrial partners enhances the applicability of their research works and increases the funding to support their research activities (D'Este & Patel, 2007; Perkmann & Walsh, 2007). Moreover, the interactions between these two core components of the innovation system can promote knowledge creation, dissemination, and utilization, which is crucial for sustaining the innovativeness and competitiveness of the national economy (Etzkowitz & Leydesdorff, 2000).

UICR has been examined from various perspectives (Sjöö & Hellström, 2019). Among others, the proximity perspective has prominently contributed conceptual insights and empirical evidence into the determinants and effects of UICR (Balland et al., 2015; D'Este et al., 2013). The proximity perspective has emerged as a conceptual framework to analyze knowledge networks and cooperation for innovations. Proximity refers to the closeness or similarity between two (or more) organizations in various aspects (i.e., geographical, social, cognitive, organizational, and institutional) (Boschma, 2005). The last two decades have witnessed an increasing number of studies employing the proximity concept to examine research collaboration between firms and universities (e.g., Hong & Su, 2013; Laursen et al., 2011; Santos et al., 2021). It is argued that proximity is vital in fostering effective collaboration between firms and universities. For instance, geographical proximity between firms and universities facilitates face-to-face interactions between the two organizations, thus promoting knowledge transfer (Breschi & Lissoni, 2001). Cognitive proximity increases the effectiveness of knowledge transmission as two organizations share a common understanding of technologies and are interested in the same research issues (Nooteboom, 2000; O'Connor et al., 2020). Social proximity strengthens trust-based relationships, reduces transaction costs, and promotes efficient knowledge transfer (Boschma, 2005; Maurer, 2010).

Despite a richness of studies examining the relationship between proximity and UICR, there are still some notable gaps in this literature. First, most studies focus on the cause of proximity on UICR but less on its effect on firms' innovation under the UICR arrangement. Specifically, they mainly focus on how proximity explains the formation of UIRC. However, less attention is paid to how proximity affects the outcomes of UIRC projects, especially in terms of firms' innovation performance. Second, most studies examine the relationship between proximity and UILs in developed countries, but less is done in developing countries (Garcia et al., 2018; Ratchukool & Igel, 2018). As developing countries differ fundamentally from developed countries, especially regarding institutional settings, market structure, and firms' technological capability, UIRC in developing countries may vary considerably from developed countries (Garcia et al., 2018). Therefore, it is relevant to investigate how proximity may affect the innovation outcomes of UIRC in developing countries.

This study aims to fill the literature gaps in two ways. First, we apply the proximity concept to analyze the impacts of various forms of proximity on the innovation performance of firms collaborating on research and development with university partners. We focus on three aspects of proximity – geographical, cognitive, and social – and investigate whether these proximities enhance the innovativeness of firms that established research and development cooperation with universities. The main research question is: *Does geographical, cognitive, and social proximity strengthen the innovation of firms collaborating on research and development with universities?*

Second, we also contribute to filling the gap in the proximity and UICR literature focusing on UIRC in the context of a developing country – Thailand. The case of UIRC in Thailand is relevant, as its national innovation system is often perceived to be weak and fragmented (Intarakumnerd et al., 2002), leading to the ineffectiveness of UIRC projects in general (Brimble & Doner, 2007; Intarakumnerd & Schiller, 2009). Extant studies on UICR in Thailand show that the success of UIRC projects is still limited (Doner et al., 2013; Intarakumnerd & Schiller, 2009; Tippakoon, 2018). However, these studies focus on the overall performance of UIRC, not specifically on firms' innovation. Moreover, these studies do not apply the concept of proximity to the success of firms' innovation under the UIRC arrangement. Therefore, little is known to what extent proximity is vital for UIRC's success in enhancing firms' innovation.

This study focuses on the UIRC subsidized by the Research and Researchers for Industries (RRI) Program. The RRI has been carried out by The Thailand Research Fund (TRF), the largest governmental research granting agency. RRI aims to solve technical problems and develop new/improved products for firms using universities' expertise. This program differs from other publicly funded UIRC programs focusing on pre-competitive research where commercialization is not a primary goal (Perkmann & West, 2014). Therefore, the RRI provides relevant cases to examine UIRC's innovation performance. In this study, we assess the innovation performance from a firm's perspective by looking at the outcomes of UIRC regarding whether it produces product/process innovations for firms and whether firms exploit product/process innovations for the commercial end.

It is worth noting that we omit the institutional and organizational proximities as independent variables in our analysis. This is because universities and firms are embedded in different institutional settings and have different organizational routines (Okamuro & Nishimura, 2013). We believe that investigating the impact of geographical, cognitive, and social proximity in the context of URIC is vital, as it allows us to see what proximity significantly affects the outcomes of research collaboration between two actors that differ institutionally and organizationally. We acknowledge the limitation that our data come from the RRI program only. Though this program is open for firms with various characteristics to participate, the data cannot represent all UIRC programs in Thailand.

The rest of this paper proceeds as follows. Section 2 provides a conceptual background of UIRC and discusses how geographical, cognitive, and social proximity may affect research cooperation. Section 3 provides brief information on the context of Thailand's innovation system and UIRC. Section 4 discusses data, variables, and analytical methods. Section 5 presents the analysis results, and Section 6 discusses the results. Finally, we provide the conclusion, implications, and limitations in Section 7.

2. Literature Review

2.1. Some nature of research collaboration between firms and universities

Firms can source knowledge from universities through various linkages, each requiring different organizational arrangements and degrees of engagement. Research collaboration is one mechanism through which firms can access basic scientific knowledge, advanced technologies, and expertise available at the university. It differs from other kinds of university-industry linkages in that it is a formal collaborative arrangement aiming to cooperate on research and development activities (Perkmann & Walsh, 2007, p.268). Research collaboration often involves the sharing of resources between firms and universities. Its advantage over other linkages rests on partners' ability to exploit the complementarity of valuable resources possessed by other partners (Poyago-Theotoky et al., 2002). Therefore, it is expected to enhance the innovation performance of both firms and universities (Mascarenhas et al., 2018).

Establishing research collaboration is not easy, and in general, firms use this mode less frequently when sourcing knowledge from universities (Poyago-Theotoky et al., 2002). Some barriers thwart establishing UIRC or push it away from success. First, universities and firms are embedded in different institutional settings that can lead to conflicts in attitudes, interests, and goals. Universities are governed by the institutional norm of open science in which academics' research progress is generally evaluated by their academic contribution based on a peer review system. Under this norm, academics are likely to focus on basic research and are less interested in applied works for industrial usage. They tend to publish research findings as early as original discoveries are attained.

Conversely, industrial firms often respond to market incentives. Their competitive advantage rests on the appropriability of the economic value of their knowledge. Hence, they are less prone to public disclosure of core technology. When they perform research activities, they tend to focus on practical problems or develop products that appeal to market demands (Bruneel et al., 2010).

Second, advanced technological knowledge is characterized by knowledge ambiguity, which arises from the tacit nature, complexity, and limited possibility for knowledge specification. This nature makes knowledge transfer difficult, as knowledge components are hard to identify and comprehend by the cooperating partners (Balconi, 2002; Cujba & Filip, 2022). Universities and firms must have a joint knowledge base to resolve the ambiguity. Without this, knowledge transfer may not be possible, and UIRC may fail to produce innovative outcomes (De Wit-de Vries, 2019).

Third, some potential conflict may arise over intellectual property (IP) issues, undermining UIRC. As a general trend over the past four decades, universities have increasingly been interested in patenting and administering their IPs. This is partly explained by introducing the regulatory framework that encourages universities to engage in entrepreneurial activities in many countries following the Bayh-Dole Act 1980. Conflicts over IP issues are explained as an outcome of universities increasingly attempting to capture economic benefits or overvaluing their IPs (Bruneel et al., 2010).

In sum, for UIRC to produce innovative outcomes, it must overcome various barriers. This study presumes that geographical, cognitive, and social proximities reduce disparities between firms and universities, leading to success in research collaboration. The following section discusses the roles of geographical, cognitive, and social proximities in strengthening cooperation and innovation.

2.2.1. Geographical proximity

Geographical proximity matters to the success of research collaboration in some ways. First, a significant part of technical knowledge is tacit, meaning that it is embedded in an actor who possesses it and is difficult (if not possible) to codify. To efficiently transfer this knowledge, actors need intensive face-to-face interaction, and geographical proximity increases the chance of such interaction (Breschi & Lissoni, 2001). Not only does geographical proximity matter for the exchange of tacit knowledge, but it is also necessary to transmit codified knowledge, as its interpretation and assimilation require tacit knowledge and geographical closeness (Howells, 2002). Second, research collaboration involves exchanging complex technological knowledge subject to high uncertainty, information asymmetry, and opportunistic behavior (Veugelers & Cassiman, 2005). Geographical proximity can attenuate these problems by easing the monitoring and execution of contracts and reducing the transaction costs involved in knowledge exchange (Landry & Amara, 1998).

Many scholars argue that geographical proximity is a vital determinant of the innovative performance of university-industry collaboration. For instance, Mahdad et al. (2020) illustrate the role of geographical proximity as an enabler of social, cognitive, organizational, and institutional proximities. Being geographically close to each other increases the frequency of interactions, reduces cultural gaps, triggers trust and mutual understanding, and enhances the learning ability of partners. Mowery & Ziedonis (2015) show that the effect of geographical proximity to academic inventors is pronounced because information on licensed inventions is often incomplete, forcing firms to maintain contact with inventors to access their know-how. Crescenzi et al. (2017) observe that geographical proximity is essential in fostering collaboration and is a substitute for the institutional dissimilarities between firms and universities.

Therefore, we can expect that when firms and universities are geographically proximate, their research collaboration can lead to success regarding firms' innovative outcomes, as geographical proximity increases the frequency of face-to-face interactions and tacit knowledge transfer. We hence propose the following hypothesis for the empirical test.

Hypothesis 1: Geographical proximity enhances firms' innovation performance under the UIRC arrangement.

2.2.2. Cognitive proximity

Cognitive proximity is the closeness between two or more organizations in the cognitive space. It denotes the similarity in the knowledge base, technological know-how, and how they interpret information (Boshma, 2005). It is argued that the transmission of knowledge between organizations with an overlapping knowledge base and technical expertise can occur more quickly than between those with a differential knowledge base (Balland et al., 2015). Cognitive proximity can lead to effective knowledge transfer that results in innovations because actors need a similar frame of reference to reduce misunderstandings and information loss in knowledge exchanges (Nooteboom, 2000).

According to Knoben & Oerlemans (2006), the concept of cognitive proximity may constitute two vital components – absorptive capacity and compatibility of knowledgebases. Absorptive capacity involves an organization's ability to identify, assimilate, and utilize relevant knowledge from external sources. The second component refers to the compatibility of knowledge bases between organizations. For the success of knowledge transmission, firms need sufficient absorptive capacity to learn from their knowledge partners and have overlapping knowledge bases with their knowledge partners to facilitate communication and knowledge exchanges. Moreover, cognitive proximity can encompass the sharing of interests and the alignment of incentives between firms and universities. In this case, universities and firms are cognitively proximate when they focus on the same research area or attempt to address similar technological issues (O'Connor et al., 2020).

In empirical work, Molina-Morales et al. (2014) find that cognitive proximity directly and indirectly affects firms' innovative performance by increasing knowledge acquisition ability. These scholars argue that firms' ability to acquire external knowledge will increase if they and their knowledge partners have a similar way of perceiving, interpreting, and understanding the information. Nguyen et al. (2019) reveal that cognitive proximity facilitates decision synchronization (i.e., joint decision-making on new products and market development) and incentive alignment (i.e., willingness to share costs, benefits, and risks) between firms. These are critical elements of firms' radical and incremental innovations. Ratchukool & Igel (2018) find that firms specializing in the same technological field as their university research partners tend to interact and exchange knowledge more with their partners and are more likely to innovate.

Based on the above literature, it can be argued that when firms establish research collaboration with universities that share a common understanding of technologies or have overlapping knowledge bases, it will enhance the effectiveness of knowledge transmission, thus resulting in superior innovation performance. We, therefore, propose the following hypothesis.

Hypothesis 2: Cognitive proximity enhances firms' innovation performance under the UIRC arrangement.

2.2.3. Social proximity

Social proximity is the closeness between actors in a socially relational space (Boschma, 2005). The concept of social proximity emerges from the theory of social embeddedness, which proposes that social relations facilitate economic transactions (Granovetter, 1985). Two actors are socially proximate when they are embedded in social networks based on trust and reciprocal relationships. Social proximity can be strengthened when actors are linked through friendship, kinship, or shared socio-cultural and professional characteristics (Balland et al., 2015).

Social proximity may help enrich interactive learning and firms' innovation in some ways. First, trust and reciprocal relationships help reduce transaction costs involved in knowledge exchange. They make actors' behaviors more predictable, increase their commitments to each other, and minimize opportunistic behavior (Boschma, 2005; Dyer & Chu, 2003). Maurer (2010) shows that trust significantly prevents free-riding and opportunistic behavior and increases the willingness to share information among partners involved in inter-organizational projects, resulting in superior product innovation performance. Second, social proximity may help firms to extend their search for knowledge. It enables firms to source knowledge from long-distance sources (Agrawal et al., 2008), thus increasing the diversity of ideas and overcoming the limit of regions in generating new knowledge (Bathelt et al., 2004).

Based on these arguments, we can expect that firms having strong social ties and establishing trust-based relationships with their university research partners will have superior innovation performance. We propose the following hypothesis.

Hypothesis 3: Social proximity enhances firms' innovation performance under the UIRC arrangement.

3. UIRC in Thailand

Some innovation-related indicators show that Thailand's innovation system is weak and needs further improvements in many areas. In 2019, Thailand was in 43rd place in the global innovation index ranking, lagging behind Singapore (8th), Malaysia (35th), and Vietnam (42nd). Gross R&D expenditure was 1% of GDP, lower than Singapore (1.95%) and Malaysia (1.44%). Full-time equivalent research personnel were 2.09 persons per 1,000 population, much lower than Taiwan (10.94), South Korea (9.16), and Singapore (7.93). Though the private sector had doubled its share of national R&D expenditure in the past five years (from 47% in 2013 to 78% in 2018), its investment was still mainly concentrated in the downstream experimental activities, lacking investment in developing deep technologies (National Research Council of Thailand, 2020).

Regarding UIRC, firms generally do not see universities as an essential source of knowledge. They tend to rely less on universities than other knowledge sources when they need information for technological upgrading or innovation. In the surveys carried out by the National Science Technology and Innovation Policy Office, universities ranked in the tenth (in 2015) and twelfth (in 2019) places regarding their significance as manufacturing firms' knowledge sources for innovation (Table 1). These surveys also found that most sample firms had no linkage with universities. For instance, out of 3,891 manufacturing firms in the 2019 survey, only 166 (4.27%) indicated that universities were their essential sources of information. Among those who suggested having linkages with universities, most of them linked through student internship mode (27.35%) and only a small share through collaborative research mode (4.08%) (National Science Technology and Innovation Policy Office, 2019).

These results are consistent with Tippakoon's (2018) study on UILs in the Thai food-processing industry. It shows that food-processing firms rank universities in the 10th and 11th places regarding their importance in firms' innovation process. This study also finds that Thai food firms rarely use research collaboration to source knowledge from academic institutions. Similarly, the survey of UIL projects by Schiller (2006) also finds that, when sourcing knowledge from universities, firms generally prefer basic consulting and technical services rather than sophisticated research outputs.

Table 1. Rank of knowledge sources for innovations in manufacturing firms, 2015 & 2019

Rank	2015 Survey (n = 3,327 firms)	2019 Survey (n = 3,891 firms)
1st	Firm's internal sources	Clients
2nd	Foreign suppliers	Firm's internal sources
3rd	Clients	Mother or affiliated companies
4th	Internet	Thai suppliers
5th	Industrial associations	Internet
6th	Trade or industrial exhibitions	Foreign suppliers
7th	Mother or affiliated companies	Competitors
8th	Thai suppliers	Conferences
9th	Published papers	Public Research Organizations
10th	Universities	Trade or industrial exhibitions
11th	Conferences	Published papers
12th	Public Research Organizations	Universities
13th	Knowledge service providers	Trade or industrial exhibitions
14th	Business service providers	Knowledge service providers
15th	Non-profit organisations	Non-profit organisations
16th	Competitors	Business service providers
17th	Patents	Patents

Source: National Science Technology and Innovation Policy Office (2015 & 2019)

Existing studies often mentioned industry-related, university-related, and policy-related factors as impediments in establishing university-industry knowledge linkages. On the industry side, Thai firms rarely invest in R&D activities. According to the National Science Technology and Innovation Policy Office (2019), in 2018, 3,552 manufacturing firms invested in R&D, accounting for only about 0.80% of all manufacturing firms in Thailand (443,188) (National Statistical Office, 2017). Most Thai firms are SMEs (99.25%) that lack R&D resources and absorptive capacity to operate UIL projects. Lacking absorptive capacity means they cannot identify technological problems and exploit scientific knowledge. While large multinational subsidiaries have higher technological capabilities, they are generally not interested in establishing research cooperation with universities, as they mainly acquire technologies from abroad (Schiller, 2006).

On the university side, critical obstacles are the lack of incentive to cooperate with the private sector and the lack of capacity to manage UIL mechanisms. Universities with high research potential are generally public ones operating in a semi-bureaucratic environment. Private universities focus only on teaching and have limited scientific research capacity. For academics to work with the private sector, they must undergo a cumbersome approval process. Although they can count other workloads apart from teaching and research missions (e.g., social services) for their career promotion, in practice, the evaluation system is still based on the quality of teaching and the number of publications. And even if more universities currently have established mechanisms for knowledge transfer and commercialization (e.g., TTO, UBI, and science parks), these mechanisms still run under a dearth of expertise and financial support (Brimble & Doner, 2007; Schiller & Brimble, 2009).

At the policy level, Thailand's industrial development has primarily focused on an extensive growth strategy of factor accumulation based on abundant labor and low wages. The country has mainly imported foreign technologies and made little effort to enhance absorptive capacity and build up its own technologies. Consequently, there has been no clear policy and support for promoting indigenous technologies through UILs. Although several policy initiatives to encourage UILs have been launched in the past decade, many are implemented ad hoc and lack continuous government support. There are also problems of fragmentation, overlapping, and unclear missions of the implementation agencies

(Doner et al., 2013; Pittayasophon & Intarakumnerd, 2015).

Despite various impediments, some studies do find successful UIRC cases. For instance, Pittayasophon & Intarakumnerd (2015) demonstrate three cases of UIRC where cooperation leads to successful development and commercialization of innovations. The first case is the research cooperation between Chareon Pokphand Foods Public Company Limited (CPF) and food science researchers at Mahidol University (MU) for developing the shrimp disease diagnosis technology. The success of this case is due to a long-term personal relationship between MU researchers who served as research consultants for the CPF laboratory for 25 years, coupling with the ability of the firm to identify the right research questions. The Center of Excellence for Shrimp Molecular Biology and Biotechnology (CENTEX SHRIM) was established to coordinate joint research projects between MU and CPF.

The second case is the cooperation between Lion Corporation (Thailand) and professors at the Faculty of Science (Chemistry division), Chulalongkorn University (CU). In this case, the cooperation develops based on mutual trust between a managing director of Lion and an alumnus of the science faculty. The joint research project successfully developed a low-cost silver raw material, which later led to the development and introduction of new products into the market. The third case is the joint research project between Artith Ventilator (AV) and the Rajamangala University of Technology Lanna (RMUTL) to develop a ventilator prototype that meets the international standard for export. The project was developed based on a long-term personal relationship between the AV owner and a senior professor at the RMUTL, who were former classmates. With the continual assistance of the professor and his doctoral students, AV set up its laboratory. A prototype was developed and could obtain an international standard for marketing abroad.

Another case is the cooperation between Seagate (a multinational hard-disk drive company) and Khon Kaen University (KKU). This case reveals that the success of the UIL project is based on long-term personal contact between a leading engineer of Seagate and the head of the electrical engineering of KKU. The cooperation began with a joint research project based on the intimate relation between the two partners' research teams. Later, it develops into broader partnerships such as joint research labs, training, and co-publications (Intarakumnerd & Schiller, 2009; Schiller, 2006).

These cases highlight the importance of trust-based cooperation between partners who focus on the same research area and share common knowledge and expertise, suggesting that social and cognitive proximities are vital to the performance of UIRC projects. When two partners are embedded in a relational network, it can generate frequent knowledge interactions and deep cooperation, consequently leading to the success of the projects. The similarity between academic and industry partners regarding knowledge base, technological capabilities, educational background, and research interest also matters. As illustrated by the cases, the cooperating firms have sufficient R&D resources. Those firms can identify their research problems and need for technological solutions and operate research projects alongside their academic partners (Pittayasophon & Intarakumnerd (2015).

Studies using a quantitative approach based on a larger sample size support these findings. For instance, Ratchukool & Igel (2018) employ the SEM approach to analyze the effect on firms' innovativeness of three types of proximity (geographical, organizational, and technological) between firms and universities/PROs. This study measures organizational proximity mainly in terms of personal contacts and previous collaborations, consistent with the social proximity concept. Technological proximity is measured as the similarity of knowledge base and shared expertise in the same technical field, coherent with the cognitive proximity concept. These authors find that all types of proximity strengthen knowledge interactions between the two partners, subsequently leading to firms' better innovative performances. Sugandhavanija et al. (2011) examine the effectiveness of university-industry joint research for photovoltaic technology transfer using the confirmatory factor analysis. These researchers find that one of the project success factors is the knowledge base of firms that determines their capabilities to receive new technologies and conduct joint research projects, suggesting the importance of cognitive proximity.

From a review of the theoretical and empirical literature (Section 2) and the success cases of UIRC in Thailand, we expect geographical, cognitive, and social proximities to have positive effects on the innovation performance of UIRC projects.

4. Research Methodology

4.1. Data and sample characteristics

The data used for analysis in this paper stem from the postal survey of firms that had a research collaboration with universities through the Research and Researchers for Industries (RRI) Program of the Thailand Research Fund (TRF), one of Thailand's most prominent public research funding agencies. The RRI program has operated since 2012 to provide research grants to university-firm collaborative research projects. The main objective of the RRI is to assist industrial firms in solving their technical problems, developing their products, and upgrading technologies through R&D using the expertise of graduate students and academic staff.

RRI has various granting platforms, such as science and technology graduate research scholarships for industrial usage, industrial problem-solving research grants, and research and innovation funds for small-scale enterprises. The essential condition of the RRI's grant is that research questions must be drawn on the industrial context and firms' demand. In the early years of operation, firms were not obliged to co-finance the research project. Thus, their contribution to the project was minimal and primarily provided in the in-kind type of cooperation (e.g., sharing research facilities and personnel). From 2015 onward, the RRi's grant has been provided on a co-funding basis, where the proportion of firms' contribution to the projects may vary from 5% to 50%. The RRI-granted projects mainly focus on applied research, experimental development, and technical problem-solving rather than basic research. The success of projects is viewed in terms of applicable technical solutions or new/improved products that meet firms' demands. Thus, in this context, the performance of RRI-supported projects can be evaluated in terms of firms' innovative products/processes and the market launch/application of such products/processes.

In this study, our units of analysis are firms. To create the population of firms for the survey, we first selected 1,326 projects completed between 2013-2018. These projects involved 801 firms, many of them engaged in more than one project. For those multi-project firms, we randomly chose one project. As there is no case of firms cooperating with research partners from more than one university, our sample included firms collaborating with one university research team.

We developed a draft questionnaire based on the theoretical and empirical literature reviewed. The questionnaire was then evaluated by five experts in innovation and technology management and business economics. We then finalized the questionnaire based on comments and suggestions from those experts. The final questionnaire consists of three sections, including general information about the firm, its experience in knowledge interaction with universities via various modes of linkages, and information about the collaborative research funded by the RRI. The last section consists of questions about the outcomes of the project and multiple characteristics of a research partnership, which define the spatial and non-spatial proximity between the firm and its university research partners.

We conducted the survey between April and May 2019. Questionnaires were sent by postal mail to 801 firms with a cover letter requesting the head of the firm's research staff or manager(s) involved in the RRI-supported project to provide answers. By the end of April, we received 99 returned questionnaires. Thus, we sent reminder emails to non-responded firms and received 65 more questionnaires by the end of May. Therefore, in total, 164 firms responded to our survey. However, after removing questionnaires with incomplete information, 153 are retained, making up the net return rate of 18.9%.

We assess the non-response bias by comparing the characteristics of early and late respondents regarding age, sale revenue, employees, employees with higher education, and the number of new products in the past three years using a two-tailed t-test (Lahaut et al., 2003). The results show no statistical significance (Table 2), suggesting no severe non-response bias in the sample.

The survey research relying on a single data source, as in our case, may suffer a common method bias (CMB) that is likely to occur when the so-called method, as a causal factor, meaningfully distorts substantively driven causal effects (Fuller et al., 2016, p.3192). We used Harman's single-factor test to check for the CMB. The exploratory factor analysis (EFA) was run on eight Likert-scale questionnaire items (see Table 4) related to characteristics of research collaboration with university partners. The result shows that a single factor explains only 44.39% of the variance in the data, suggesting that CMB is unlikely to be a severe problem (Podsakoff & Organ, 1986).

Table 2. Comparing variable means between early and late response firms

Variables	Response type	N	Mean	SD	*t*-stat	Sig. (2-tailed)
Age(log)	Early	93	2.68	.81	1.24	.217
	Late	60	2.46	1.14		
Employees(log)	Early	93	3.89	1.79	1.32	.188
	Late	60	3.43	2.24		
Employees with higher education(log)	Early	93	2.77	1.89	.49	.625
	Late	60	2.60	2.20		
Sale revenue (log)	Early	93	19.42	2.83	1.12	.266
	Late	60	18.80	3.65		
New products	Early	93	4.56	21.33	.32	.751
	Late	60	3.68	13.09		

Note: Equal variances not assumed

Table 3 shows the distribution of sample firms relative to the population of manufacturing firms by region, size, and industry. Most of the sample firms are concentrated in the BMR. Perhaps this is because about 42% of universities in Thailand (72 of 173)[1], particularly top universities, are in this region. Also, as the RRI office is in Bangkok, firms in and around this city are more likely to access the RRI. Almost one-third of the sample firms (49 of 153) cooperated with top universities in Bangkok, including Chulalongkorn University (14), Mahidol University (11), King Mongkut's University of Technology Thonburi (8), Kasetsart University (14), and Thammasat University (2). About half of the sample is small firms. Most are in food processing, agricultural products, petrochemicals, rubbers & plastics, and business services sectors. Generally, our sample is not reflective of population firms. This may be because RRI's projects tend to include firms that want to develop their innovative capacity in collaboration with universities, which differs from general Thai firms.

[1] www.data3.mua.go.th/dataS/

Table 3. Distribution of sample firms by region, size, and sector

	Number and percentage of firms	
	Sample	**Population***
Region		
BMR (Bangkok and five vicinity	67 (43.79%)	71,161 (16.06%)
provinces)	24 (15.69%)	55,308 (12.48%)
Central	15 (9.80%)	100,419 (22.66%)
Northern	38 (24.84%)	180,711 (40.78%)
North-eastern	9 (5.88%)	35,589 (8.03%)
Southern	153 (100%)	443,188 (100%)
Total		
Size (# employees)		
Small (up to 50)	82 (53.59%)	432,533 (97.60%)
Medium (51 to 200)	42 (27.45%)	7,343 (1.66%)
Large (more than 200)	29 (18.95%)	3,312 (.75%)
Total	153 (100%)	443,188 (100%)
Industry		
Agricultural products	28 (18.30)	-
Food processing	43 (28.10)	112,115 (25.30%)
Textile & Clothing	5 (3.27)	142,181 (32.08%)
Petrochemicals, rubbers & plastics	19 (12.42%)	9,962 (2.25%)
Computers, electronics & electrical	12 (7.84%)	2,739 (.62%)
devices	13 (8.50%)	3,181 (.72%)
Pharmaceutical & medical products	14 (9.15%)	4,323 (.98%)
Automobile and auto-parts	19 (12.42%)	-
Business services	-	168,687 (38.06)
Others	153 (100%)	443,188 (100%)
Total		

Note: * The 2017 Census of Manufacturing Industry, National Statistical Office (2017)

4.2. Variables and estimation method

The dependent variable in this study measures firms' innovative performance under the UIRC arrangement. As our sample firms set up UIRC projects under the RRI program, which mainly aims at finding a technical solution or new/improved products for firms, it is possible to assess the success of UIRC projects regarding how they achieve this goal. We asked firms two related questions: (1) Did the collaborative research project result in new/improved product or production techniques/processes (Yes/No)? and (2) If yes, did your firm commercialize the product(s) or apply production techniques/processes (Yes/No)? From these questions, we get information on whether the project leads to product and process innovations and whether they are commercialized in terms of market launch or industrial application. We then construct an ordinal variable with three outcomes, including (1) no product or process innovation (Failed, coded 0), (2) has product or process innovations but not yet commercialized (Partial success, coded 1), and (3) has product or process innovations and already commercialized (Full success, coded 2). In the sample, there are 34(22.2%), 42(27.5%), and 77(50.3%) observations for failed, partial success, and full success cases, respectively.

The key independent variables are geographical proximity (GeoProx), cognitive proximity (CogProx), and social proximity (SocProx). GeoProx is measured as the log of the distance (in kilometers) between a firm and its university partner. We construct CogProx and SocProx variables using eight five-point Likert scale questions (1 = not at all or extremely little, …, 5 = mostly) (Table 4). We used the Exploratory Factor Analysis (EFA) to derive the constructs from this data. The EFA extracts two factors, each with four items having a factor loading of 0.50 or more. As shown in Table 4, items 1-4 are highly loaded to Factor 1 and related to the cognitive proximity concept, while items 5-8 are highly loaded to Factor 2 and associated with the social proximity concept. We construct CogProx by taking the average of items 1-4 and SocProx by taking the average of items 5-8. Thus, CogProx and SocProg are continuous variables ranging between 1 and 5. The Cronbach alpha coefficients for these variables are acceptable at 0.690 and 0.730, respectively.

Table 4. EFA results for CogProx and SocProx

Questionnaire items	**Factor loading**	
	Factor 1 (CogProx)	**Factor 2 (SocProx)**
1. Common research interest	**.75**	
2. Shared knowledge base	**.54**	
3. Responsiveness of university research to industrial needs	**.56**	
4. Previous research collaborations	**.50**	
5. Duration of knowing each other		**.75**
6. Level of acquaintanceship	.39	**.73**
7. Frequency of prior contacts		**.61**
8. Level of trust	.48	**.53**
Eigenvalue	3.44	1.31
Total variance explained	23.75	23.09
Cronbach's alpha	.69	.73

Notes: (1) Determinant = .07; (2) Kaiser-Meyer-Olkin (KMO) test of sampling adequacy = 0.76; (2) Bartlett's test of sphericity is statistically significant at $p < 0.01$; (3) Extraction method = Principal axis factoring; (4) Rotation method = Varimax with Kaiser normalization.

We enter variables *Age*, *Size*, *Skilled*, *R&D*, *Top5_U*, *BMR*, *Year*, and industry dummies to control their potential effects on a dependent variable. *Age* is the number of years that the firm has been operating since its establishment. *Size* is the number of full-time employees. Variable *Skilled* is the share of employees with at least a bachelor's degree. *R&D* is measured by the average firm's annual investment in R&D (in Thai baht) three years prior to the survey. *Top5_U* is the dummy variable coded 1 if a firm cooperated with Top-5 universities in Thailand and 0 otherwise[2]. The inclusion of *Top5_U is* to control for the quality of partner universities that may affect the innovative outcomes (Laursen et al., 2011). *BMR* is a binary dummy variable denoting firms located in the BMR region (coded 1) and is included in the analysis to capture the agglomeration effect that may arise from a high concentration of universities in the region, especially national top ones. *Year* is a binary dummy variable coded 1 if the projects were completed between 2016-2018, and 0 if completed between 2013-2015. This variable is included to control for the lag time that outputs of UIRC projects will be commercialized. We use industry dummies - *Agri* (agricultural products), *FTC* (food-processing, textile, and clothing), *Petro* (petrochemicals, rubbers & plastics), *Comp* (computers, electronics & electrical devices), *Auto* (automobile and auto-parts), and *BServ* (business services) – to control for sector-specific effect on a dependent variable. *Pharma* (pharmaceutical & and medical products) is a base industry. *Age*, *size*, and *R&D* variables are log-transformed to reduce the overdispersion and potential outliers in the sample.

As our dependent variable is ordinal, we analyze the data using ordinal logistic regression. With an

[2] The information about top5 universities in Thailand is derived from the QS World University Ranking, the Times Higher Education World University Rankings, and Shanghai Jiao Tong University Ranking during 2012-2017.

ordinal dependent variable, the linear regression method is inappropriate as data distribution violates critical assumptions of linear regression - homoscedasticity and normality of errors - potentially producing misleading results. The ordinal logistic regression, estimated using the maximum likelihood estimation, is proven more efficient in producing reliable coefficients (Long, 1997).

We conducted a statistical diagnosis to check for violations of ordinal logistic regression assumptions. First, we checked the multicollinearity assumption by running a binary correlation analysis for each pair of variables and running a linear regression to derive the Variance Inflation Factor (VIF) for all independent variables. The correlation and VIF results are displayed in Table 5. As shown, no correlation is exceptionally high. The VIF statistics for all independent variables are well below the cut-point of 10 (Wooldridge, 2016), indicating no multicollinearity problem. Second, we also checked whether the assumption of proportional odds is violated. This was done by running a chi-square test of parallel lines. The results show no violation of this assumption (see Table 6).

Table 5. Mean, standard deviation (SD), variance inflation factor (VIF), and binary correlations of independent variables

	1	2	3	4	5	6	7	8	9	10
1. GeoProx	1									
2. CogProx		1								
3. SocProx		.37(.000)	1							
4. Age		-.22(.007)		1						
5. Size				.49(.000)	1					
6. Skilled				.38(.000)	.78(.000)	1				
7. R&D							1			
8. Top-5								1		
9. Year		.19(.014)		-.19(.017)					1	
10. BMR					.21(.006)	.28(.000)	-.20(.013)			1
Mean	4.47	3.25	2.96	2.59	3.71	0.49	9.01	0.42	0.51	0.43
SD	1.34	0.74	0.94	0.96	1.98	0.33	6.62	0.49	0.5	0.49
VIF	1.13	1.52	1.43	1.53	1.66	1.18	1.42	1.09	1.29	1.28

Note: Only significant correlations are reported

5. Results

The ordinal regression results with six model specifications are displayed in Table 6. Specification 1 is the baseline specification, including seven control variables. In specification 2, we add six industry dummies. However, adding these dummies affects the model substantially, resulting in statistical significances of Pearson's Chi-square and Chi-square test of parallel lines (at $p < 0.10$) and suggesting the poor fit of the model and the violation of the proportional odds assumption, respectively. Moreover, all these dummies are not statistically significant, and including them does not improve the Cog-Snell R^2 remarkably. Thus, we decided to drop them from subsequent specifications. Specifications 3 to 5 assess the effects of seven control variables and geographical, cognitive, and social proximities, respectively. Specification 6 includes all three proximity variables and seven control variables (full model).

Regarding the model summary statistics, it is found that all specifications have statically significant model Chi-square, indicating a substantial improvement of the final models over the baseline intercept-only models. Pearson's Chi-square, which captures the goodness-of-fit of the model, is not significant in all specifications (except specification 2), suggesting that the observed data are consistent with the fitted model. Finally, Cog-Snell R^2 improves substantially in the full model (0.316 in Sepec.6) from the baseline specification (0.166 in Spec.1), suggesting that proximity variables significantly increase the predictive power of the models.

GeoProx has negative and statistically significant coefficients ($p < 0.01$) in specifications 3 and 6, and the magnitude of the estimate changes only marginally when we include *CogProx* and *SocProx* in specification 6. A negative coefficient of *GeoProx* means that as the distance between firms and universities increases, the probability of success of UIRC projects decreases (note that *GeoProx* is measured by the log of distance in kilometers between firms and universities). In other words, geographical proximity between the two partners is needed to ensure the project's success in promoting firms' innovation. This result supports Hypothesis 1, which states that geographical proximity enhances firms' innovative performance under the UIRC arrangement.

CogProx has positive and statistically significant coefficients ($p < 0.01$) in specifications 3 and 6, with a trivial change in the magnitude of the estimate between the two specifications. This gives the interpretation that the more firms are cognitively proximate to their university research partners, the more likely it will result in success regarding innovation and commercialization. Specifically, project success is enhanced when a firm cooperates with academic partners who focus their research on industrial needs and share common research interests and overlapping knowledge bases. This result confirms Hypothesis 2, stating that cognitive proximity enhances firms' innovative performance under the UIRC arrangement.

The estimate of *SocProx* is not statistically significant, though its coefficient sign is positive. This result gives an interpretation that social proximity between firms and their academic partners is not likely to be a critical factor determining the degree of success of the UIRC. This result is inconsistent with various case studies of UIRC in Thailand that highlight the significance of personal ties, trust, and social relationships between partners. The inconsistency may be attributable to using different research methods, specifically surveys vis-a-vis case-study methods. We also suspected that social proximity might have a threshold effect whereby its positive and statistically significant impact could be found at a high social proximity level. We experimented with this by running regressions replacing the original *SocProx* variable with binary dummies that indicate high social proximity using various cut-points (3, 3.5, 4, and 4.5) (Note that *SocProx* is originally a continuous variable valuing between 1 to 5). When evaluating other proximity and control variables, as in specification 6, the resulting coefficients are all positive but statistically insignificant, consistent with the results shown in Table 6. We conclude that in the context of firms cooperating with universities under the RRI program, social proximity is not likely to affect firms' innovative performance. Thus, our empirical evidence does not support Hypothesis 3 (i.e., social proximity enhances firms' innovation performance under the UIRC arrangement).

Regarding control variables, only *R&D* and *Year* are statistically significant. *R&D* is positive and significant at $p < 0.05$, while *Year* is also positive and moderately significant at $p < 0.10$ in specification 6. Thus, as firms increase their investment in R&D activities, the likelihood that their research collaboration with universities will result in innovation and commercialization also increases. This result is consistent with the absorptive capacity paradigm, which argues that firms must develop internal R&D capabilities to assimilate and exploit external knowledge efficiently (Cohen & Levinthal, 1990). The positive effect of *Year* is unexpected. We expected the negative impact of this variable, based on the reasoning that the outputs of projects that were completed in the early years (2013-2015) could be commercialized in the later period (2016-2018). Perhaps this positive effect may be explained by a co-funding condition that was imposed in 2015. The reason behind imposing this condition is to improve the effectiveness of the projects. Forcing firms to co-invest would increase their commitment and activeness in driving the project to success.

Variable *age* is only negative and statistically significant in the baseline specification but loses its significance when proximity variables are included. Size and *Skill* are not statistically significant in any specifications. Thus, in this study, we find no evidence to establish that firms' age, size, and skilled workers are critical to the success of UIRC projects. Variable *BMR* and *UTop5* are also statistically insignificant, though their coefficients are positive. The insignificance of *BMR* can be interpreted that firms located in the BMR region with a high concentration of universities, especially the top ones, are not in a better position than those located elsewhere in Thailand to achieve superior performance of UIRC projects. Also, cooperating with Top-5 universities is not significantly different from collaborating with other universities regarding UIRC project success. Thus, this study does not establish the superior university partner effect (Laursen et al., 2011)[3].

[3] We also ran a regression using a dummy variable denoting a cooperation with Top10 universities based on the same ranking criteria used for deriving Top5 universities (see footnote 1). The resulting coefficient of this variable was also positive but statistically insignificant.

Table 6. Ordinal logistic regression results

	Specification 1		Specification 2		Specification 3		Specification 4		Specification 5		Specification 6	
	Estimates (SE)	*p*	*Estimates (SE)*	*p*	*Estimates (SE)*	*p*	*Estimates (SE)*	*p*	*Estimates (SE)*	*p*	*Estimates (SE)*	*p*
Outcome = Failed (0)	-2.76(.68)	.000	-1.88(3.11)	.545	-4.80(.94)	.000	.52(1.07)	.624	-1.82(.90)	.043	-1.51(1.28)	.238
Outcome = Partial success (1)	-1.33(.65)	.042	-.41(3.11)	.895	-3.26(.89)	.000	2.10(1.09)	.053	-.37(.89)	.670	.18(1.27)	.883
Key independent variables												
GeoProx					-.46(.12)	.000					-.46(.13)	.001
CogProx							.98(.25)	.000			.91(.27)	.001
SocProx									.28(.18)	.119	.11(.21)	.590
Control variables												
Age	-.47(.21)	.027	-.48(.22)	.028	-.38(.21)	.082	-.33(.21)	.131	-.47(.21)	.027	-.26(.22)	.231
Size	-.09(.18)	.591	-.06(.18)	.729	-.19(.18)	.308	-.15(.18)	.403	-.07(.18)	.690	-.23(.19)	.217
Skilled	.12(.17)	.469	.12(.18)	.493	.17(.17)	.338	.19(.18)	.288	.11(.17)	.503	.23(.18)	.201
R&D	.06(.02)	.013	.07(.02)	.008	.07(.02)	.011	.05(.02)	.037	.06(.02)	.012	.06(.02)	.024
Year (after 2015 = 1)	.78(.33)	.018	.85(.35)	.016	.76(.33)	.023	.59(.34)	.083	.70(.33)	.038	.59(.35)	.094
BMR (=1)	.35(.34)	.301	.33(.36)	.365	.31(.34)	.371	.47(.35)	.185	.36(.34)	.279	.44(.36)	.214
UTop5 (= 1)	.17(.32)	.600	.29(.33)	.387	.06(.34)	.860	.26(.34)	.430	.14(.33)	.672	.17(.35)	.615
Industry dummy												
Agri			.33(.69)	.632								
FTC			-.195(.64)	.762								
Petro			-.498(.72)	.495								
Comp			.61(.87)	.483								
Auto			-.61(.75)	.421								
Bserv			-.62(.75)	.412								
Model Chi-square (Sig)	27.82(.000)		32.94(.002)		41.31(.000)		45.70(.000)		286.32(.000)		58.03(.000)	
Pearson's Chi-square (Sig)	288.76(.245)		298.30(.091)		287.74(.331)		295.07(.284)		294.85(.347)		318.54(.390)	
Cog-Snell R^2	.17		.19		.24		.26		.18		.31	
χ^2 test of parallel lines (Sig)	4.63(.704)		22.02(.055)		7.32(.502)		4.27(.831)		7.11(.524)		8.34(.595)	
n	153		153		153		153		153		153	

6. Discussion

6.1. Theoretical implications

The ordinal regression results in Table 6 reveal that geographical and cognitive proximities are crucial for UIRC's success regarding firms' innovations, whereas social proximity is insignificant. These results have theoretical implications as follows. First, a positive and significant effect of *GeoProx* is consistent with existing theoretical and empirical literature. Based on the localization theory of economic geography (Audretsch & Feldman, 2004), geographical proximity is vital to innovative performance because it generates involuntary knowledge spillovers and facilitates direct interactions, networking, and exchange of tacit knowledge (Boschma, 2005). In the context of UIRC, the impact of geographical proximity on project achievement can even be more pronounced, as it requires a high level of engagement and intensive interactions of the cooperating parties (Perkmann & Walsh, 2007).

Geographical closeness can reduce the costs of monitoring and executing contracts, subsequently attenuating the problem of information asymmetry and transaction costs involved in collaborative research (Landry & Amara, 1998). In experimental development research, where innovative ideas are to be converted into commercial use, geographical proximity between academic inventors and firms can be crucial, as it eases the transmission of inventors' uncoded trial-and-error experiences to be used for producing marketable products (Buenstorf & Schacht, 2013). In our case, UIRC projects aim to find new/improved products or novel solutions to technical problems for firms. Frequent contact between firms and university researchers may be necessary to exchange information about technical problems that may happen recurrently in this process. Firms located close to universities are more likely to contact and exchange information with their university research partners.

The positive effect of geographical proximity found in the current study is consistent with some previous empirical studies. For instance, Tang et al. (2019) find that intra-regional interactions with universities strengthen firms' ability to introduce incremental product innovations. Laursen et al. (2011) suggest that firms located close to high-quality universities tend to source innovative ideas from university partners successfully. Lindelöf & Löfsten (2004) demonstrate that cooperation between firms and universities co-located in a science park is more significant for firms' new product development than cooperation between firms and universities outside the science park, indicating that geographical proximity matters. These studies indicate that geographical proximity is necessary for facilitating trust-based and frequent face-to-face interaction, which is crucial for transferring complex technological knowledge, as in the case of university-industry knowledge transmission.

Second, the positive and significant effects of cognitive proximity suggest that knowledge transfer between firms and universities will be most effective when sharing the same knowledge base (Nooteboom, 2000). The closeness in knowledge base will lead them to use similar tools, languages, theories, or mental maps to interpret, understand, and evaluate information, thus making communication and exchanging knowledge easier (Thune, 2009). Additionally, cognitive proximity may involve how actors share interests and focus on the same issues or technology field, which is crucial to mutual understanding, commitment, and intensive knowledge interaction between them (O'Connor et al., 2020).

In our cases, firms cooperate in research with universities to develop new/improved products or technologies. Cognitive proximity plays an essential role in the initiation and execution phases of the project. In the beginning, it is crucial that firms identify the right research questions and the right research partners with relevant knowledge and expertise. When a research proposal is prepared in cooperation with academic partners, firms must be able to identify the scope of the research project and the methodologies to be employed. During the project execution phase, they need to communicate and exchange information with their partners on various issues (both technical and managerial) that may potentially occur when research and development activities are carried out. It may be difficult to move the project toward achieving its objectives without similarity in the knowledge base, common research focus, or mutual understanding of research issues. This finding is consistent with the studies of

Thailand's UIRC by Ratchukool & Igel (2018), Pittayasophon & Intarakumnerd (2015), and Sugandhavanija et al. (2011).

Finally, the social proximity effect is positive but not statistically significant, especially when the effects of geographical and cognitive proximities are accounted for (Specification 6 in Table 6). Thus, compared to geographical and cognitive proximities, social proximity is less crucial for UIRC project success regarding firms' innovations. A possible interpretation is that social proximity can be less necessary for firms' innovative outcomes under the UIRC arrangement when geographical and cognitive proximities are dominant. It is possible that in the research cooperation between firms and universities, the transmission of complex technological knowledge requires firms and universities to be located nearby (i.e., geographical proximity) to increase the frequency of knowledge exchange (Mowery & Ziedonis, 2015). It may also require that two organizations share common research interests and overlapping knowledge bases (i.e., cognitive proximity) so that advanced technological knowledge produced by universities will be efficiently transferred to firms (Nooteboom, 2000). Thus, social proximity can be less relevant in the UIRC arrangement with a strong presence of geographical and cognitive proximities. Another possible explanation is that when research collaboration is built on the logic of strong social ties, it can be insignificant (or even harmful) to learning and innovation. According to Boschma (2005), strong social ties can lead partners to commit to the established ways of doing things and deny the entry of new ideas, which will result in reducing innovative capability in the long run.

6.2. Policy implication

Some policy implications can be drawn from the findings of this study. First, policies or initiatives to promote localized research collaboration between co-located firms and universities may help to enhance firms' innovative capabilities. As geographical proximity can reduce the costs of communication and knowledge exchange between firms and universities, promoting such localized collaboration can reinforce the innovative outcomes of UIRC projects. This finding supports the Thai government's current policy that encourages universities' active engagement in local business development under the third mission of knowledge transfer (Buasuwan, 2018).

Second, cognitive proximity is needed for UIRC projects to foster firms' innovative performance. This means that finding the right research partners who share the same knowledge base, operate in related technological fields, or focus on similar research issues is vital. However, as Brimble & Doner (2007) mentioned, there is a problem of imperfect information in establishing effective university-industry linkages in Thailand, meaning that finding the right partners is not easy. Moreover, Thai firms generally have low technological and absorptive capacities (Schiller, 2006). This may reduce the possibilities of establishing research collaboration and drive UIRC projects toward enhancing innovation outcomes. Policymakers may consider developing or strengthening intermediary organizations (e.g., TTOs, UBIs, and science parks) that can bridge cognitive gaps between universities and firms. As demonstrated by some studies (e.g., De Wit-de Vries et al., 2019; Villani et al., 2016), these organizations can serve as effective knowledge transfer mechanisms and bridge various gaps existing between universities and firms.

7. Conclusion, limitations, and future research

There has been an increasing interest in using the proximity perspective to analyze knowledge linkages and research collaboration between firms and universities in recent years. However, most studies on proximity and university-industry research collaboration focus on the role of proximity in the formation of university-industry research collaborations (UIRC). Less attention is paid to the effects of proximity on UIRC success regarding firms' innovative performance. Moreover, most studies focus on UIRC in developed countries. Studies focusing on the success of UIRC regarding firms' innovations in developing countries are still limited. This study contributes to the literature on proximity and innovation by examining the effects of proximity on the innovation performance of firms collaborating on R&D with university partners. It focuses on Thailand, where the institutional settings involving UIRC differ fundamentally from developed countries.

The current study aims to examine the impacts of geographical, cognitive, and social proximities on the innovation performance of UIRC projects. The key research question that this study aims to address is: Does geographical, cognitive, and social proximity strengthen the innovation of firms collaborating on research and development with universities? To answer this research question, we employ a sample of firms cooperating in research with universities through the RRI program. This program provides research grants for university-industry research collaboration projects to find innovative products and processes for firms using the university's knowledge and expertise. The performance of UIRC projects is measured from the firms' perspective regarding whether the project results in innovative products/processes and whether firms use those products/processes for commercial ends. The results from ordinal regression analysis show that geographical and cognitive proximities exert positive and statistically significant effects on the success of UIRC projects. However, the effect of social proximity is not statistically significant.

It is worth noting that this study suffers some limitations. First, as we use the data from one public research granting program (RRI program), the results produced here may be of limited generalizability. Future research should extend the scope of study to cover a broader range of UIRC projects, encompassing those financed by other public agencies and those not going through public programs. Despite this limitation, we believe that findings from our study can provide some implications for other programs that are designed to use UIRC projects to respond to firms' demands using universities' knowledge and expertise. Second, this study only focuses on the direct effects of proximities on UIRC project success regarding firms' innovative performance. It may be interesting for future research to explore additional factors that may mediate or moderate the relationship between proximities and UIRC project success. Third, with a limitation in using cross-sectional data for analysis, this study cannot assess a dynamic process of proximities. Some scholars (e.g., Balland et al., 2015; Steinmo & Rasmussen, 2016) illustrate that the role of different proximity dimensions on interactive learning changes over time. Studies that examine the evolutionary and dynamic process of proximities are still needed (Lauvas & Steinmo, 2019). Future research should address this issue using longitudinal data.

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