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The Role of Proximity Dimensions in Facilitating University-Industry Collaboration in Peripheral Regions: Insights from a Comparative Case Study in Northern Norway

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Abstract
It is commonly argued in the literature on regional innovation that regions must continuously develop new economic activities to compensate for economic decline. If a region manages to diversify from an existing path, it can sustain long-term economic development. One of the measures taken to increase these types of opportunities and to avoid lock-in is to stimulate a closer relationship and collaboration between universities and industry partners. However, we know little about the formation and investigation of successful university-industry relationships in regions outside metropolitan areas. This paper seeks to fill this research gap by investigating how different dimensions of cognitive, organizational, social and geographical proximity facilitate or hinder innovation processes in collaborations between industry and universities in peripheral regions. We find that social proximity, combined with high organizational proximity, overcomes the barriers presented by low geographical proximity. Social proximity compensates for thin regional structures with few high-tech firms, a lack of knowledge producers and a weak support system. An important policy implication is that stimulating collaboration within areas of expertise possessed by university and industry partners create potential for innovation.

Keywords: *proximity dimensions; cognitive; organizational; social; geographical; R&D; research; innovation*

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1. Introduction

Strengthened global economic competition, unreliable market demand and the complexity of technological systems contribute to the need for collaboration between multiple actors in innovation processes.[1] It is widely claimed in the literature that firms and regions must continuously develop new economic activities to compensate for economic decline in the economic system.[2] The aftermath of the 2008–2010 economic crisis, the decline in raw material prices and the increased economic globalization of production processes pose new challenges for regions. If a region manages to develop vital, innovative economic activities and diversify from existing paths, then it can maintain long-term economic development.[3] One of the policy instruments used to increase diversification in regions, and thus to avoid lock-in, is stimulating a closer relationship and collaboration between universities and industry.[4] The proposed concept is as follows: If a region lacks the ability to renew regional industrial structures and break out of existing paths, it will in the long term encounter phases of economic decline with severe consequences for firms in these regions. However, the sourcing of new knowledge can be initiated by increased collaboration with universities, and the argument is that firms can participate in innovation projects that they would not have been able to initiate under their own capacity.[5]

The literature in evolutionary economic geography has taught us that regional policies targeted towards one type of region do not offer much help to a region with differing characteristics.[6] While 'thick' regional innovation systems (RIS) contain powerful clusters, strong institutions and dense networks between research and industries, 'thin' and peripheral regions often lack strong institutions, have poor networks external to the region and contain few dynamic industries. Typically, peripheral regions have poor physical and research and development (R&D) infrastructure. Lagging regions often experience a decline in local economic sectors and poor preconditions for new growth paths. Given these preconditions, it is highly relevant to assess how innovation policies are established in 'thin' innovation systems to increase the capabilities within "thin" RIS and thus contribute to increased regional balance between core and non-core regions. However, as the literature on successful university-industry collaboration has mostly concentrated on core regions and 'thick' RIS, we know surprisingly little about successful university-industry relationships in peripheral regions[7].

The regions in this study, Finnmark, Troms and Nordland, are characterized by comparatively large distances between firms and possible research partners, the latter including two universities and their associated (and small) research institutes and some other research institutions located within a geographical area of 113 000 square miles. A significant part of the infrastructure is located in and around the two main university cities. Operating within this context, firms from these three regions are less innovative and perform less research than other Norwegian firms.[8] The long and narrow shape of the region of Northern Norway creates long internal distances and related climatic, economic and cultural differences.[9] In regard to economic development, the region of Troms and Finnmark, especially, is among Norway's weakest and has been a target region for regional policy. Accordingly, a range of policy mechanisms have been implemented to attract capital and skilled labour to this region. Nordland, by contrast, has witnessed more positive industrial and economic development in past years compared to the other regions in this study due to increased exports and a highly profitable aquaculture sector.[10]

The geographical context of relevance in this paper is the 13 million Euro research programme "Nordsatsing" initiated by the Norwegian Research Council (RCN) and the Norwegian government, which aims to stimulate research and industry collaboration in Northern Norway within the area of 'Arctic Technology'. Nordsatsing was orchestrated to build stronger relationships with geographically proximate research partners, and to reduce and break down, in a Schumpeterian tradition, "barriers to entry"[11] into new industries and markets for Northern Norwegian firms. However, the scholarly literature points to the fact that universities and industry consist of different logics in terms of time horizon, incentives, formal structures and knowledge status.[12] Because proximity dimensions provide a nuanced framework for understanding collaborative processes,[13] it is relevant to investigate how cognitive, organizational, social and geographical proximity dimensions influence the actual university-industry collaborations (UICs). It is also of relevance to understand more on how these collaborations develop over time. Thus, the overall aim of this paper is to develop a better understanding of the development of UICs in Northern Norway by focusing on the drivers and barriers to such relationships. This background shapes the cornerstone for the following research question: "In what way can different proximities facilitate a stronger link between universities and industry in the peripheral region of Northern Norway?"

The remainder of this paper is organized as follows. The next section (section 2) introduces the relevant theoretical debates on university-industry collaboration and how different proximity dimensions can hinder or facilitate increased collaboration. Section 3 introduces the methods applied to collect the data for this paper and introduces regional characteristics. Section 4 presents the data in more detail, while section 5 discusses the empirical material. Section 6 concludes by answering the research question and introducing some policy implications.

2. Theoretical discussion

In this section, we introduce and combine the two strands of literature on university-industry collaboration and the proximity dimensions: cognitive, organizational, organizational, social and geographical proximity.

2.1 University-industry collaboration

Due to increased international economic competition, difficulties in obtaining funding, shifting market demand, and complex technologies, many firms can no longer afford to become involved in innovation processes that require comprehensive resources.[14] Consequently, firms must find new ways of coping with this situation, and research demonstrates for a large number of sectors that firms are involved in some form of system collaboration[15] or interorganizational collaboration.[16] One of the main measures of interorganizational collaboration for firms is collaboration with universities and public or private research organizations.[17] One international example is the collaboration between Rolls-Royce and top-ranked universities in 30 research centres worldwide.[18] Newly announced, firms in Nordland County, in Mo i Rana, are to participate in one of the leading Norwegian centres for environmentally friendly energy research.[19] Such collaborations are often referred to as university-industry collaboration (UIC) in the innovation literature.[20]

Engaging in university-industry collaboration gives firms access to specialized knowledge and the opportunity to conduct high-quality research.[21] Universities may contribute relevant expertise and new knowledge to a firm's technological resource base and create new possibilities for developing innovations.[22] Consequently, the scholarly literature has emphasized the contribution of collaboration to achieve increased productivity, regional development and renewal of industry.[23] Outputs of successful collaborations between universities and industry have been identified, and studies have demonstrated outcomes such as knowledge transfer,[24] firm innovation,[25] products,[26] patents and licences.[27]

There is, however, a regional bias towards core areas in the UIC literature[28] that are significantly dissimilar from Northern Norway, the region studied within this paper. A majority of the studies have been conducted in regions with high geographical proximity to specialized universities. Northern Europe has been more or less absent in the dominant areas of discussion, as a majority of the literature stems from the US context. Typically, and present in the literature on new path development in evolutionary economic geography, the literature has investigated large universities located in high-technology clusters[29] such as Silicon Valley.[30] However, the literature often overlooks challenges and successes in connecting industry and universities in sparsely populated areas and economically lagging geographical regions. This is an essential research gap, as these regions often lack high-tech firms with high levels of R&D and knowledge institutions such as universities.[31]

By addressing how successful UICs are developed in Northern Norway, we aim to contribute to the theoretical understanding of how UICs develop, which is important because the organizational dynamics and processes of UIC are under-researched.[32] Scholars have also called for more in-depth research on those factors that make UICs successful.[33] In studying how UICs develop, we employ the proximity perspective and build on earlier proximity studies that have indicated that more proximate actors collaborate and interact more easily.[34]

2.2 Proximity dimensions

The proximity concept refers to "being close to something measured on a certain dimension".[35] The first proximity dimension to receive focus in the literature was the geographical dimension.[36] Subsequently, dimensions such as cognitive, social, cultural and organizational proximity were introduced.[37] Boschma[38] states that the common denominator of these dimensions is that being proximate in either one or several of the proximity dimensions can enhance coordination, reduce uncertainty and risk and, consequently, contribute to knowledge production and innovation. Bochma[39] regards these proximity dimensions as overlapping, and in the literature, different labels are often used for the same idea, or umbrella terms comprising several other concepts are applied. For example, Coenen[40] denotes social aspects as "personal proximity", which is often referred to as social proximity in the innovation literature. "Relational proximity" is another term that is used that overlaps with both social and personal proximity. In the remainder of the paper, we refer to social proximity as the main category for social dimensions in the relationship between industry and universities.

In our analysis, we distinguish between four dimensions of proximity, namely, social, cognitive, organizational and geographical. In this respect, we follow Oort and Frenkens[41] and treat institutional proximity as a component of organizational proximity, as institutional proximity entails humanly devised constraints that structure political, social and economic interactions.[42] Each of these dimensions has a specific influence on the collaboration process and outcomes.[43]

Following Broekel and Boschma[44], we understand *geographical proximity* as the distance between the workplace of, in this context, university and industry partners that are relevant to the conducted R&D. Geographical proximity might also sometimes be combined with other geographical indicators such as national and regional borders, where the latter is the most important from our perspective in this study. As much of the literature within RIS demonstrates, geographical proximity can stimulate and facilitate learning and innovation processes, sometimes by complementing or substituting for other dimensions of proximity.[45] However, the growing literature on regional path renewal demonstrates that other factors have as much influence as geographical proximity for regional renewal.[46]

Inspired by Broekel and Boschma[47] we understand *social proximity* as involving trust and being based on friendship, kinship, or personal experiences. Social proximity is considered to facilitate and foster joint knowledge production and knowledge exchange.[48] Empirical work on social proximity (using collaboration history as a proxy) demonstrates that social proximity leads to more joint patents.[49] However, this statement is balanced by other scholars such as Balland[50], who demonstrates in the navigation industry that the partners of partners in the project (which he defines as social proximity) are not more likely to interact than random actors. Boschma[51] argues that too much social proximity can be detrimental for effective learning and innovation because a relationship largely based on trust and loyalty may lead to an underestimation of opportunistic behaviour.

Organizational proximity is based on commonalities or similarities in incentives and routines between organizations. It is argued that organizational proximity reduces the opportunism involved in knowledge creation. It facilitates the control mechanisms necessary to shelter intellectual property and secure returns for the knowledge produced.[52] Broekel and Boschma[53] demonstrate a positive effect of organizational proximity on knowledge network formation among firms, but at the same time, their analysis demonstrates no effect on firm performance in terms of innovation. Cunningham and Werker[54] find that collaborations with only academic partners are better for overcoming large technical distances than mixed or non-academic collaborations.

Last, we understand *cognitive proximity* as similarity in the professional knowledge base between university and industry partners.[55] Nooteboom[56] argued that cognitive distance is required for innovation and that the cognitive distance should be small enough that partners are to be able to understand each other and efficiently process the acquired information, yet large enough to yield new knowledge. The research within this field demonstrates that results are contested. On the other hand, Broekel and Boschma[57] find a negative effect on innovative performance based on cognitive proximity.

3. Methods

The R&D programme "Nordsatsing" was launched by the Norwegian government through the Ministry of Local Government and Modernisation in 2009. The funding was a joint initiative between the Norwegian Research Council and the government. The aim of the programme was to strengthen and develop research competence in Northern Norway, increase research for innovation and increase relationships between universities and firms within Arctic technology and tourism. The sectors subject to research within this paper are remote sensing, cold climate technology and environmental waste management. The aim was to stimulate long-term research (2009–2017) and innovation in close collaboration with educational institutions and industry in the thematic priority areas. By launching this programme, the funding institutions seek to "develop this region as a hub of international competency in these areas in the long term".[58,59] Further, as outlined in the initiative, close contact and dialogue between industry-relevant research groups and companies were important. The initiative was not exclusively directed towards the research component and education, as it had ambitions to connect to existing firms in the region, strengthen existing networks and forms of collaboration, and develop new ones through expanded research collaboration between educational institutions, research institutions and firms in Northern Norway.

A joint research team in Northern Norway studied these processes. All of the data in this paper are a result of the study. The data collection was organized into two different periods, first in 2012 followed by a single round in 2015. The reason for the long timespan between the two rounds of interviews was to ensure that both the collaborative processes and the outputs for firms and research institutions were captured. In this context, we conducted 52 interviews with project partners, firms and private and public research institutions in the programme during the 2012–2016 period. All interviews were taped to ensure accuracy and transcribed to ensure us that the most important information was documented. Approximately 80 percent of the interviews were conducted face-to-face in Tromsø and Narvik, while the remaining 20 percent were conducted by telephone. The interview guide covered a variety of topics, and three main aspects were stressed during the interviews. First, we searched for knowledge on the initial process before and during the application process in order to investigate the motivation and the involvement of the collaborative partners. Second, we tried to explore the factors that obstructed or facilitated gaining new knowledge and sharing knowledge between universities and industries. Within this topic, we searched actively during the interviews for different proximity dimensions. Third, we concentrated on the output of the innovation processes in terms of new industrial networks, products, services and academic merit. The operationalization of the research question is based on three research projects within the Nordsatsing programme, interpreted by the authors as three individual innovation processes. In the following section, we present an outlook on these innovation processes.

4. Empirical material

One of the measures taken to increase the competitive position of Northern Norway and increase the innovation capacity within the region, the Nordsatsing initiative is clearly targeted towards competency development projects conducted under the auspices of educational and research communities in the region. The primary objective of the Nordsatsing initiative is to strengthen and further develop knowledge-based development processes in Northern Norway. This aim was followed by a 13 million Euro long-term research programme in close collaboration with research groups, educational institutions and industry in the thematic priority areas of Arctic technology. Grant applications were submitted by independent research institutes, universities or university colleges in the counties of Nordland, Troms or Finnmark on behalf of consortiums comprising several educational and research partners from the northern counties as well as other national and international R&D groups when relevant.

4.1 Innovation initiatives and development projects

In the following section, we will present the data relevant to this study based on the theoretical framework presented in section 2. As mentioned in section 3, we interpret the different research projects as innovation processes in the remainder of this paper.

4.1.1 Subsea sensor innovation project

One of the innovation processes in the Nordsatsing was named subsea sensor technology. The overall objective of the project was to develop sensor technology adapted to Arctic challenges for use in Northern Norway in the oil and gas sector. The project aimed at contributing to innovation by helping firms in the region adopt new technology and research within the field of subsea oil and gas. More precisely, the project aimed to develop a sensor for measuring the concentration of methane in sea and air. Ultrasound was a key resource for imaging in industrial environments. Methane is a well-known greenhouse gas, and ultrasound imaging can be used for quality control. This project ran over two periods, as it was a continuation of the project "Subsea sensors for oil and gas", which ran from 2009–2014.

This project, more generally, reflected a need for external funding to support the research environment:

> *You can say there are two ways to look at it; either you have something (idea) that you want to do, and you are also looking for money. Alternatively, you can do the opposite; you see what the call asks for, and you will determine what you can do to match the call. In this case, it was the second… Then, we looked for what theme we could find that would fit during the call. Before we hit the finish line, (…) we determined that we would focus on oil and gas and sensor technology* (Project Manager)

The project team observed the call as an opportunity to obtain funding and succeeded at this point. However, the team lacked experience in the subsea oil and gas sector:

> *Therefore, we have started, if not from scratch, at least we had not done anything before in this industry field outside university. If you have a project that is established, you had a research activity that was in motion, and then you proceeded in a straight line. Then, in one way, you can go straight to the business to start talking with them. We had some skills, but then we changed direction. When we started that project, there was a new direction for us. In that case, it takes time before you get up to a high level… We carefully examined two fields. We thought of medical technology, where we would have been more experienced. However, we found no collaborators, industrial partners. There are not many in that field. While in oil and gas, we thought it would be simpler.* (Project assistant)

Before 2009, Northern Norway had been subject to great expectations related to the socioeconomic impact from the oil and gas industry. Oil companies, NGOs and government organizations announced that "*Now it is Northern Norway's turn*" meaning that Northern Norway was the last region in Norway where the wealth from the oil and gas industry had not yet taken root. During the 2009–2010 period, one multinational oil company, Discovery Petroleum, decided to locate its engineering and research department in Tromsø based on the raised expectations and industry advice regarding further development in the Barents Sea. In the same period, the boom in the oil sector increased, and oil prices were high (Nilsen 2016). During this time, the oil company DONG and several global oil service companies such as Aker Solution and Subsea7 established departments in Tromsø with R&D staff, and all the companies had the ambition to recruit highly educated personnel. This was the overall industrial context for the research project when the Nordsatsing was proposed as an exogenous policy by the Research Council of Norway and the government. Consequently, the project manager in subsea sensors had expectations as well regarding the link to industrial surroundings.

> *We noticed that the oil industry would build up in the region and expected that SMBs in the region would need technology support in developing products and services in this respect [as subcontractors]* (Project Manager)

However, a hasty downsizing due to changing corporate strategies followed the rapid build-up of the oil industry. The main industrial partner in the subsea sensor innovation process, Discovery Petroleum, unexpectedly decided to close its R&D department in Tromsø during the first year of the Nordsatsing programme. This altered the plans for the project and led to the reduction of one work package (WP) in the project, but more importantly, the project team lost their core industrial and funding partner. Later, a steep decline in oil prices from USD 120 to USD 30 from 2012–2015 led to a general cost-cutting trend in the sector and the withdrawal of investment plans. The market for the subsea sensor project was altered due to global economic shifts.

Despite industrial changes in the system, the project continued, but the path leading to knowledge utilization within the university and systems changed.

> *Technology development has taken a much longer time for us. Therefore, it is first in 2016 that we truly are ready to talk to and about industrial partners. Not four years ago, when we thought that "In a year we can go more into dialogue with them," but it is truly now that we can do that job.* (Project Manager)

Starting from scratch within the unknown oil sector and expecting rapid industrial links based on academic research were not in balance with the ongoing regional industrial contextual process in the period of 2009–2012. As most of the multinational firms, which were supposed to support the research initiative, had their own R&D departments, often located elsewhere than in Northern Norway, the contact persons in local companies were not "spot-on" when the innovation process for subsea sensors searched for knowledge exchange. The R&D departments in MNCs in Norway are located in either Trondheim, Oslo, or Stavanger. This situation challenged the subsea sensor project in its early phase.

Another important challenge for the subsea sensor innovation process was the struggle to locate industrial surroundings that could serve as substitutes for the MNCs that were lacking within the innovation process and to find SMEs that could handle the knowledge developed in the project: "*We also struggled to find the firms. Northern Norway lacks technological firms*". (Project Assistant)

Academically, the outputs of the project have resulted in an increased number of employees, new Ph.D. students, post-doc positions and several international academic publications. Consequently, the research group has become more robust and resilient.

4.1.2 Cold climate technology project

ColdTech was led by the applied research institute Norut Narvik with its main consortium partner Narvik University College. ColdTech aims to "*ensure that the skills required to tackle the particular challenges of Arctic technology are at the forefront of the respective disciplines and available in the North*" (Project description). ColdTech focuses on the areas of winterization, ice forces, atmospheric icing, and their applications. Apart from supporting research, publication, and attendance at international conferences, new research connections with the National Research Council Canada and the Cryospheric Environment Laboratory, Snow and Ice Research Center in Japan have been forged in the areas of ice mechanics, atmospheric icing and winterization. The background for the research project was a combination of earlier research tasks in related research areas and an application for the Centre for Research Based Innovation (SFI)

> *We had searched for the first round of Centre for Excellent Research (SFI) on something like 'Sustainable Infrastructure'. Therefore, when the research programme came along, we started preparatory work on developing the project concept, and we entered the college system here in Narvik. We had experience working with firms; an applied research institute has that.* (Project Manager)

The project had major MNCs involved as industrial partners, such as the oil companies Total and Shell, which provided industrial funding. The process of involving these actors was rather challenging, but the research partners managed to involve the industry partners in the first phase of the project based on common interests.

> *I have a background that is slightly in both 'camps'. Both industrial and research camps. I worked on the 'floor' at Kværner and as an Executive Director of the company. The dialogue with the industry went pretty well. Large industrial players have their requirements and are relatively demanding. So, I feel we were able to satisfy that enough to become project partners.* (Project manager, ColdTech)

However, several challenges occurred based on the collaboration with industry. One of the challenges was related to the question of shared aims and incentives in the project.

> *It may be that a researcher will point in one direction, and it does not quite match what the industrialist expects then. Therefore, of course, there is enough of what we have struggled with. Perhaps it would have been a little better with a few fewer industrial actors and spending some more time on each of the partners, other than agreeing on good research tasks as such.*

It turned out that collaboration with large MNCs such as Total and Shell implied rather strong expectations for administrative requirements driven by the companies. Because the administrative capacity was rather low in the applied research institute managing this project, it took a great deal of effort to fulfil the industrial needs and requirements. Specific schemes, reporting on progress in percentages, and close follow-up from the oil companies on the expected progress in each WP represented a very new approach to project management in the applied and public research arena. It was obvious that the routines of the research and industry partners differed during the first phase of the project.

Another challenge also emerged during the internal collaboration between the applied researchers and the college involved in the project.

> *The university and college system is a different body compared to the applied research sector. We (the applied research sector) have almost no basic funding. Thus, we need to have an industrial collaboration and external funding. In addition, this is not necessarily the case at a university. Therefore, you have academia for the academy's bit and… Therefore, it's clear that there is probably a grey zone in such a consortium that can be slightly challenging.* (Project Manager)

In the beginning of 2014, Total and Shell decided not to be involved in the second phase of the project. Some of the reasoning behind this decision was that both Total and Shell had major R&D departments inside their own organizations and that the general downturn in the market had reduced the amount of funding to be distributed to external R&D projects.

Relevant outputs from the project have been increased infrastructure and testing labs for cold climate equipment. These have led to increased interest from outside in hiring new and successful candidates and an interest from industry. Increased academic publication has been another output of the project. The main output has been the industrial contacts, networks and applied services that the project facilitated by supplying new knowledge. New infrastructure on wind tunnels in Narvik and the knowledge applied by local firms in creating new solutions of concrete work in winter conditions have been commercialized. New Ph.D. students and post-doc positions have fulfilled the expectation.

4.1.3 Environmental Waste Management

Environmental Waste Management (EWMA) aimed to develop a research-based competence cluster on waste handling in the Arctic oil, shipping, and mineral industries. Thus, the project concentrates its attention on research and education connected to the petroleum and mineral industries in a cold environment. The research concentrated within two priority areas: the effects of environmental pollution and the actions preventing and reducing the effects of potential environmental impacts. EWMA aimed to pay special attention to the establishment and further development of educational programmes that fall within these priority areas. A new BSc programme in environmental management and pollution biology is already established at UiT - The Arctic University of Norway and will be expanded to the MSc. and Ph.D. level in the second period of EWMA. Furthermore, a dedicated upgrading course "Arctic Environment and Surroundings" will offer relevant and important education for candidates from within both the governmental and private sector. In the coming three-year period, EWMA will be organized into three larger WPs, thereby increasing the synergies and impact from the ongoing research activities.

The process started as a joint initiative between the oil company Eni Norge (Eni S&P), UiT and the regional county administration in Troms to develop a new competence cluster based on EWMA in 2006. The industry was a driving force in the initiative: "*It was Eni who came to the university and asked for a long-term competence approach. Simply. Therefore, it was actually them who had contacts*" (UIT-employee). This initiative was taken 3 years before the Nordsatsing initiative. The already established relations between industrial partner Eni Norge and an organization called UVETT at UIT on a personal level facilitated this process from the start: "*It is the acquaintances that were established before I became involved in this. (...) There were established personal contacts. We benefitted from these relations in the early phases of the initiative*" (UIT-employee).

When the call became public, the industrial partner was already a familiar contact for the research environment. In addition, their professional incentives were rather similar:

> *It was during this period the oil companies needed to document whether waste from drilling the top in wells had a negative environmental impact. Off course, they disagreed, but now they needed scientific documentation. The timing was rather good!* (Project Manager)

The EWMA project team increased their networks to the industry and especially the role of Eni Norge, who took an active part in strengthening the education provided by the university in the area of waste management. The university set up courses within biology, social science and engineering.

> *For the introductory course on 'Arctic marine biology', it was actually Eni who filled up. With their people. Then, they came here and stayed for a week. In addition, it was something they imposed on their leaders in different departments because they wanted better biological knowledge and understanding of what they were doing up there. The ones who came up here were Italians, French, people from all over the world.* (Project Manager)

Ecology courses from bachelor's to Ph.D. level were established at UIT based on knowledge from EWMA. Ecotoxicology is a new field within UIT that has been subject to great success. In 2014, a new master within EWMA-related studies was established based on industry needs. Other relevant outputs of the project are increased academic publications and the project BARCUT, which is a new UIC that builds on the knowledge developed in EWMA. Further, other research-driven projects have been established as well as several new Ph.D. and post-doc positions that support the output of the project.

5. Discussion

5.1 Sharing a common knowledge base (cognitive proximity) facilitates dialogue and networks

As we observed in the theoretical section, most UIC studies are based on firms with qualified personnel located close to universities, leaving a gap on our knowledge on how these processes are experienced by less R&D-intense firms in peripheral regions[60] such as Northern Norway. Our data demonstrate that the peripheral dimension becomes prominent in the subsea sensor process both because the region in the study is the last Norwegian region involved in value creation in the oil and gas sector and because few and "thin" firms in the region could meet the needs of the technology that was developed in the innovation process. The unexpected circumstances in the wider context of the project altered the progress plan and reduced the ability to link with industry within the subsea sector.

Hence, cognitive proximity[61] was low in the subsea sensor project, as few firms in the region shared a joint knowledge base with the researchers (see Table 1). The unsuccessful efforts to link with relevant firms in the initial phase of the project underlines this point. Recent studies emphasize that a region's future capability partly depends on what it has done in the past and what it has learned from the past.[62] Regional policies do not evolve in a vacuum, nor are they developed from scratch, and therefore the recent past may be a guide to the near future.[63] However, during the last phase of the subsea sensor project, the researchers changed paths and concentrated on circulating their work within medicine, where they had previous experience utilizing sensor technology within ultrasound technology.

Comparing ColdTech to the two other innovation developments in the study, the amount of cognitive proximity varies strongly between the innovation processes. In the empirical section, we demonstrated that the ColdTech innovation process had high levels of cognitive proximity between the involved research milieus and industry representatives, which demonstrates at least two important features of this project. First, in developing research technology for a cold climate, the project manager had industry experience from a multinational company within the same area of expertise as the research project. This experience facilitated several advantages between the research institute and industry within this project. Having a project manager that understood and shared a knowledge base with the industry was important in creating a collaboration-friendly environment for the project and securing industry participation, which was a requirement for obtaining funding. Second, an applied research environment drove the project, with experience in sustaining industrial links with both SMEs and MNCs. Even though the university and industry sectors have significant differences in logics and knowledge bases, the experience of working in joint projects made it easier for the research institution to establish and maintain a productive dialogue with industry both inside and outside the region.

5.2 Social proximity- a key factor for initiating new collaboration and overcoming the lack of geographical proximity

Collaborative challenges between industry and university partners have been analysed through different dimensions of proximity.[64] The concept of social proximity, following Boschma[65], focuses on the role of common understanding and trust. We find that social proximity plays an important role in understanding the precursor of collaboration in the ColdTech and EWMA innovation processes. The ColdTech project had a history in the field and personal networks including strategic companies, which facilitated a trusting relationship on behalf of the project that was important in keeping the innovation process going. The applied research institution had experience with applied research and knew how to approach multinational firms from a research perspective. In addition, the project manager knew who to call in the companies based on his former position, not only in the initial phase when they planned the project but also when challenges occurred in different operational stages in the project.

We find a parallel situation for EWMA, as the initiation of the whole project grew out of a personal friendship and a productive personal experience (interview data). Key persons at Eni Norge contacted UIT based on former contact between two individuals, and the process was initiated in 2006, three years before the Nordsatsing process was launched. The starting point was a professional need based on a new political regulation that was being contested, and further dialogue around the mobilization of academic resources was facilitated based on trust and friendship between two key persons within the two organizations.

Hence, we further observe that Schumpeter's[66] concept of "barriers to entry"[67] relates to the initiative of Nordsatsing itself. Nordsatsing was established to build stronger relationships with geographically proximate research partners and to reduce and break down "barriers to entry" into new industries and markets for Northern Norwegian firms. Conversely, firms involved in the Nordsatsing initiative that increase their levels of social and cognitive proximity through the innovation processes could create advantages over other non-participating local firms. However, for non-participating firms, this will not be a permanent barrier that is impossible to breach.

5.3 Differences in organizational proximity may create potential for innovation

The challenges between university and industry partners are often rooted in tensions between firms and universities.[68] These tensions may often stem from differences in incentives and routines between these organizations. Dissimilarities in organizational structures, goals, and problem solving sometimes make collaborations between universities and firms challenging.[69] Universities aim to educate and conduct academic research; firms seek to commercially present products and services in a market.[70] This dissimilarity is not synonymous with a lack of potential, because the partners most likely to provide complementary knowledge are also the most challenging actors with which to collaborate.[71]

Accordingly, we have demonstrated that during the innovation process in EWMA, although the industry and university initially had different logics, they identified a common objective and aspiration around the question of increased knowledge of the environmental impacts from drilling the "tophole" in wells. While the industry wanted to document whether this process had a specific or extraordinary negative effect on the environment that might require significant (and costly) operations, the university milieu was interested in externally funded research and increased knowledge within this field, which they had aspired to introduce for several years. The industry "push" from Eni Norge created a dynamic innovation process that included SMEs, educational institutions and research institutions. Hence, we find that successful UICs that take both universities' and industry partners' interests into consideration are not dependent on organizational proximity through similar routines[72] but can facilitate successful innovation processes through common incentives[73] (organizational proximity) and common objectives.

However, in the Subsea Sensor and ColdTech innovation processes, we find low levels of organizational proximity, where both incentives and routines vary significantly between the universities and industry. The industry wanted short-term results from the research activity, whereas the research environment took a more long-term perspective, as is commonly found in the literature on UIC.[74] One illustrative example from the subsea sensor project was that the project manager and his team were ready to discuss technological applications with the industry after four years, while the industry expected this to be taking place at the start. We find the same result regarding time-horizons in the existing literature.[75] Further, the industry wanted a major administrative and reporting system that did not match the dynamic applied research system and created unexpected challenges in ColdTech. These findings indicate that medium levels of organizational proximity may be the most beneficial for innovation processes and outcomes that bring mutual benefits to both university and industry partners.

Table 1. Summarized innovation processes, proximity dimensions and innovation outcomes within the Nordsatsing initiative

Innovation process	**Geographical proximity**	**Social proximity**	**Cognitive proximity**	**Organizational proximity**	**Innovation outcomes**
Subsea Sensors	High	Low	Low	Low	Low industrial, but high academic outcomes
ColdTech	Medium	High	High	Low	Medium academic and industrial outcomes
EWMA	High	High	High	Medium	High academic and industrial outcomes

6. Concluding remarks

This paper started by asking the following research question: "*In what way can different proximities facilitate a stronger link between universities and industry in the peripheral* *region of Northern Norway?*" The empirical presentation of the data and relevant theoretical material has demonstrated that proximity dimensions as an analytical tool may shed light on the collaboration process between firms and university researchers in the Nordsatsing project. However, the proximity dimensions influence the university-industry collaboration processes in different ways in the three studied innovation projects.

The innovation processes in ColdTech are found to have high social and cognitive proximity due to the project manager's experience and qualifications as a former industrial partner. These two proximity dimensions increase the ability to collaborate and reduce the level of misinterpretation between university and industry, a common problem noted in the UIC literature.[76] High levels of social and cognitive proximity further facilitate communication and dialogue processes, as the researchers and industry speak "the same language". A common language increases the amount of shared knowledge and, thus, can facilitate innovation processes. Important knowledge on cold climate technology has been introduced by the project and is now implemented and commercialized by local firms in the region.

The innovation process for subsea sensor technology demonstrated low scores on organizational, social and cognitive proximity between the university and industry partners. Although the innovation process demonstrated a high level of geographical proximity, it was not sufficient to overcome the lack of organizational, social and cognitive proximity. The unexpected and dramatic changes in the contextual frame of the project played an important role in explaining why the project lost its momentum within subsea oil and gas. However, the situation was almost the opposite to that for the EWMA project, as the university and industry actors demonstrated a high level of social and cognitive proximity but low geographical proximity. Thus, we have demonstrated that personal trust, friendship and mutual interest and incentives have been fundamental to facilitating the innovation process.

The peripheral dimension is evident in all of the innovation processes but especially in the subsea sensor process, as there were few accessible high-tech firms that could be mobilized as partners and that could utilize the knowledge developed in the project. Thus, we find that when starting a UIC from scratch, geographical proximity to industrial partners becomes a vital source in establishing and running a fruitful collaboration. Findings from ColdTech demonstrate that skilled experience developed in one field can compensate for the lag in regional characteristics, as they could build on already established knowledge bases.

To sum up and conclude the paper, we have demonstrated that a high level of cognitive and social proximity between actors in university and industry collaboration, combined with a certain degree of organizational proximity, plays a significant role in university and industry collaborations[77]. It plays an important role in initiating networks and building joint research and industry teams but is also incredibly important in facilitating committed and relevant contact and dialogue between industry and university environments.

We have learned that in peripheral regions such as the one studied in this paper, cognitive and social proximity, combined with high organizational proximity, appear to overcome barriers such as low geographical proximity between partners and the "thinness" of regional support systems such as innovative firms and knowledge producers. The analysis in this study is only valid for a peripheral region. Consequently, we cannot draw conclusions or connections for other types of regions compared with metropolitan regions based on our data material, which is an important aspect for future research. Finally, social proximity is important to integrating different milieus in new ways, as the social dimension facilitates dialogue that cuts across established professional relationships and formal systems.

Finally, the policy implications from this study are twofold. First, stimulating new sectors for a region without a history, tradition, knowledge base and weak ties to existing industries will confront important deficiencies. When firms cannot draw on existing competencies, resources and networks in developing new innovations, they face important challenges. Second, and closely related to the above, starting from scratch in new areas of competence in high-tech research and expecting constructive industrial and university collaboration output as new products and services need to be reconsidered in light of context-sensitive and regional structural capacities.

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NOTES

1. Vrande et al., 2009; Oerlemans et al. 2013.
2. Boschma and Frenken 2011; Isaksen and Trippl 2016.
3. Boschma and Frenken 2011.
4. García-Aracil and Fernández De Lucio, 2008.
5. Broström 2012.
6. Tödtling and Trippl 2005; Isaksen and Trippl, 2016.
7. Yigitcanlar et al., 2017, Yigitcanlar et al., 2015.
8. Forskningsrådet, 2015.
9. Fitjar, 2013.
10. Bullvåg et al 2018.
11. Schumpeter 1934.
12. Bjerregaard, 2010, Steinmo, 2015.
13. Steinmo og Rasmussen, 2016.
14. Vrande et al., 2009, Oerlemans et al., 2013.
15. Isaksen and Trippl, 2016.
16. Chesbrough, 2003.

17. Hagedoorn, 2002, Sampson, 2007.
18. Perkmann and Salter, 2012.
19. Karijord, 2016.
20. Gulbrandsen et al., 2011, e.g., Freitas et al., 2013.
21. Hussler et al., 2010, Laursen and Salter, 2004, Raesfeld et al., 2012.
22. Mansfield, 1991, Cohen et al., 2002, Dahlander and Gann, 2010.
23. Laursen and Salter, 2004, Nieto and Santamaría, 2007.
24. George et al., 2002, Kaiser and Kuhn, 2012.
25. Mansfield, 1991, Cohen et al., 2002, Sampson, 2007, Robin and Schubert, 2013.
26. Kaiser and Kuhn, 2012.
27. Cohen et al., 2002, Perkmann and Walsh, 2007, Gulbrandsen et al., 2011.
28. Yigitcanlar et al., 2017.
29. Rothaermel et al., 2007.
30. Doloreux and Dionne, 2008.
31. Tödtling et al., 2012; Nilsen and Karlstad 2016.
32. Perkmann and Walsh, 2007, Balland, 2011, Thune and Gulbrandsen, 2014.
33. Giuliani and Arza, 2009.
34. Knoben and Oerlemans, 2006, Balland et al., 2015.
35. Knoben and Oerlemans, 2006 pp. 71–72.
36. Audretsch and Feldman, 1996.
37. Heringa et al., 2014.
38. Boschma, 2005.
39. Op.cit.
40. Coenen, et al. 2004.
41. 2007.
42. North, 1991.
43. Boschma, 2005, Steinmo and Rasmussen, 2016.
44. 2012.
45. Isaksen and Jakobsen 2017; Asheim et al. 2005; Rallet and Torre 1999.
46. Nilsen 2017; Isaksen and Trippl, 2016; Dahl-Fitjar and Rodrigues-Pose 2013.
47. 2012.
48. op.cit.
49. Wal 2009.
50. 2012.
51. 2005.
52. Boschma 2005.
53. 2012.
54. 2012.
55. Broekel and Boschma 2012.
56. 1999.
57. 2012.
58. Nordsatsing 2009.
59. https://www.forskningsradet.no/prognett-nordsatsing/Forside/1228296261486.
60. Yigitcanlar et al., 2017, Yigitcanlar et al., 2015.
61. Boschma, 2005, Broekel and Boschma, 2012.
62. Morgan 2013.
63. Op.cit.
64. Steinmo and Rasmussen, 2016.
65. 2005.
66. Schumpeter 1934.

67. We are grateful to an anonymous reviewer for suggesting this point of relevance.
68. Fang et al., 2011, p. 774.
69. Ambos et al., 2008.
70. Op.cit.
71. Howells et al., 2012.
72. Boschma, 2005.
73. Boschma, 2005.
74. Steinmo, 2015, Galán-Muros and Plewa, 2016.
75. Spithoven et al., 2011.
76. Steinmo, 2015.
77. That medium levels of organisational proximity may be the most beneficial for successful innovation processes and outcomes indicates an inverted u-shape function, which could be tested in future research.

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