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ACADEMIC KNOWLEDGE CREATION AS A SPATIO-TEMPORAL PROCESS

THE CASE OF INTERNATIONAL RESEARCH GROUPS IN FINLAND

UNIVERSITY OF OULU,
FACULTY OF SCIENCE,
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ACADEMIC KNOWLEDGE CREATION AS A SPATIO-TEMPORAL PROCESS

The case of international research groups in Finland

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Abstract

The thesis is an investigation into the spatio-temporal knowledge creation of international research groups. Knowledge is spatial: it is created in geographical places, shared in communicative space and analyzed in the cognitive space of the mind. Knowledge is a process that evolves in the interactions and interpretations of people. It is created in the tempo of working days that is experienced as flowing or disrupted time. These dimensions of spaces and times come together as the contexts of knowledge creation.

In current internationalizing universities, work groups increasingly consist of members from different countries and with varying professional backgrounds. In their endeavor to create globally renowned results, the international research groups are both challenged and enabled by their diversity. Multiple views can benefit the creation of novelty, but reaching a common understanding in a diverse group might not be easy. Current research calls for a more detailed understanding of the processes and contexts of knowledge creation in international groups.

The empirical part of the thesis is comprised of two case study compilations. Case A focuses on the University of Oulu, with its foreign employees and three international research groups from the humanist, scientific and technical fields. Four international research groups from the fields of science and technology, led by top foreign professors and funded by the Finland Distinguished Professor Programme, form case B. Altogether, the main materials include 37 interviews, 123 weekly diaries, observation and a survey (67 replies). The main methods applied are mental mapping, discourse analysis and content analysis.

According to the results, knowledge creation is a complex spatio-temporal process that often leads to unexpected results. Processes of interaction and interpretation enable the group to reach cognitive friction. This fertile ground of knowledge creation can be reached when a group possesses enough common understanding and enough diversity in their individual interpretations. Humanist, scientific and technical knowledges are created in multiple contexts through group-specific discourses. Knowledge itself is a spatio-temporal process of stages, flows and disruptions towards the not-yet-known. Knowledge is inseparable from individuals, groups, the processes and contexts of creation.

Keywords: ba, cognitive proximity, international, knowledge, knowledge creation, research group, SECI model, space-time, university

Hautala, Johanna, Akateemisen tiedon jalostamisen prosessi tilassa ja ajassa: tapauksena kansainväliset tutkimusryhmät Suomessa
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Tiivistelmä

Väitöskirjassa tarkastellaan tiedon jalostamista tilassa ja ajassa kansainvälisissä tutkimusryhmissä. Tieto on tilallista: sitä jalostetaan maantieteellisissä paikoissa, jaetaan kommunikaation tilassa ja analysoidaan mielen kognitiivisessa tilassa. Tieto on prosessi, jota ihmiset jalostavat vuorovaikutuksen ja tulkinnan kautta. Tietoa jalostetaan aikarajojen ja työpäivien määrittelemässä ajassa, joka voi tuntua virtaavan tai pysähtelevän. Nämä tilan ja ajan ulottuvuudet yhdistyvät tiedon jalostamisen kontekstiksi.

Kansainvälistyvissä yliopistoissa työryhmät koostuvat enenevissä määrin jäsenistä, jotka edustavat eri kansallisuuksia ja joiden ammatilliset taustat ovat erilaiset. Monimuotoisuus on sekä haaste että mahdollisuus ryhmien tavoitteelle luoda kansainvälisesti merkittäviä tuloksia. Monipuoliset näkökulmat voivat edesauttaa tiedon jalostamista, mutta yhteisymmärryksen muodostaminen ryhmässä voi olla haastavaa. Nykytutkimuksessa tarvitaan syvällisempää ymmärrystä tiedon jalostamisen prosesseista ja konteksteista kansainvälisissä ryhmissä.

Väitöskirjan empiirinen osa sisältää kaksi tapaustutkimuskokonaisuutta. Tapaus A koskee Oulun yliopiston ulkomaalaisia työntekijöitä ja kolmea kansainvälistä tutkimusryhmää humanistiselta, luonnontieteelliseltä ja tekniseltä alalta. Tapauksen B muodostavat neljä kansainvälistä luonnontieteen ja tekniikan alan tutkimusryhmää, joiden johtajat ovat ulkomaalaisia huippuprofessoreita ja jotka ovat Finland Distinguished Professor -ohjelman rahoittamia. Yhteensä pääaineisto koostuu 37 haastattelusta, 123 viikkopäiväkirjasta, havainnoinnista ja kyselystä (67 vastausta). Aineiston käsittelyn päämenetelmät ovat mentaalikartta-, diskurssi- ja sisällönanalyysi.

Tulosten mukaan tiedon jalostaminen on monimutkainen prosessi, joka usein johtaa odottamattomiin tuloksiin. Vuorovaikutuksen ja tulkitsemisen prosessit mahdollistavat kognitiivisen kitkan muodostumisen, joka on hedelmällinen maaperä tiedon jalostamiselle. Sen saavuttamiseksi ryhmässä tarvitaan riittävästi yhteisymmärrystä ja riittävästi monimuotoisuutta jäsenten yksilöllisissä tulkinnoissa. Humanistiset, luonnontieteelliset ja tekniset tiedot jalostetaan ryhmän sisäisissä diskursseissa monipuolisissa konteksteissa. Tieto on tilallinen ja ajallinen prosessi kohti toistaiseksi tietämätöntä. Tieto on erottamaton osa ihmisiä, ryhmiä ja jalostamisen prosesseja ja konteksteja.

Asiasanat: ba, kansainvälinen, kognitiivinen läheisyys, SECI malli, tiedon jalostaminen, tieto, tila-aika, tutkimusryhmä, yliopisto

Acknowledgements

One summer evening, a seventeen-year-old girl was sitting on a rock by the Baltic Sea, watching the sunset. I was her, wondering whether songs exist “there” waiting to be “found” by the people who can, or whether they only come into existence when people create them. Now, about ten years and a PhD thesis later, I can give her an answer which is by no means exhaustive. When the right people are combined with the right times and places, it seems that they are able to “find” unexpected ideas. But to make a song out of that idea requires the process of creation. I want to thank that girl for wondering such intriguing thoughts.

My space-time of knowledge creation has been contributed to by many people. For the FiDiPro groups and S-, T-, and H-groups, as well as the survey respondents of the University of Oulu, I owe my deepest gratitude. Your journeys into the unknown and passions to create distinguished knowledge have been exciting to follow, both as a researcher and a person. Without your help, this thesis would not exist.

I thank my main supervisor professor Jussi S. Jauhiainen, whose never-ending-spirit of making things happen has been inspiring and has also transmitted to my pursuit to become a good researcher one day. He has believed in this research subject — knowledge creation — to be justified part of geography, and myself to be a good PhD-candidate. Supervisor docent Topiantti Äikäs, thank you for your support and for being such an approachable person. Professor Sami Moisio, thank you for your support, discussions and comments concerning my thesis. Even though not being an official supervisor, in my eyes, doctor Katri Suorsa has indeed been one. Her guidance (and friendship!), especially during the final stage of this thesis, has been important.

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My closest research colleagues along the way and our research groups “SUMA” and “AA”: Katariina Ala-Rämi, Juho Luukkonen, Helka Moilanen, Tarmo Pikner, Eeva-Kaisa Prokkola, Tea Remahl, Aila Ryhänen and Katri Suorsa (to whom I have already dedicated a couple of sentences) deserve my greatest appreciation. We have “been there” for each other and created knowledge together. The “lunch team” of geographers, I thank for creating a friendly and trusting atmosphere in our department. I thank all the staff and students of the Department of Geography of the University of Oulu, especially those who have commented upon my work.

In 2010, I worked as a visiting researcher in the University of Uppsala, in the Department of Cultural Geography and Centre for Research on Innovation and Industrial Dynamics (CIND). From there, I thank professor Anders Malmberg, who made the visit possible and provided important insights on my work. Thank you, Kerstin Edlund, Akira Endo, Tobias Fridholm, Ann Rodenstedt, Johan Jansson, Jörgen Lindell, Henrik Mattsson, Jacob Nobuoka, Pepijn Olders, professor Gunnar Olsson, Erika Sigvardsdotter, Susanne Stenbacka and Anders Waxell for your kindness, constructive comments and our interesting discussions. The time that I spent in Uppsala was exciting, focused and inspiring for me.

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Oulu, October 2011

Abbreviations

FiDiPro	Finland Distinguished Professor Programme
H-group	Research group of humanists (Case A)
P	FidiPro professor (Case B)
R1	FiDiPro researcher (more experienced) (Case B)
R2	FiDiPro researcher (less experienced) (Case B)
Science group	FidiPro research group of scientists (Case B)
S-group	Research group of scientists (Case A)
Tec1 group	FiDiPro research group of engineers (Case B)
Tec2 group	FiDiPro research group of engineers (Case B)
Tec3 group	FiDiPro research group of engineers (Case B)
T-group	Research group of engineers (Case A)

List of original publications

This thesis is is based on the following papers, which are referred to in the text by their Roman numerals:

I Hautala J (2008) Internationalization of knowledge creation at the university. The case of the University of Oulu, Finland. In Ylinenpää H (ed) Proceedings. 2nd Conference on Nordic Innovation Research, December 3–4 2007; Luleå University of Technology: 126–142.

II Hautala J (2011a) International academic knowledge creation and *ba*. A case study from Finland. Knowledge Management Research and Practice 9(1): 4–16.

III Hautala J (2011b) Cognitive proximity in international research groups. Journal of Knowledge Management 15(4): 601–624.

IV Hautala J & Jauhiainen J S (2011) Spatio-temporal processes of knowledge creation. Manuscript.

The specific contribution of Johanna Hautala in the original article IV: research plan and empirical study. The article was written jointly with Jussi S. Jauhiainen.

Contents

1 Introduction

Knowledge creation, resulting in new products, findings and theories, is the key activity in current knowledge economies, such as Finland (Cooke *et al.* 2007). Universities are cradles of knowledge creation and of importance for the competitiveness of their regions and companies (Bramwell & Wolfe 2008). The researchers and groups of universities create knowledge, educate skilled employees, collaborate with employees of companies and governing bodies and form international networks that also benefit other local actors (Benneworth *et al.* 2009: 1645, Youtie & Shapira 2008). Currently universities are becoming more international and entrepreunial (Etzkowitz & Viale 2010). The Finnish universities are challenged by growing international competition on funding, the best researchers, ideas and publication forums. Winning out in this competition requires sufficient facilities of, for example, funding and laboratories and distinguished researchers who have the ability to form good research groups.

Knowledge creation is spatial. People, laboratories, computers, concepts, theories and ideas that are part of the knowledge creation are located in geographical space and the cognitive space of the mind. These are connected into networks, projects and organizations in communicative space, where people interact with each other and with their material surroundings to create knowledge. Communication with people is performed through several channels: face-to-face, mobile phone and e-mail. The comprehensiveness of the communication which is achieved in these channels differs. Most comprehensively, knowledge can be shared face-to-face (Collins 2001).

Knowledge creation is also temporal. Knowledge is created in rhythms of paradigms, deadlines and working hours. The time of the knowledge creation is not only about calendars and clocks, but is experienced as a flow (Csikszentmihalyi 1997), hectic and slow. The dimensions of space and time come together to form spatio-temporal contexts of knowledge creation. Knowledge is a process that evolves and changes as it travels through these contexts: times, places, cultures, methods and interpretations (Said 1983: 226). Knowledge does not travel alone: it travels with people who share, analyze, test and interpret. It is people possessing a vision, who make ideas (Flower & Hayes 1980: 21) that can be processed into knowledge.

Groups outperform individuals in creating novel and innovative knowledge (Amin & Roberts 2008, Nonaka & Takeuchi 1995, Singh & Fleming 2010), which is why knowledge, both in business and academic organizations, is

increasingly created in groups. In current internationalizing organizations, the knowledge creating groups more often consist of people from different countries and time-zones. Their communication is affected by distance in geographical space. The cultural and professional backgrounds of the members of international groups vary as well. These different forms of distances, for example, geographical, cultural and professional, generate particular social dynamics between the group members and their creation of collaborative knowledge. The groups face the opportunity and challenge of diversity. On the one hand, the international (Maddux & Galinsky 2009) and different backgrounds of researchers allow multiple views and skills which can benefit the creation of novelty (Intemann 2009: 261). On the other hand, different researchers communicating mostly with their non-native language might not come upon a common understanding that is necessary for group work (Nooteboom *et al.* 2007). Therefore, there is also distance in cognitive space.

This thesis focuses on academic knowledge creation in international research groups. Knowledge creation is theoretically considered to be a triangle formed of the intertwined corners of knowledge, processes and contexts that are combined through people. Knowledge, an interpreted justified true belief, exists in a continuum of explicit and tacit dimensions of knowledge. Explicit dimension is communicable, for instance, with language, whereas tacit, for example, riding a bike, is difficult to explain (Polanyi 1983: 4). Knowledge creating processes include interaction and interpretation. Researchers interact with each other and with their surroundings by discussing, writing and applying, for example. They interpret their everyday world and interaction by organizing it into mental maps that guide working. Mental maps consist of concepts and statements and their interrelations (McComb 2007). Interactive and interpretative processes progress knowledge through socialization, externalization, combination and internalization (the SECI model by Nonaka & Takeuchi 1995). The research groups aim to form a common understanding by becoming cognitively proximate (Boschma 2005, Nooteboom 1992), or by sharing parts of their mental maps. Contexts include arenas and space-times. Physical, mental and virtual *ba*s (Nonaka & Konno 1998) are arenas of knowledge creating discourses. Material, communicative and cognitive spaces are combined with linear and relational times into space-times of knowledge creation (Dodgshon 2008).

The overall aim is to understand in more detail the processes and contexts of academic knowledge creation in international research groups. This aim is empirically approached through two case studies that are reported in the articles

I–IV. Case A of the University of Oulu includes a survey (67 answers) that was collected in 2005 from foreign employees and 12 interviews of the members of three international case research groups from the faculties of Humanities, Science and Technology in 2006–2007. The interviews are analyzed with content and discourse analysis and the survey with cross-tabulation (χ^2-test) and Pearson's correlation. The articles I and II, consider case A. Case B focuses on the four scientific and technological groups of the Finland Distinguished Professor (FiDiPro) programme. The FiDiPro programme funds distinguished foreign professors to build new research groups and projects in Finnish universities. These groups are temporally geographically dispersed, since the professors travel between their home and Finnish universities. The beginning stage of the FiDiPro groups has been followed during 2007–2009. The main materials include 25 interviews, 120 weekly diaries and the observation of seven events. The main methods applied are mental mapping and content analysis. These studies are reported in articles III and IV. All of the groups are international, since they include both foreign and Finnish members, publish articles in international forums and attend international conferences, for example.

This thesis mainly contributes to (academic) knowledge creation studies in the fields of knowledge management, economic geography and science and technology studies. Within these fields, there is need for additional studies on knowledge creation in different kinds of groups (e.g. Garcia-Perez & Ayres 2009: 62), especially those that are international and geographically dispersed (e.g. Chen *et al.* 2010: 240). Neither is known enough about the processes (e.g. Hong *et al.* 2010: 62) and contexts (e.g. Choo & de Alvarenga Neto 2010: 606) of knowledge creation. Much of the research in knowledge management and economic geography adopts a rationalist approach that sees knowledge as an object and extracts knowledge from people (see chapter 2.4.1 Approaches to knowledge..). Therefore, there is a call for a more holistic and people focused approach to knowledge (e.g. Jakubik 2011), especially one that includes a cognitive dimension (e.g. Harquail & King 2010: 1619). A more holistic view to knowledge is provided by the constructionist-cognitive approach of this thesis. This approach views knowledge creation as an intertwined triangle and includes a cognitive dimension of interpretation, mental maps, mental *ba* and cognitive space. The needs for further studies are formulated into the research questions of this thesis (see chapter 1.2 Research questions..).

This thesis shows knowledge creation as a spatio-temporal process. It is a complex process of interactive tacit-explicit and never ending continuums (article

I). The creation of knowledge is an untamed process with twists, turns, tacitness and, often, unpredictable results. Enough complex interpretations of the researchers and common understanding enable the forming of cognitive friction, which is a fertile ground for the creation of novelty (article III). Multiple technical, scientific and humanist knowledges are created in multiple bas through group-specific discourses (article II). Knowledge itself is a spatio-temporal process of stages, flows and disruptions towards the not-yet-known (article IV). The results confirm knowledge, its creation processes and contexts form an intertwined triangle by individuals and groups.

1.1 Internationalizing Finnish universities

The internationalizing and reforming Finnish universities are an interesting empirical context for the study of knowledge creation in international groups. Next, this context is discussed in brief and the decision to focus empirically on two cases among the Finnish universities is justified. Article II of this thesis includes a comparison of the most recent strategies in 2008 of the ten Finnish multidisciplinary universities. The comparison included general and international (or internationalization) strategies. If the university did not have an international strategy, a human resource strategy was included. Only half of the universities had an international strategy, the University of Oulu being one of them. The comparison revealed that although all of the universities strive for internationalization in their strategies, the University of Oulu stands out. The international ambitions related, for example, to increasing the amount of foreign employees are the most detailed and internationality overall, are notably emphasized a great deal.

The amount of foreign employees in the universities is increasing (figure 1). Therefore, research is increasingly performed in groups consisting of researchers from varying nationalities. In the University of Helsinki, which is double the size, the absolute number of foreign employees exceeds that of the University of Oulu. However, compared to other multidisciplinary universities, the relative number of foreign employees in the University of Oulu is large: even larger than in the University of Helsinki. These are the reasons that the University of Oulu has been selected as case A for this thesis.

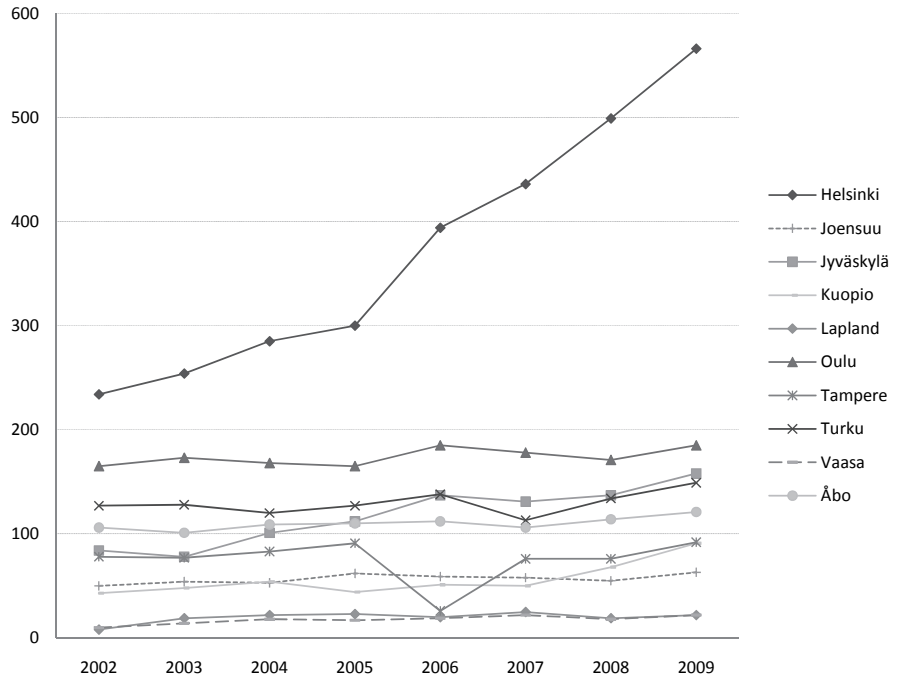

Fig. 1. The number of foreign staff in Finnish multidisciplinary universities in 2002–2009 (Statistics Finland 2011).

Another measure to enhance the international competitiveness of Finnish Universities is the FiDiPro programme. It was launched in 2007 to attract distinguished foreign researchers to Finnish universities. The peripheral, cold and small country with low salaries and high taxes has not attracted distinguished experts from abroad (Raunio 2001). The FiDiPro programme offers competitive funding for large scale cutting edge research projects. By the year 2011, 70 distinguished scholars and their groups have been funded by the programme (FiDiPro 2011). The FiDiPro is a key channel for building distinguished international research groups in Finland. Therefore, the FiDiPro groups were selected as case B of this thesis.

The ability to respond quickly to changing global conditions framing the internationalizing and competing university realm requires a flexible university organization. From this viewpoint, the Finnish university system is unable to meet the requirements of globalization (Ministry of Education 2007: 9). According to Etzkowitz & Viale (2010: 595), universities globally are undergoing the third academic revolution of becoming more international and entrepreunial. In

Finland, this has led to university reforms. From the beginning of 2010, all Finnish universities became independent legal entities instead of being governmental units. One major change is the establishment of the world class Aalto-university, which unites the Helsinki School of Economics, School of Art and Design Helsinki and Helsinki University of Technology. Another major change pertains to funding, which is only partly secured by the government — now, universities collect their own funds. Under the reform, it is even more important to promote the establishment of good international research groups and good knowledge creation management.

1.2 Research questions

The thesis consists of two sets of research questions. The first level questions (A–C) are formulated for this synopsis. The needs and calls for further research in current research on (academic) knowledge creation are the basis of formulation. The second level research questions (Ia–IVb) are those posed and answered in the four articles. Each article takes selected theories forward. Articles I and III are focused on the processes of knowledge creation, whereas, articles II and IV concentrate on the knowledge creation contexts.

Research question A: *what are the appropriate processes of interaction and interpretation of knowledge creation like in international research groups?* (Mainly articles I and III)

Article I (Hautala 2008)

Ia. What kind of knowledge do the selected research groups utilize?

Ib. How is knowledge shared and conversed about from the viewpoint of foreign employees in the University of Oulu?

Ic. How is knowledge created and refined in the selected research groups?

Article III (Hautala 2011b)

IIIa. How do the research group members become cognitively more proximate or maintain their distance?

IIIb. During what cognitive proximity or distance are the results in a study-period achieved?

Knowledge creating processes, and especially their cognitive dimension, require further case study research. Question A contributes to this need. Article I focuses on a more general level of knowledge creation and interaction process (the SECI model). The second process of knowledge creation is interpretation, or mental mapping. The similarity of the group members' mental maps is called cognitive proximity. Article III goes into the group-specific knowledge creation and also considers the interpretation process. When the group members consider these processes to be appropriate for achieving the aims of their projects and their work progresses into explicit results, the processes are considered to be "appropriate".

> Research question B: *what are the central contexts of knowledge creation like in international research groups?* (Mainly articles II and IV)

Article II (Hautala 2011a)

> IIa. In what kind of *ba* (as a virtual, physical and mental context here) do the research groups create knowledge?
>
> IIb. What does *ba* (as an arena of discourse here) consist of in the research groups?

Article IV (Hautala & Jauhiainen 2011)

> IVa. What kind of combinations of space and time exist in the knowledge creation processes?
>
> IVb. How are these combinations of space and time related to the knowledge creation of individual researchers and research groups?

Not enough is known about the context of knowledge creation, especially about the context that is more than the physical environment (e.g. Sismondo 2010: 11). Question B is formulated to contribute to the filling of this gap. The two theories selected to study the context of knowledge creation are *ba* (article II) and space-time (article IV).

> Research question C: *how are the processes and contexts of knowledge creation related to the explicit results achieved in international research groups?* (articles I–IV)

Question C expands the details of knowledge creating processes and contexts through connecting them to actual explicit results received by the groups. Therefore, this question further contributes to filling the gaps in current research

on processes and the contexts of knowledge creation. The explicit results that the groups achieved include texts, for instance articles, research plans and calculations, technological devices such as prototypes and software, and new or enhanced research methods and concepts. This research question is answered on the basis of all articles. A summary of all the articles is in table 1.

Table 1. A summary of the articles.

Article	I: Internationalization of knowledge creation at the university.	II: International academic knowledge creation and *ba*.	III: Cognitive proximity in research groups.	IV: Spatio-temporal processes of knowledge creation
Questions	Ia. What kind of knowledge do the […] groups utilize? Ib. How is knowledge shared and conversed about […]? Ic. How is knowledge created and refined in the […] research groups?	IIa. In what kind of *ba* […] do the research groups create knowledge? IIb. What does *ba* […] consist of in the research groups?	IIIa. How do the […] members become cognitively more proximate or maintain their cognitive distance? IIIb. During what cognitive proximity or distance are the results […] achieved?	IVa. What kinds of combinations of space and time exist […]? IVb. How are these combinations of space and time related to the knowledge creation […]?
Theory	SECI (process)	*Ba* (context)	Cognitive proximity (process)	Space-time (context)
Case	Case A	Case A	Case B	Case B
Material	Interviews, survey	Interviews	Interviews, diaries, observation	Diaries, interviews, observation
Method	Content analysis, cross-tabulation (χ^2), Pearson's correlation	Discourse analysis	Mental mapping	Content analysis
Results	Ia. Knowledge along a tacit-explicit continuum Ib. Through interactive activities (e.g. discussions) that converse knowledge in the continuum Ic. Through group specific complex progress, including the (simultaneous) SECI stages in loops and skips	IIa. Combinations of physical, virtual and mental *ba*s that promote the creation of certain knowledge with a certain discourse. IIb. Knowledge type (e.g. humanist, technological and scientific), individual characteristics and structural factors (administration)	IIIa. Cognitive proximity is received in face-to-face collaboration within a suitable task. Cognitive distance is maintained in collaborations beyond the group, applications of individual views and by employing new members. IIIb. During cognitive friction that enables a shared understanding of the project and individual interpretations.	IVa. Time-space of stages, space-time of flows and disruptions and spacetime of knowledge network. IVb. Space-times enable knowledge to become known. Shared space-times enable group members to collaborate in distant geographical locations.

1.3 The structure of the thesis

The present thesis consists of five elements: four independent articles and a synopsis that compiles their theoretical and empirical interrelations. In addition to an introduction, the synopsis consists of four sections. The second section, "Academic knowledge creation", builds the theory on academic knowledge creation and identifies needs for further empirical research, which are addressed in this thesis. These gaps are identified among the interdisciplinary research fields of knowledge management, economic geography and science and technology studies, among others. The third section, "Methodology and empirical study" presents the study design, as well as ponders the methodological underpinnings adopted in this study. In the fourth section, "Review of the results", the main findings of the articles and answers to the second level research questions, Ia–IVb, are presented. In "Discussion and conclusions" of the fifth section, the first level research questions A–C are answered, and the empirical and theoretical contribution of this thesis is considered. Based on the results, further conclusions and future research areas are discussed. When referencing other parts of this synopsis in the text, a mention of "section" refers to text under titles 1, 2, 3, 4 and 5, whereas "chapter" refers to text under their subtitles, for example, 1.1.

2 Academic knowledge creation

The aim of this section is to build the theoretical framework and identify needs for further research areas suggested in current research. The strategy to contribute towards filling these gaps is outlined. The chapter consists of two parts. In the first part, theoretical underpinnings of academic knowledge creation are discussed. Academic knowledge is defined and presented as being intertwined with its creation processes and contexts, which are presented as the corners of a triangle in figure 2. People and groups connect these corners into a triangle of knowledge creation. A similar approach can be found, for example, in education research (Brown *et al.* 1989). Each corner of the triangle is discussed in turn. The four more detailed theories are included in the articles of this thesis, from which two concern processes and two contexts of knowledge creation are placed in this discussion. Literature is mainly focused on the fields of knowledge management, economic geography, and science and technology studies. In the second part, the interdisciplinary field of knowledge creation studies is discussed and five main empirical gaps in current research are pinpointed.

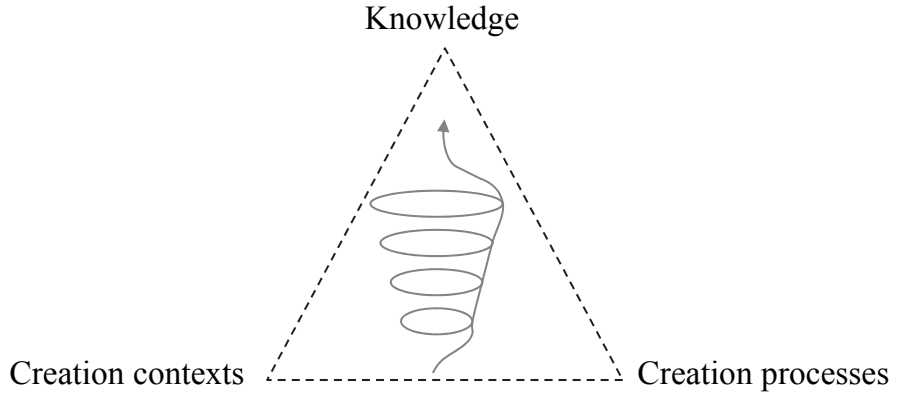

Fig. 2. Academic knowledge creation is comprised of knowledge, process and context.

2.1 Academic knowledge

Academic knowledge is defined as *individually interpreted "justified true belief"*, following Plato (1977) and Nonaka & Takeuchi (1995: 21). Knowledge, therefore, resides in individuals. They interpret knowledge, which means relating the piece of knowledge within their mental map by organizing key concepts and

statements (e.g. Johnson-Laird 1983). All interpretations are unique, since no two persons would have exactly the same mental maps (more about interpretation in chapter 2.2 Academic knowledge..). Therefore, knowledge is individually interpreted.

Knowledge is academic when it is a justified and true belief within academic rules. Justification is an important process in academia. It includes argumenting the importance and originality of the knowledge created and proving that the process of creating has been done according to field-specific rules in the epistemic community (Knorr Cetina 1999). Through the social networks of the members of epistemic communities, micro-scale interaction is transformed into wide patterns of thought and then reflected back to the research groups (Granovetter 1973: 1360). These thoughts specify what is justified as knowledge. In academic papers, justification is shown through referencing to other studies. Also, peer-reviews, presentations and related discussions identify a further need for justification and usually follow some type of revision process.

Academia is a system of knowledge creation that is organized as universities, research institutions, academies such as the Finnish Academy, funding bodies, and also includes forums connecting researchers, for example, journals and associations. Academia itself is one form of organization, which sets the explicit and implicit rules to guide the behavior of members to achieve goals (Strati 2000: 1, Swieringa & Wierdsma 1992). Organization is the framework of common understanding, a lense that focuses interest, sets rules to justify knowledge, and institutions for knowledge creation. The aim of an organization is to arrange work and people in a way in which they maximize the quality and efficiency of production. Researchers across the globe might be included to this organizing, for example, phycisists have performed experiments including 2000 participants from 200 institutions that have taken twenty years to complete (Knorr Cetina 1999: 159–160). In this perspective, academic knowledge is "social" (Rolin 2008: 115). It is also social, since researchers work following social values (Anderson 2004) and collective beliefs (Gilbert 2000) within their networks (Jöns 2009).

The organization here is, in hierarchical terms, a superior entity for an individual and a group, for example, academia, field and university. Some of the academic rules are common for the entire academia, such as being aware of paradigms and following the ethics of telling the "truth" (Gourlay & Nurse 2005). According to Kuhn (1996: 23), paradigm is the accepted model to create knowledge in a certain field. Paradigms regulate power in society by deciding whose voice will be considered to be the "truth" (Foucault 1986: 131–132). As

knowledge cumulates, new frameworks and interests are developed, which challenge existing paradigm. When theories are tested, some of them are verified for now and some are falsified (Popper 2000: 33). This takes place in an open society that is transparent and supports the criticality and plurality of viewpoints (Popper 1966: 176,188). Feyerabend (1976: 17) considers science to be anarchistic since creating knowledge "against method" is what regenerates theories and knowledge. What is regarded 'knowledge' and how this 'knowledge' is created differs among academic fields and times. Characteristic for today's post-modern academic knowledge creation is fragmentation, a paradigm of multiple acceptable ways to create knowledge, which has, in many fields, led to the formation of sub-fields and increasingly detailed research approaches. Other rules are field-specific, for example, the methods to reach knowledge differ among fields (see chapter 2.1.1 Field-specific..).

Belief is "a feeling that something is true" (Wray 2007: 340), therefore, it "aims at the truth" (Hattiangadi 2010: 422). According to Wray (2007: 40), collectives only have acceptances. Groups can adopt views which result in compromises that not all single members would totally agree upon. However, these joint commitments are considered to be collective forms of knowledge (Rolin 2008: 117–119). Truth is not a "view from nowhere" (Shapin 1998: 5), but is always affected by local contexts. The local truth claims achieve universality (Powell 2007: 312) when they are shared and developed in global epistemic communities. Despite being greatly used, many philosophers do not consider "justified true belief" to be enough to reach knowledge (e.g. Turri 2010: 1). However, this is not discussed further, since it has not been evaluated whether the groups studied in this thesis create knowledge in a philosophical sense. The most important matter here is that the group members themselves consider to be creating knowledge. Although "justified true belief" is often associated with rationalist understanding (e.g. Amin & Cohendet 2004: 18), it should not be so. The message of that sentence depends on how the words are understood (Tuomi 1999: 97). In this thesis, the definition is applied from a constructivist viewpoint, according to which, knowledge is created in interaction (see chapter 2.2 Knowledge creation..). Thus, this is discussed more in section 3 (Methodology and empirical..).

Understanding of knowledge in this thesis can be illustrated through an article, a central piece of knowledge in academia. An article is knowledge for its authors. It has been reviewed by experts of the field, according to the rules of the journal and epistemic community. Knowledge is also justified in text, as the

content is discussed with previous research results. The article can become knowledge for those readers, to whom the subject is relevant and who possess the ability to interpret it. This requires interacting, which in this case is done by reading.

An understanding of what is not knowledge is considered with the help of the definition of knowledge. If people fail to interpret a message, they cannot create knowledge from it. The process of interpretation creates knowledge from information (Davenport & Prusak 1998: 2–6). Knowledge differs from information, or a chain of marks (data) that is relevant and has a purpose. Relevance and purpose are justified through setting the piece of knowledge into a wider context, which can be, for example, a mental map, societal need or organizational aim. It is important to notice that the article is not knowledge without a knower: a pile of paper printed out from the journal is only information. Thus, information can be extracted from people. Meaningful knowledge is created in the processes of interaction and interpretation. Information has an ability to be further created into knowledge, for instance, when a dataset on temperatures is applied to a research on climate change. However, there is no clear line or exact moment between information and knowledge. For example, different epistemic networks consider information and knowledge differently. Only knowledge brokers, people who understand several fields, might be able to bridge the structural holes in the networks and translate information into knowledge within a new field (Burt 2004).

If something cannot be justified, it is not knowledge. For example, plagiarized work that is stolen from another researcher is not knowledge. Without proper references or contracts, it is not justified (LaFollette 1992: 33). In addition, if something is not true belief, it is not knowledge. Truth in this thesis has a reflection in the wider empirical setting of scientist, technological or humanist knowledge. In other words, academic knowledge is not reached through the falsifying of scientific data, trying to apply misunderstood chemical laws in constructing a technical device or claiming all people think similar, even though only children have been interviewed.

This kind of knowledge is a continuum of explicit and tacit dimensions. *Explicit knowledge*, or codified knowledge, is communicable through a systematic set of codes, for example, through language, pattern or model (Nonaka & Takeuchi 1995: 59). Explicit knowledge includes entities (objects) and strings (Collins 2010: 9). Strings are patterns in elements, such as writing in a paper. According to Pavitt (1998: 795):

> ‘‘one of the main purposes of academic research is to produce codified theories and models that explain and predict natural reality’’.

Tacit knowledge is based on human understanding: people know more than they can tell (Polanyi 1983: 4). It is difficult to split into explicable elements, since tacit is an entity which combines personal interpretation, interaction, context and working practices (Choo *et al.* 2001: 35, Goffin & Koners 2011: 300, Leonard & Sensiper 1998: 112–113). Tacitness is embodied in body, in mind and in society. Tacit knowledge is claimed to be central in the innovative capability of people and organizations (Nonaka & Takeuchi 1995; Leonard & Sensiper 1998).

In research work, thinking is deliberately brought “to the surface” (Collins *et al.* 1991) and some tacit knowledge is therefore expressed and conversed to explicit. Collins (2010: 11) divides tacit knowledge into relational, somatic and collective dimensions on the basis of why knowledge is tacit. Relational stays tacit because people fail to understand what needs to be shared. Therefore, some of it has the potential to be explicated, or at least shared through socialization. For example, riding a bike can be explained in principal, but in practice, it includes such an amount of simultaneous detailed elements that it stays tacit. Nonaka & Takeuchi (1995: 8) identify two forms of tacit knowledge: technical, or the know-how in “the fingertips”, and cognitive, which is rooted in the (un)conscious mind with the ability to make sense, connect patterns and predict through mental models and beliefs. Collins (2010) categorizes these into relational tacit knowledge. Somatic tacit knowledge can be explicated, at least partly, but limitations of the human body and brain prevent the application. For instance, many scientific calculations and technical modelings are such that only computers can process them. Collective tacit knowledge is the “strong” form of tacit knowledge, since it cannot be explicated. Still, an individual that is embedded in society, learns this.

The division of knowledge dichotomically into tacit and explicit has been criticized, since tacitness exists in all knowing (Polanyi 1983, Tsoukas 1996: 17). There are three ways to deal with this issue. The first is to avoid discussions on tacit and explicit and focus on, for example, knowledge bases or strategies to search knowledge (e.g. Moodysson *et al.* 2008: 1040, Trippl *et al.* 2009). This approach has not been applied in the thesis since much of the discussion about knowledge is organized around tacit and explicit, especially in the fields of knowledge management and economic geography. In addition, a researcher who studies knowledge creation in the field, needs to be aware of how to observe and

what to ask to reach (some of) the tacit. The second strategy would be to accept tacit and explicit as simultaneously existing elements of knowledge. However, this strategy lacks the dynamics of changing (some) tacit into explicit and (some) explicit into tacit. In the work of researchers, and especially in international research groups, the ability to clear expression and explaining "hunches" is important. Therefore, the third strategy is adopted, when tacit and explicit is considered as a continuum, not as divided entities (Leonard & Sensiper 1998: 113). This has been concluded to be a good perspective, for example, in knowledge management studies (e.g. Jasimuddin *et al.* 2005: 102) (see chapter 2.2.2 Socializing, externalizing..).

Let us return to the previous example of the article as a piece of academic knowledge, and tacit and explicit as opposing ends of the same continuum. Knowledge can therefore combine different shares of tacitness and explicitness, but all knowledge has a tacit dimension, as all knowledge is known by somebody. For the authors, the article's knowledge probably has deeper tacit (relational and somatic) roots than the readers. Yet, through interpretation, the tacit framework of the reader, which includes collective tacit knowing of "being a member of an academic community", is combined with the article. The article becomes knowledge and parts of it have been conversed from more explicit to more tacit manifestations in the continuum.

2.1.1 Field-specific academic knowledge

Field-specific knowledge is affected by funding sources, publication media, the audience for research results and the reputational autonomy of the academic elite (Whitley 2006: 1157). The field in this thesis is understood as consisting of the people that researchers consider to be their academic community. These people cite each other in the articles and meet in conferences, for example. They form epistemic cultures (Knorr Cetina 1999) or academic tribes (Becher 1989) for the creation of field-specific knowledge. The vague boundaries of different fields are shown in the networks as structural holes that lack connections or are only tied by a few people who understand many fields (Burt 2004: 350).

Three broad fields are included in this thesis: scientific, technological and humanistic. Common to scientific (analytic) and technological (synthetic) knowledges is their empirical-analytic nature that aims to predict and control natural phenomena (Habermas 1972: 308–309). Both scientific and technological knowledge are mostly hard sciences creating knowledge with mathematical and

statistical methods. The scientific and technological understanding of the focus of research differs, which creates analytical and synthetic knowledge bases (Laestadius 1998: 222, see also Coenen *et al.* 2006). Scientific knowledge, for example, in the fields of physics, mathematics, chemistry and biology, aims for the pure scientific understanding of nature through finding conformances with the law. Science is based on analytical activities that strive for an understanding of the details of phenomena, which are isolated to be the focus of research. Technology is applied science which aims to apply the laws to further develop devices and practices for human needs (Eto 2008, see also Laestadius 2000). It is created in synthetic activities that aim at building and designing systems. The integration of components into a system requires an understanding of the sub-systems. Humanist knowledge applies "soft" methods of, for example, interviewing and discourse analysis, since the aim of knowledge is to understand the human experience and social world that speaks (Habermas 1972: 309–310, Luckmann 2008: 280). Therefore, humanist knowledge is distinguished from "hard" scientific and technological knowledges.

Field-specificity is quite often expressed through analytic, synthetic and symbolic knowledge bases, especially in economic geography (Asheim 2007: 224–228, Coenen *et al.* 2006, Laestadius 1998: 222). These knowledge bases are derived from industry, for example, medicine (analytic), information technology (synthetic) and design (symbolic). The symbolic knowledge base relates to artistic industries, such as poetry or filmmaking, with cultural and aesthetic values in knowledge creation (Asheim 2007: 226–228, Scott 1998). The knowledge base thinking is not applied in this thesis for two reasons. First, humanist knowledge does not exist as a knowledge base, since the traditional innovation industries, whose result is a marketable and explicit product, do not include sectors such as the health service or teaching, or an academic humanistic field. What is contradictory here, is that the knowledge created in these fields are nowadays increasingly included in the definitions of "social", "open" and "service" innovation (Chesbrough *et al.* 2006, Mumford 2002, Tekes 2008). Second, knowledge bases may guide researchers to think that knowledge in an industry or company is created according to one certain knowledge base. However, an individual's expertise consists of elements from all knowledge bases (Moodysson *et al.* 2008: 1053–1054). For example, an engineer designing a new mobile phone not only applies synthetic thinking, but also analytical thinking when considering the chemical characteristics of a material. They interpret the symbolic knowledge of, for example, commercials, which affect their ideas of the consumers' desires.

When they interact with others, they apply hermeneutic thinking of aiming to understand, help and ask for help.

These restrictions also consider the field-specific thinking which is adopted in this thesis. Humanist, technological and scientific realms are further divided into fields and sub-fields, from which some are interdisciplinary and combine the realms. Therefore, this dividence is a simplification of academic knowledge, but useful since academia is organized around them, for example, as faculties. Technical, scientific and humanistic realms are considered to be wide frameworks and each group's knowledge creation process is studied in detail.

2.2 Academic knowledge creation processes

The main knowledge creation processes and mechanisms of individual and collective learning are interaction and interpretation (Daft & Weick 1984: 286, Johnson-Laird 1983, Kelly 1955, Levitt & March 1988, Nonaka & Takeuchi 1995, Webb 1989). Researchers form groups to create knowledge through these processes, which are approached in the articles with two more detailed theories. The first is the theory of interactive knowledge creation through socialization, externalization, combination and internalization (SECI) (Nonaka & Takeuchi 1995). The SECI model focuses on group interaction as a source of tacit and explicit knowledge conversions, which eventually leads into the creation of new knowledge. The second is the theory of cognitive proximity (Nooteboom 1992: 2000), which explains the creation of novelty in a group through the different knowledge bases of individuals (understood here as mental maps). The focus here is both on interpretation and interaction processes. In this thesis, process is understood to evolve in (linear) time towards a goal. This section is organized as follows. The first part focuses on interaction and interpretation, the second to a group as a knowledge creating entity, the third discusses the SECI model and the fourth, cognitive proximity.

Knowledge is created through interaction. Studies show that groups with a high level of interaction more likely reach innovative results (Barron 2003, Lechler 2001). Interaction, defined in this thesis as a knowledge creating activity, that is practiced in relation to those artifacts, organizational elements (e.g. written and unwritten rules) or other people that are essential for the knowledge creating task or for the interacting persons themselves. The "essential" consists of interaction which either helps or hinders the people in their knowledge creating

task. The first form of interaction takes place when people interact with a non-human environment, for example with artifacts and other material surroundings.

The second form of interaction, human-human interaction is two-sided because of the reciprocity of expressive acts (Berger & Luckmann 1967: 29). People use a large number of senses in communication: they do not only speak and listen, but also see, smell, move and position themselves in relation to others (Scheflen 1975: 160). In addition to the depthness of face-to-face communication, it also takes place in the "now", when there are no time-lags (Storper & Venables 2004: 354). Therefore, face-to-face communication is claimed to be the key medium in knowledge creation, and also a way to share tacit elements of knowledge (e.g. Collins 2001, Goffin & Koners 2011, Nonaka & Takeuchi 1995). The "stickyness" of tacit knowledge is associated with the local as localized learning, "buzz" and "being there" (Gertler 2003, Markusen 1996, Maskell & Malmberg 1999, Storper & Venables 2004). However, not all scholars believe that tacit knowledge is only shared face-to-face (e.g. Amin & Cohendet 2004: 95, Faulconbridge 2006: 517). Virtual communication media, for example, e-mail, phone and skype, do not transmit as wide a variety of signals as face-to-face communication. Therefore, the potentiality of virtual media for sharing tacit knowledge is smaller. Despite this, virtual media is essential in knowledge creation. In addition to how knowledge is created, the position of the individuals in their networks has an affect on what is shared. According to Burt (2004: 386), the individuals who are more likely to share valuable ideas, have networks that straddle structural holes, for instance, between fields or groups.

Common to both face-to-face and virtual communication in academic knowledge creation is the central position of (English) language. Vocabulary is the basis for academic articulation. Therefore, language is the "vehicle of knowing" (Renzl 2007: 46). Vocabulary also forms the building blocks of discourse, which is "a connected set of statements, concepts, terms and expressions" (Watson 2003: 113) forming a shared way for a group of researchers to write and talk about research. Arriving at knowledge is "travelling in discoursive space" (Xu 2000: 428). Indeed, many of those field-specific rules for academic knowledge are manifested in discourses.

Interpretation and interaction are interrelated: interacting or reacting properly requires interpreting the message. Interpretation is defined as placing the message of interaction, which is central for a knowledge creating task, in relation to a personal knowledge base, or mental map. In these knowledge bases, knowledge is organized as mental models that are incomplete representations of the world

(Johnson-Laird 1983, Norman 1983). In other words, interpretation is mental mapping (e.g. Eden 2004). The existence of an interpretation process and its result (a dynamic mental map), as well as mental *ba* and cognitive space, is called a cognitive dimension in this thesis. It is quite a narrow approach to cognition or information processing, which includes, for example, the style of thinking, memorizing, classifying and drawing conclusions (Donin & Theureau 2007: 236, Hayes & Allinson 1998: 850, Sternberg 1997: 19). However, as will be showed in chapter 2.4 (Interdisciplinary research..), there is a call for a cognitive dimension in knowledge creation studies. The approach of this thesis is one interesting step that can be developed further.

Mental models offer action plans and routinize behavior. For example, a researcher has an action plan for conducting research: identify a research problem, collect material, analyze material and write an article. Each stage of the plan is manifested as a more detailed mental model. While doing their work, researchers make sense of the field-specific rules of knowledge creation and anticipate the promising directions of future research. Making sense and anticipating events are tools of the human mind for controlling the world, and derive from mental models (Johnson-Laird 1983, Kelly 1955, Weick 2001). The mental models are formed out of two building blocks. The first is the content, which includes concepts and statements. The second is the structure. According to personal associations, certain concepts and statements are linked, while others are not. This forms a networked structure to the mental map (Carley & Palmqvist 1992, Klimoski & Mohammed 1994, McComb 2007: 99). Placing a new concept or statement onto this map is interpretation. Some messages find their places when individuals learn and expand their knowledge bases. Some messages are misinterpreted, which leads to incorrect sections in the knowledge base. Some messages are not relevant for an individual's knowledge base and their placing would require learning the basics of a new field.

The processes of interaction and interpretation are intertwined with knowledge. First, the definitions of knowledge usually commit towards interpretation and/or interaction. For instance, "justification" in "justified true belief" is performed in interaction with the (epistemic) community and non-human surroundings. In addition, many definitions bring out tacit and explicit knowledge and their different ways of sharing (interacting) (Balconi *et al.* 2007: 825–828). Second, knowledge does not exist without interaction since we do not find out research results without interacting with laboratory equipment, software, literature or people. In addition, if knowledge is considered to be something that

is understood or applied in practice, interpretation is required to arrive at this knowledge.

2.2.1 Knowledge creating group and diversity

A group is the foundation for knowledge creation processes. Knowledge is increasingly created in groups, since their capability to innovate and perform in complex tasks exceeds that of lone inventors (Amin & Roberts 2008, Hoegl & Parboteeah 2007, Nonaka & Takeuchi 1995, Salas *et al.* 2008, Singh & Fleming 2010). A group is an organized set of people, working together towards a common objective (Rolin 2008: 118). A group is the unit in which the similarities and differences of the members become visible and reflect their work.

The focus of this thesis is international groups, whose members have different nationalities, they mainly communicate with a non-native language, aim to create internationally renowned knowledge in their fields, and participate in international conferences, research networks and collaborations. Nationalities have been classified according to their cultural values (e.g. Schwartz 1999). One such value is the nature of the relation between an individual and a group. In collectivist cultures, for example, in China, people tend to be considered embedded in a group, whereas in individualist culture, for example, in Canada, people are viewed more often as autonomous individuals (Schwartz 1999: 27, Thomas *et al.* 2010: 1442). Finland is quite an individualist culture (Hofstede 2001: 249). Another value is the power distance, which, in an organization, measures the difference between the employees' possibilities to determine each others' behavior (Hofstede 2001: 83). This hierarchy is approved by leaders and subordinates and supported by the social environment. According to Hofstede's (2001: 87) comparison between fifty countries, Finland is number 46, with a short power distance.

Spoken and written language is in an important role in academic knowledge creation, since academic knowledge is expressed through language in discussions, presentations and texts. The native languages of international group members might differ. Such academic groups usually speak English, which is the language of the academic world and enables knowledge to be widely shared and progressed (Ferguson *et al.* 2011). For example, in Finnish universities, students are trained to use English throughout their studies. Despite this, there is a risk of misunderstandings in a group whose members communicate with their non-native language.

Diversity in groups can benefit or hinder creating novelty. According to Jackson *et al.* (1995), diversity in groups can be task-related (e.g. education or experience) or relations oriented (e.g. cultural background), and it can be readily detectable (e.g. age or sex) or underlying (e.g. personality or values). The diversity in the focus of this thesis is relations oriented cultural background (nationality of birth) and task-related professional background. Both the professional academic experience (measured in years and accomplishments, i.e. articles, rewards, titles) and the sub-field of the researcher are included in the professional background. Different research projects can benefit from different kinds of diversities (Intemann 2009: 262). For example, research on global issues such as climate change and its local effects might benefit from diversity in the researchers' nationalities, whereas research on voting might benefit from diversity in the researchers' political standpoints.

Both interaction and interpretation explain the innovative capability of diverse groups. Interpretation is unique because knowledge bases are individual. Members of a group all have different views of the research problem. Diverse views lead to cognitive distance (e.g. Nooteboom *et al.* 2007), relational tension (Fridholm 2010) or relational distance (Ibert 2010).These views are negotiated, explained and reformed through interaction. In a group, interactive knowledge creation, at best, achieves novelty that could not be achieved alone. It is like building a ladder: each member can reach further when interpreting and reacting to previous comments. Because of the members' different knowledge bases, diverse work groups can expose the group to a wider variety of external knowledge (Cummings 2004: 352). There are more methods and materials to build the ladder. The intersection of ideas, concepts, fields and cultures is the most fertile ground for novelty. This intersection creates a "medici effect" of learning with an open mind (Johansson 2004: 2–3). According to Burt's (2004: 349) study, the people "in between" the fields, called knowledge brokers, see more possibilities and create ideas that are more likely to be valuable.

The international experience of researchers affects creativity: living abroad and gaining multicultural experiences increases an individual's ability to reach creative results (Leung & Chiu 2010, Maddux & Galinsky 2009). In addition, highly mobile professors can improve the quality of a research unit (Jöns 2010, Meusburger & Schuch 2010). Results on the effect of varying cultural backgrounds on knowledge creation are mixed. Cultural diversity has been found to benefit (e.g. Dahlin *et al.* 2005, Elron 1997, Lee *et al.* 2004, Niebuhr 2010), having no effect (e.g. Østergaard *et al.* 2011), or hinder (e.g. Dahlin *et al.* 2005)

knowledge creation through communication difficulties. The diversity of education and knowledge bases has been found to benefit knowledge creation (Niebuhr 2010, Østergaard *et al.* 2011). However, the line between optimal, too much and too little diversity in knowledge creation is fine (Nooteboom *et al.* 2007) (see chapter 2.2.3 Cognitive proximity). The ability to exploit diversity is group-specific. If interacting participants are able to create a common understanding, there is the possibility to find new insights (e.g. Fridholm 2010: 88–89) and learn from others. If not, diversity may become a burden and hinder knowledge creation. When the group-members have wide or similar absorptive capacities, they are more likely to find a common understanding (Cohen & Levinthal 1990: 132–133). The absorptive capacity of an individual includes the phenomena that they observe and can make sense of, defined by their knowledge base. Absorptive capacity is built from organizational elements, such as rules, the focus of interest and aims (Nooteboom 1992, Nonaka & Takeuchi 1995). Even though groups have wider possibilities to absorb knowledge, a group's absorptive capacity is not simply a combination of the individual absorptive capacities. The members form a group-specific absorptive capacity through shared elements in an organizational framework.

2.2.2 Socializing, externalizing, combining and internalizing knowledge

According to the SECI model, interaction creates knowledge through conversing knowledge, or re-placing knowledge in a tacit-explicit continuum (Nonaka & von Krogh 2009: 640–641, Nonaka & Takeuchi 1995: 62). Knowledge is created through four stages. In the first stage of socialization, tacit knowledge is shared and created between individuals, mainly through face-to-face communication. Tacit knowledge is conversed to explicit in the second stage of externalization. The group can exploit, for instance, new concepts, sketches, and prototypes. During the third stage, explicit knowledge is widened through combining knowledge into another existing knowledge and sharing explicit knowledge in the organization. Finally, the explicit knowledge is internalized and conversed into tacit knowledge, when individuals apply the knowledge. These four stages form a spiral of knowledge creation, which combines the creators (individual, group and organization) with knowledge (tacit and explicit).

The SECI model is one of the most influential and applied models of knowledge creation. Its main criticism considers two themes: who knows and

what is knowledge. The SECI stages present knowledge as processing from a subjective tacit known by an individual into an objective explicit known by a group (Nonaka & Toyama 2005: 422). This evokes the idea that knowledge is, at least in some stages, separable from the knower (e.g. Thompson & Walsham 2004: 725−726). As far as knowledge in the SECI is concerned, the dividence between tacit and explicit has been questioned (see section 2 Academic knowledge and chapter 2.4.1 Approaches to knowledge..). The SECI model has been clarified in terms of this criticism (Nonaka & von Krogh 2009). The simultaneous existence of the tacit and explicit elements of knowledge has been accentuated. The changes of knowledge in explicit-tacit continuum has been argumented to reveal some of the process concerning how individuals tap into social practices of organizations, acquire the tacit and apply it in knowledge creating work (Nonaka & von Krogh 2009: 645, Storper & Venables 2004: 366–367).

The SECI model was applied in this thesis for three reasons. First, the model has been applied in many studies, and it has been concluded to offer a good insight into knowledge creation and management processes (e.g. Bergman 2005, Harmaakorpi & Melkas 2005, Lambregts 2008). Second, the model considers tacit knowledge to be important and provides a view into understanding the tacit-explicit dynamics of knowledge, which are also central for economic geographical understandings of knowledge (see chapter 2.4.1 Approaches to knowledge..). The SECI model has influenced this development and, therefore, it is also a way to learn to understand critically economic geographical discourses on knowledge. Third, the SECI model has not been applied a great deal in academia (except for Travaille & Hendriks 2010), nor in groups whose members have different nationalities. Therefore, the application of the SECI in academic knowledge creation might also reveal new aspects of the SECI (see article I).

2.2.3 Cognitive proximity

Cognitive is only one, but a salient dimension of several proximities and distances, for instance geographical, cultural, organizational, social, institutional and technological (Boschma 2005, Knoben & Oerlemans 2006). All of these distances affect the knowledge creation of international research groups. The theory on cognitive proximity focuses on the dynamics of optimal knowledge base diversity for knowledge creation (Boschma 2005, Nooteboom 1992, Nooteboom *et al.* 2007). Knowledge base, or mental map, consists of mental

models, as explained in section 2.2 (Academic knowledge..). The diversity and internationality of groups generates both possibilities to novelty through multiple views, and the challenges of misunderstanding. In other words, a suitable amount of cultural and professional diversity in a group may lead into optimal cognitive distance, which is the source of novelty. While the members of the groups create knowledge together, they also (re)form ties to each other. The group members often strengthen their (weak) ties through time, emotion and trust (Granovetter 1973: 1361). Becoming cognitively more proximate, cognitively more distant, or maintaining a cognitive distance is connected to this process. The capabilities of individuals in brokering different knowledge bases (Burt 2004) also have an affect on the process of cognitive proximity or distance. In this thesis, the empirical focus of cognitive proximity has been on the process of interpretation or constructing (in interaction) work-related mental maps, and on the process of interaction, or communicating the mental maps to others.

Cognitive proximity was selected into this thesis for three reasons. First, a theory tapping into the interpretation process of knowledge creation was needed to complete and deepen the interaction process approached by the SECI model. Second, in economic geography, cognitive proximity is receiving growing attention. It has been stated to be the most salient dimension among proximities to explain innovative capability (Boschma 2005: 71). Third, there are some gaps in current cognitive proximity studies that enabled an attempt to develop the theory further.

The first gap is a lack of studies on cognitive proximity as a process, even though it is acknowledged that achieving an optimal cognitive proximity or, for example, ending up with too much cognitive proximity is an outcome of a process. Instead of focusing on the process itself, the research has been interested in its result (e.g. Eriksson 2011, Li & Vanhaverbeke 2009), such as regional lock-ins, due to too much cognitive proximity (e.g. Boschma & Iammarino 2009). Research has also concentrated on the optimal cognitive proximity that has been found to explain the benefits of agglomerations through cooperative knowledge creation (Dangelico *et al.* 2010: 142). The second gap is the lack of studies on cognitive proximity in a group (except Dettmann & Brenner 2010). This deficiency is further connected to a multilevel issue. Multiple levels become an issue when cognitive proximity, which is based on the individual level of cognition, is mostly studied at the levels of companies (e.g. Aslesen & Jakobsen 2007, Cantner *et al.* 2010, Li & Vanhaverbeke 2009), industries and regions (e.g. Boschma & Iammarino 2009, Broekel & Boschma 2009) without adequately

theorizing the relations between these levels (Nooteboom 2000). Bypassing the multilevel issue has led to excess generalization and partial definitions of cognitive proximity (Knoben & Oerlemans 2006). What seems to be especially difficult to define is the knowledge base (e.g. Aslesen & Jakobsen 2007, Boschma & Frenken 2009, Sternberg 2007). These challenges are tackled in article III.

2.3 Academic knowledge creation contexts

Knowledge and its creation processes are intertwined with context, or in geographical terms: place (here as an arena) and space. Context is understood here in relational terms. In other words, it is not only a container, material space, nor a geographical location, but interacted with and interpreted, therefore, framing the knowledge creating activity and also changed by it (Amin & Cohendet 2005, Augier *et al.* 2001: 129, Nonaka & Konno 1998: 40–41). Within the relational approach, concepts of *ba* and space-time are selected to study the context of knowledge creation in this thesis and a further definition of context is done through these theories (see chapters 2.3.1 *Ba* and 2.3.2 Space-time). This section is organized into three parts. First, context is defined and discussed in relation to knowledge creation. Second, the concept of *ba* is presented, and third, the concept of space-time is presented.

Cognition is embodied, or situated, as well as distributed (Brown *et al.* 1989, Hotton & Yoshmini 2010, Salomon 2001). In other words, brains and body are situated in a context which cannot be separated from the knowledge created. Cognition is also distributed among the members of a group and within an organization. The definition of knowledge and processes of knowledge creation bind context into knowledge, which enables information or an artifact to become knowledge. Knowledge is "justified" among the peers and/or in practice. For example, a bench becomes meaningful (knowledge) when it is sat on (Tuomi 1999: 99). Justification interacts with the context: time is experienced through tired feet, a bench exists in physical space and the situation allows a breather. A bench is justified through sitting, and context is interpreted as enabling the activity of sitting. The focus of this thesis is in the context that is essential for the knowledge creation. Therefore instead of benches, the focus of material context is on laboratory equipment, articles and softwares, for example. We "know" about the context because the surroundings become the context as they are interpreted. The reaction to the context is individual. For example, somebody might find a

noisy group of people in the corridor irritating, someone else frightening and another will experience the event as an opportunity to make new friends.

The relation of context and knowledge creation processes is also reciprocal. According to McCormack (2008: 2, original emphasis):

> "thinking-space is *both* a processual movement of thought *and* a privileged site at which this movement is amplified and inflected by novel configurations of ideas, things and bodies."

The context is the place and space of knowledge creation process. Researchers work in workplaces (e.g. offices and laboratories) and belong to networks of peers. Their work is enabled and restricted by context — not all is possible to be known with the level of learning and equipment that people have in a certain time and space. In addition, knowledge is created out of context. For example, a biologist studying an ecosystem is studying a context of certain people, animals and plants.

It is not the purpose of this thesis to discuss place extensively as a meaningful and experienced location. According to Tuan (2002: 6), the difference between space and place is movement and pause: whereas space allows movement, place allows pause, which enables transforming location into place. People regenerate meanings and interpretations that they attach to places. Thus, places are cultural constructions of these discourses. Recent geographical discussion has emphasized this side of place, which sees place as a process (e.g. Bauder 2001, Nayak 2004, see also Hägerstrand 1985) or event (Massey 2006: 140). In this thesis, place is understood as an arena (*ba*) of knowledge creation. The statement "knowledge creation takes place" is true, at least, in two approaches to place. Knowledge creation takes location since people, who create knowledge, always locate somewhere. Knowledge creation also takes place, since people excavate ideas and creativity from places that are meaningful to them. According to Drake (2003: 522–523) places offer stimulation, excitement and traditions, which in turn, have an affect on individual creativity.

2.3.1 Ba

A Japanese word *ba* translates into 'place' in English (Nonaka & Konno 1998: 40). It is an arena of knowledge creating interaction. This arena is a combination of elements (e.g. infrastructure and actors), characteristics (e.g. hierarchy and communication) and relationships (Nakamori 2006: 12). *Ba* enables the creation

and sharing of knowledge (Nonaka & Toyama 2003) in physical (e.g. office), mental (e.g. sharing personal experiences) and sometimes virtual (e.g. e-mail) arenas (Nonaka & Konno 1998: 40–41, Rafaeli *et al.* 2009). To define *ba* further, Nonaka & Konno (1998) describe four bas to correspond to the stages of the SECI process (Nonaka & Takeuchi 1995). These are an originating *ba* that supports face-to-face communication and therefore socialization, interacting *ba* that supports externalization of tacit knowledge, cyber *ba* that supports combining knowledge and excercising *ba* that supports internalizing knowledge.

However, these four *ba*s are not adopted in the thesis. Following Amin & Cohendet (2004: 95), they are seen as dividing knowledge quite strictly to either tacit or explicit. The four *ba*s also restrict each arena to only support one stage of knowledge creation. Another critical comment is directed to the manageability of *ba*. Placing activities to some of the four arenas provides the temptation to suggest detailed ways to manage each *ba* (e.g. Bennett 2001: 194–195). Yet, managing *ba* would mean managing interaction, which is a tricky and even impossible task. The studies have not focused on this task, or considering the relation of communication, language and *ba*. Instead, the recent focus has been based on some parts of *ba*, especially virtual (Kivijärvi 2008, Rafaeli *et al.* 2009, Senoo *et al.* 2007). The final critical comment covers the vague definitions of *ba*, as, for example, the processes inside *ba* need to be understood better (e.g. Fayard 2003, Nakamori 2006).

The concept of *ba* was selected for this thesis for two main reasons. First, it is an interesting attempt to conceptualize the context of knowledge creation. *Ba* is also greatly applied and proved to be a promising framework. It has also gained the interest of geographers (e.g. Kostiainen 2002). Second, a possibility to further develop *ba* was identified. This possibility derives from an unfinished definition of *ba* and a lack of studies considering *ba* as an arena of discourse. These are discussed further in article II.

2.3.2 Space-time

Space-time is a network that links objects, people and parts of mental maps through knowledge creating interaction and interpretation. This kind of space includes objects as well as communicative and cognitive dimensions, and is connected to the linear time of clocks and calendars and relational experienced time (Dodgshon 2008, Eco 1999, Giddens 1981, Törnqvist 2004). The material environment, with a focus on the objects that are essential for knowledge creation,

such as laboratory equipment, is called the object space. The knowledge creating interaction with objects and people forms the communicative space. The cognitive space of mental maps is formed from interpretations of the interaction. These spaces overlap and all exist in the creation of knowledge. The definition is broad in purpose, since the aim in the article is to identify different space-time combinations that knowledge creation includes, and to show how knowledge is manifested in a variety of ways when viewed through different space-times (article IV).

Space-time was included in this thesis for three main reasons. First, applications of space-time, as a concept in knowledge creating studies, are sparse. This becomes clear in knowledge management and science and technology studies literature. There are gaps, for example, in theoretical conceptualizations of context and empirical research on the relations between context and knowledge creation processes (e.g. Brachos *et al.* 2007: 32, Crevoisier 2004, Gertler 2003, Nonaka *et al.* 2006). Despite this, according to Beyers & Steyaert (2011: 4), there has been a "minor spatial turn" in organization theory that has been inspired by Lefebvre's (1991, 2004) work (e.g. Halford & Leonard 2006, Taylor & Spicer 2007). However, this body of work has concentrated on "spatial products", not on their production as a spatio-temporal process (Beyes & Steyaert 2011: 5). Recently, the latter viewpoint has been taken into consideration, for example, through a non-representational framework, when space is theoretically discussed as spacing (e.g. Beyes & Steyaert 2011). There is a call to conceptualize and empirically understand the context of knowledge creation (e.g. Brachos *et al.* 2007: 32, Nonaka *et al.* 2006). Space-time opens a large number of possibilities to contribute to answering this call and is less restrictive than *ba*, for example.

Second, the full potential of space as a concept in relation to knowledge is rarely exploited. For instance, in economic geography, space is often narrowed to mean only a geographical location or material environment. This is the case, for example, when knowledge is considered to "spill over" (e.g. Audretsch *et al.* 2005), accumulate in regions (e.g. Crevoisier 2004) or when the arena of knowledge is a material place of working (e.g. Fawcett & Song 2009). In economic geography, opening the "black box of organizations" has been stated to be important, but not many scholars study micro scale spatiality inside organizations. Micro scale, such as an office, has been adapted to knowledge management and organization studies (e.g. Toker & Gray 2008), but "spatial" is also often reduced there to mean mainly a material environment or arena of interaction.

Third, the time related to knowledge is often only seen as being linear. However, several studies have shown that in knowledge creation, time is also relational, for example "flow" (Csikszentmihalyi 1997) or experienced through change (Dodgshon 2008: 9). Therefore, space-time provides interesting insights to contextual knowledge creation as further discussed in article IV.

2.4 The interdisciplinary research area of academic knowledge creation

Empirical and theoretical literature on academic knowledge creation falls into the scope of several research fields, and is therefore interdisciplinary (Lawrence & Despres 2004: 400). The central fields for this thesis are knowledge management, economic geography and science and technology studies (figure 3). In addition, literature from organization studies, business studies and psychology are included. This section presents the central research fields and identifies gaps in knowledge creation research by applying the theoretical framework of the triangle of knowledge creation. The extent to which this thesis aims to fill those gaps is discussed.

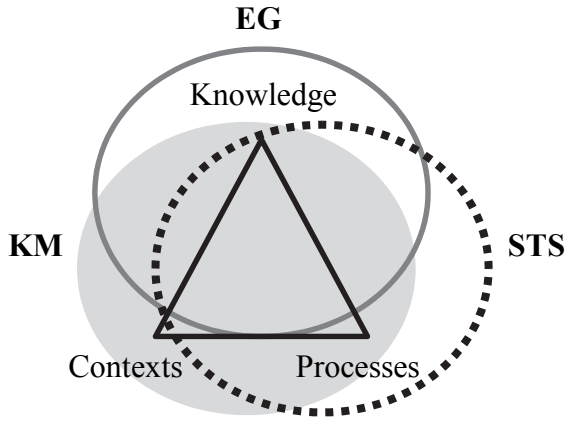

Fig. 3. Academic knowledge creation in the fields of knowledge management (KM), economic geography (EG) and science and technology studies (STS).

Knowledge management is quite a young field that has developed in the age of knowledge economy (Ma & Yu 2010: 175). Its theoretical roots extend from the psychology of cognition to the economics of market structure (Argote *et al.* 2003: 572). The research aims at understanding organizational knowledge processes and

applies results from a management point of view (Schultze & Stabell 2004: 551–552). Despite being applied in many fields, the theories of SECI and *ba* have had a major effect in knowledge management (Grover & Davenport 2001: 7–8, Ma & Yu 2010: 178–180). Managing here means an activity that aims to enable knowledge creation, either directly or indirectly. It includes activities, such as organizing, finding, sharing, storing and applying knowledge (Jelavic 2011: 2, Magnier-Watanabe & Senoo 2010: 215). Managing can be a direct activity as the group leaders guide their projects and members. It can also be indirect, enabling, for example, the promotion of knowledge creation through setting a working environment and cultivating organizational practices. In addition, the focus of managing extends from groups to networks and regions. This thesis relates to the field of knowledge management, since all the corners of the triangle: knowledge, processes and contexts are covered in the knowledge management research (figure 3). The theories applied in articles I and II: the SECI model and *ba*, are developed and much applied in the field of knowledge management. Articles II and III are published in knowledge management journals.

Science and technology studies and knowledge management have much in common. In both fields, knowledge creation is the key research area (Sismondo 2010: 11). One of their differences resides in the empirical study area, which, in the knowledge management field, is mostly focused on business organizations, whereas studies on academic organizations can be more likely found in science and technology studies. Another difference lies in their purposes (Bos *et al.* 2008: 384). Knowledge management research is often designed to be applicable in real life organizations. Organizations are considered as something to be actively managed and, therefore, implications for managers and practitioners are offered in many studies. Empirical science and technology studies research includes descriptions that bind academic research to its historical, social and political contexts (Lynch 2011: 4). An important aim is to open up the academia to the society (Fuller & Collier 2004: xi).

Science and technology studies covers the triangle of knowledge creation, but is mostly focused on the processes of knowledge creation (Sismondo 2010: 10) (figure 3). Science and technology studies begin with a thought that academic research is social activity: researchers belong to wider communities who set the rules and practices to achieve knowledge (Knorr Cetina 1999, Sismondo 2010: 10–11). This idea can be found in the definition of knowledge in the current thesis (see section 2 Academic knowledge). Processes that have gained empirical attention are, for instance, knowledge sharing and dissemination (Evans 2010),

integration (Zierhofer & Burger 2007), the evolution of a project (Morris & Hebden 2008) and the progress of academic knowledge (e.g. Callon 1994, Kuhn 1996). After "geographical turn" in science and technology studies (also called geographies of science), the interest in the spatialities and localities of scientific knowledge has increased (Jöns *et al.* 2010: ix; Shapin 1998: 5). It has been stated that even though the world of knowledge is globalizing, the affect of localities to knowledge, for instance, as local interpretations of knowledge (Livingstone 2010), reflect geography where knowledge will remain diverse (Stehr 2010). The space of science is seen to be more than material (Shrum *et al.* 2010), for example, interactive (Yaneva 2010). However, according to Powell (2007: 321), the micro scale details of the spatiality of science still remain vague.

Economic geography aims at explaining the causes and consequences of uneven development (Aoyama *et al.* 2011: 1), or to be more precise, the spatial configuration of companies, industries and nations in today's knowledge economies (Combes *et al.* 2008: xiii, Feldman & Gertler 2000: vii). As a field, economic geography exists in the focal point of geography and economics, but differs from geographical economics (also called new economic geography) pioneered by Krugman (1991) (e.g. Arnott & Wrigley 2003: 2). A simplified description of this multidimensional intersection of geography and economics (Brakman *et al.* 2011), is included. Geographical economics locate the economic models (e.g. Bosker *et al.* 2010). Most economic models are based on an assumption that individuals act according to rational decision making and self-regarding preferences (Camerer & Fehr 2006: 47). However, economic geography is not interested about hypothetical, but "actually existing" economic landscapes (Martin 2011: 54) and aims to be more sensitive to their "soft side" (Amin & Thrift 2000: 7), such as social behaviour of individuals, complex organizations and knowledge being partly tacit. The individuals are often called "actors", which refers to their existence as social actors whose (economic) activity is socially embedded and performed in relation to other actors.

The interest in the ways how the socio-spatial relations of actors are interconnected with economic change evoked a "relational turn" in economic geography (Boggs & Rantisi 2003: 109, Yeung 2005: 37). Relational approaches note actors, their contextuality, and the time (path-dependency) and contingency of economic processes (Bathelt & Glückler 2003: 128–129). Relational economic geography has been criticized for being a loose collection of approaches, focusing on microscale processes and ambiguous networks that do not contribute to understanding economic life in general. Economy, afterall, also forms through

institutions, structures and the absence of connections (Sunley 2008: 19). Evolutionary economics, another recent approach in economic geography, draws attention to the spatial evolution of economic processes (Boschma & Frenken 2011). According to Boschma and Frenken (2006: 277–278), the starting point is to "open the black box of organizations" by tapping into organizational practices and routines as they are evolved in time. The level of study is then a company and also the tacitness of knowledge is acknowledged.

Economic geography is focused on applying the concept of knowledge with less attention paid to its contexts and processes (figure 3).This thesis associates with the "soft side" of economic geography, relational economic geography and the endeavour of evolutionary economic geography to open the black box of organization. In addition, the theories of cognitive proximity and space-time that are applied in articles III and IV, have roots in geography, and are applied and further developed in economic geographical literature.

The fields of knowledge management, science and technology studies and economic geography, among others, reveal five main gaps in current research on (academic) knowledge creation. The first gap is the overall need for further empirical case study research on knowledge creation. This derives from realizing that knowledge is a complex and contextual process. Therefore, research results cannot be applied to any organization, field of knowledge or group (Lundvall 2010: 23). Case studies are called for exploring knowledge creation in general (Garcia-Perez & Ayres 2009: 62, Janhonen & Johanson 2011: 217, Magnier-Watanabe & Senoo 2010: 214, van Winkelen & McDermott 2010: 569, Zierhofer & Burger 2007: 53) and linking knowledge creation to diversity (Lundvall 2010: 22). More precise studies are needed in cross cultural settings (Chen *et al.* 2010: 240, Nam *et al.* 2009: 781), international geography of science (Powell 2007: 321), the management of diverse groups (Yang & Konrad 2011: 6–7) and geographically distributed groups, not only from virtual point of view (Bosch-Sijtsema *et al.* 2011: 276–277, Uflacker & Zeier 2011: 88).

The empirical cases A and B of this thesis offer valuable insights into the need of further case studies. They include many kinds of knowledges (technological, scientific and humanist), groups that are more advanced (case A) and new (case B), groups that are international, and temporally geographically distributed (case B).

The second gap can be found in knowledge creation processes. In general, economic geographers have, so far, been mainly interested in the time related to knowledge in a historical sense, but not in following the knowledge processes

through shorter time-frames of years, months, weeks or days. The focus is not knowledge creation "here and now", but the later, often managerial, representations of the process that are measured in one point in time (despite e.g. Ibert 2010, Power & Jansson 2009). Process focus is pointed out to be important in geographies of knowing and learning (Bathelt & Glückler 2011: 7). Some scholars call for more detailed studies on interaction (Gorse & Emmitt 2007: 1195, Hong *et al.* 2010: 62, Raes *et al.* 2011: 102, Sosa 2011: 1, Tolsby & Kirkebak 2007: 115). In economic geography, attention has been increasingly paid on interaction, but this is only one side of knowledge creation. According to Dolfsma (2008: 2), economists often ignore interpretation and, therefore, cannot see knowledge more than explicit. As it comes to academic knowledge creation, a collaboration project includes stages of initiation, 'growing pains', maturity, closure, and afterlife. It is usual for an academic project that after the excitement of early findings, a long period of work is needed to create those intuitive thoughts into knowledge (Morris & Hebden 2008: 28). Despite these results, there is a call for studying evolution and the organization of academic collaborations (Bos *et al.* 2008: 384–385, Morris & Hebden 2008: 27, Sundberg 2010: 37) and early phases of knowledge creation (Kogler *et al.* 2011: 275) in academic (Evans 2010: 760) and engineering projects (Uflacker & Zeier 2011: 88). Ethnographic methodology is encouraged in particular in such studies (Beaulieu 2010: 455).

Related to the second gap, the third gap is identified as the need for a cognitive dimension in (academic) knowledge creation research (Bruun & Sierla 2008: 133, Choo & de Alvarenga Neto 2010: 606, Harquail & King 2010: 1619). Theoretical definitions of knowledge in economic geography adopt interpretation in constructionist (e.g. Amin and Roberts 2008, Faulconbridge 2006), and also increasingly in rationalist (e.g. Lambgrets 2008, Rosiello 2007) frameworks, as will be shown in chapter 2.4.1 (Approaches to knowledge..). However, empirical work has not followed this through, which is shown, for example, in the levels of study. Interpretation cannot be tapped into when studying, for example, an organization and not an actor and group. In the fields in general, it is suggested that cognition should be connected to diversity (Kearney *et al.* 2009: 581, Mitchell & Nicholas 2006: 67), decision making (Randolph-Seng & Norris 2011: 420), cross-understanding (Huber & Lewis 2010: 6) and temporal rhythms (He 2011: 22) in groups. In addition, there is a call for studies in forming a common understanding in groups (Rimor *et al.* 2010: 357,363, Slotegraaf & Atuahene-Gima 2011: 105).

The gaps two and three are taken into account. One of the focus areas of the thesis is interaction, and the study includes an ethnographic attitude (see more in section 3 Methodology and empirical..). The process dimension of following knowledge creation in time is contained. In case B, knowledge creation is followed during the early stage, when even the researchers who followed do not know what they will accomplish. This allows attention to be paid to the "real" nuances of the knowledge creation process, not the later, rational explanations of what the result of the projects was and why. In addition, the cognitive dimension forming of the interpretation process, mental maps, mental *ba* and cognitive space is included. With the concept of cognitive proximity, this thesis considers how the members of a group form a common understanding. Cognitive dimension is connected to the diversity of group members.

The fourth gap resides on the context of knowledge creation. Its study is usually focused on the material space in economic geography, knowledge management and science and technology studies (e.g. Breschi & Lissoni 2009, Nicholas 2008, Sismondo 2010: 11) and theorization, as well as empirical research of the context could be taken forward (Allen & Höpfl 2009: 382, Choo & de Alvarenga Neto 2010: 606, Cruywagen *et al.* 2008: 101, Janhonen 2010: 88). In this thesis, both aspects are reacted to (articles II and IV).

The level of the group is seen to be important, especially in economic geography, where it is mostly substituted by the levels of organization, industry and region (see article III). Additional studies are needed, for example, to explore knowledge sharing or transferral in cross-cultural groups (Chen *et al.* 2010: 240, Li 2010: 47) and consider knowledge creation in relation to group climates and management styles (Xue *et al.* 2011: 299). However, groups consist of individuals and, therefore, this level should also be visible. For example, some individuals have key positions in their networks and, therefore, affect the knowledge creation on the level of the epistemic community (Whelan *et al.* 2010: 486–487). The level of the organization needs to be considered as well. In economic geography, there is a call for opening the black boxes of the organization (Amin & Thrift 2000: 8, Boschma & Frenken 2006: 277–278, Brenner *et al.* 2011: 114, Hervas-Oliver & Albors-Garrigos 2009: 265; Taylor & Asheim 2001: 315) and the economics of knowledge — in other words, how knowledge moves between places (Malecki 2010: 493–494).

In the thesis, people are considered to connect the corners of knowledge, processes and contexts into a triangle of knowledge creation. Even though the main level is the group, the members are considered to be individuals. This is

shown in the materials that are collected from each member and individual as the level of the analysis. Opening the black box of the organization is not the aim of this thesis, but it is still considered through studying processes inside organizations. Understanding people and groups within the organizations is important for explaining the role of contexts (as places) and processes (of knowledge) in knowledge economies, as well as understanding the geographies of innovation.

The fifth gap is epistemological: there is a call for a deeper understanding of knowledge. According to Jakubik (2011: 374), the knowledge creation paradigm should be shifted towards "becoming to know" instead of "knowledge". In the knowledge management field, there are quite a lot of studies that adopt a rationalist view on knowledge and, therefore, study knowledge as something which is quantifiable from surveys and statistics and extractable from people (Garcia-Perez & Ayres 2009: 55). A similar approach to knowledge can also be found in economic geography (see chapter 2.4.1 Approaches to knowledge..). In other words, some scholars call for a more human focused approach (Jakubik 2011: 374, Sanderson 2008: 301), a deeper understanding of knowledge, such as considering knowledge "seeing" (Styhre 2010: 371) and paying more attention to tacit knowledge (Puusa & Eerikäinen 2010: 307). Applying a cognitive dimension is important as both interaction and the interpretation processes should be included to the knowledge creation. As Jakubik (2011: 386) notes, knowing is also discovering relations between ideas, in other words, connecting concepts and statements in mental maps. In economic geography, this is not a novel suggestion (Ancori *et al.* 2000: 262, Cappello 2009). This thesis takes the knowing paradigm into account as knowledge is seen to be part of individuals, groups, processes and contexts and existing in the tacit-explicit continuum. The becoming to know paradigm is related to the constructionist framework of knowledge (see section 3 Methodology and empirical..) and the cognitive dimension, which are also adopted in the thesis.

2.4.1 Approaches to knowledge: an example of economic geography

Economic geography is a good field for opening up a more detailed picture of epistemological approaches to knowledge. This is because knowledge is a central concept in economic geography and is found at the heart of theories applied and developed in economic geography to explain an uneven development. Economies are described as a "learning economy" (e.g. Storper 1997: 163) or a "knowledge

economy" (e.g. Amidon 1997, Cooke *et al.* 2007, OECD 1996), which accentuates the meaning of knowledge in the era of fast and intense global interconnections (Moodysson 2007: 9). Analysing a knowledge economy requires understanding the extending and changing roles of knowledge (Dolfsma 2008: 1). Another reason for selecting economic geography as an example of approaches to knowledge is that economic geographers are interested in tacit and explicit dimensions of knowledge (Malecki 2010: 495), which they combine to geographical proximities and spaces. It is usually thought that tacit is mainly shared in close proximity, whereas explicit can be also shared from a distance.

In this section, the main approaches to understand and apply knowledge in economic geography are discussed following the theoretical framework of a triangle of knowledge. These main approaches are rationalist and constructionist (Amin & Cohendet 2004, Ibert 2007). Even though these two do not encompass all of the multiple understandings of knowledge in economic geography, they enable access to the important concepts and theories in economic geography. The approach to knowledge which is adopted in this thesis, called constructionist-cognitive, is considered in this light.

Knowledge is seen as an object or possession in rationalist framework (Amin & Cohendet 2004: 19–20, Cook & Brown 1999, Ibert 2007, Schultze & Stabell 2004: 553) (table 2). According to rationalist thinking, there exists:

> "an *a priori* knowable external reality, which is true at all times and in all places and which is the highest grade of knowledge." (Ancori *et al.* 2000: 260, original emphasis).

Therefore, knowledge is disconnected from people, and seen as a possession of companies, industries or regions. This kind of knowledge, an economic good (Foray 2004: 91) such as a patent and product, can be empirically studied through statistics and surveys. The processes of knowledge include movements and production. Knowledge can "spill over" (e.g. Audretsch & Feldman 1996), be transferred (e.g. Rosiello 2007), flow (e.g. Carayol & Roux 2009, Dahl & Pedersen 2004), diffuse (e.g. Buckley & Ghauri 2004) and accumulate (e.g. Fujita & Mori 2005: 396). The context of these processes is mainly material space or geographical location.

Table 2. Rationalist, constructionist and constructionist-cognitive understandings of knowledge.

Approach	Knowledge	Process	Context
Rationalist	Possession, asset, stock Explicit/(tacit) Disconnected from people Empirically studied: statistics, surveys	Processes of movements and production Processed by a company, industry, region	Material space Cluster
Constructionist	Practice Explicit-tacit Embedded in networks, communities of practice Empirically studied: surveys, interviews	Process of interaction Processed by a company, individuals in networks/communities	Material and communicative space Place
Constructionist-cognitive	Contextual process Explicit-tacit Embedded in people, groups and organizations Empirically studied: interviews, diaries, observation	Processes of interaction and interpretation Processed by individuals and groups	*Ba*: virtual, mental and social Space-time: material, communicative and cognitive

The literature included in the rationalist approach is discussed in relation to an explicit/tacit division of knowledge. Some of the literature only encompasses the explicit forms of knowledge, both in theory and empiria. Knowledge is often referred to as innovation, which persists to be one of the key concepts in economic geography, instead of knowledge (Aoyama *et al.* 2011). The interest is to model or enhance its production or existence in agglomerations (Antonelli *et al.* 2010, Copus *et al.* 2008, McCann 2007, Srholec 2010) and enhance its production in national, regional and sectoral innovation systems, linking companies, universities and governmental actors (e.g. Cooke 2006). Another example is the spillover literature that concludes knowledge to have spilled over from one organization to another, for example, through labour mobility, collaboration and patent citations (e.g. Anselin & Varga 1997, Audretsch & Feldman 1996, Eriksson 2011, Ponds *et al.* 2010). Some spillover studies do cater for tacit knowledge, but apply patents or another statistical data as empirical material (Breschi & Lissoni 2001a, 2001b, 2009, Ibrahim *et al.* 2009, Maggioni *et al.* 2007). Innovations and

patents undoubtedly represent some — but only a small — friction of knowledge (Malecki 2010: 496).

A large body of literature has taken the tacit dimension of knowledge into account. Tacit knowledge has been especially applied to a cluster that is "a geographically proximate group of inter-connected companies and associated institutions in a particular field" (Porter 2000: 254). Tacit knowledge, trust, localized learning and face-to-face communication explain the formation and success of clusters (Maskell & Malmberg 1999, Maskell 2001, Pinch *et al.* 2003, Storper & Venables 2004) and proximate collaborations (Broström 2010). This has led to a dualism of "here" (local) and "there" (global). Since tacit knowledge is mainly shared face-to-face, it is "sticky" and local, whereas, explicit knowledge is "ubiquitos" and global (Asheim & Isaksen 2002). Stepping away from the local/global dualism is not necessarily stepping away from tacit/explicit dualism. For example, a buzz-and-pipeline model of cluster competitiveness suggests that the better global pipelines a cluster has, the higher quality of local "buzz" created by communicating people there is. This "buzz" then benefits all the companies in the cluster that are "tuned in" (Bathelt *et al.* 2004: 46).

Attempts to go beyond tacit/explicit dichotomy have been taken either by accepting tacit and explicit as simultaneously existing elements of knowledge, considering tacit-explicit as a continuum when the conversions from tacit to explicit and vice versa are discussed, or simply by avoiding using the terms "tacit" and "explicit". For example, Trippl *et al.* (2009: 443) have suggested knowledge linkages of market relations, formal and informal networks and spillovers to explain how the actors in clusters access knowledge. This view is proposed as a replacement of buzz (tacit) and pipelines (explicit). The studies that adopt tacit-explicit continuum or their simultaneous existence often contain expressions from both rationalist and constructivist discourses. In general, knowledge is created through interaction (constructionist), which results in knowledge which is innovations and economic goods (rationalist). In rationalist terms, these can then be possessed, transferred, and spilled over. The blending of constructionist expressions can also be seen in tacit/explicit literature. What is different here are the more multiple roles of context in relation to knowledge. Knowledge-based collaboration, for example, is affected by historical context (Žižalová 2010). Or knowledge is intertwined with its market-related, product-related and regulation-related context (Lambregts 2008: 1181). Even though the rationalist literature considering tacit-explicit continuum or simultaneous existence has deepened the understanding of knowledge as a contextual process, it

usually does not consider knowledge (at least empirically) as "interpreted" or "applied". Therefore, the difference between knowledge and information remains vague.

The main rationalist knowledge "producer" is company. However, literature does not often consider company to be an entity formed of people working towards a common goal. Therefore, it is left unclear that a "company" does not create knowledge, but people do. Similarly, Suorsa (2009: 46) notes that an innovation system framework focuses on "organization", which is misleading since innovations do not rise from systems or organizations, but from people and their collaborations. A company is the meaningful setting of re-created and contested routines, aims and rules that enable people to organize their activity in an optimal way to achieve common goals. Opening the "black box" of organizations requires the researchers to enter organizations and also study them with other methods than formal modeling, even though these methods are called for in evolutionary economic geography (Boschma & Frenken 2006: 277–278). Indeed, rationalist literature has recently shifted the focus from companies and regions towards people. Instead of focusing on companies, knowledge is seen more and more as a possession of people. The interest is, for example, in labour mobility (Kelly 2011) as an advantage of clusters (Bienkowska *et al.* 2011), or mechanisms of collaboration in inventive teams (Bercovitz & Feldman 2011). Also, the heterogeneity of people is taken into account (Ottaviano 2011). Members of the "creative class" (Florida 2002) are heterogeneous: they have occupation-related knowledge bases and respectively different locational preferences (Asheim & Hansen 2009).

Constructionist framework considers knowledge as practice (Amin & Cohendet 2004, Cook & Brown 1999, Ibert 2007: 105–106, Schultze & Stabell 2004: 553) (table 2). In fact, instead of "knowledge", one should discuss about "knowing" that is manifested in action (Schön 1983: 49). This knowing is created and embedded in groups, networks and communities (Granovetter 1985: 504). Even though knowledge itself is a process, other expressions of processes are sharing, interacting and learning. These expressions include the embedded nature of knowledge. For example, if people share knowledge, they interpret the communication, since "thoughts do not travel" (Sperber & Wilson 1995: 1). This is very different from the rationalist idea that knowledge is transferred when objects move in material space.

What is characteristic for a constructionist framework is concentrating on communities, for example, communities of practice (Lave & Wenger 1991) or

networks (e.g. Coe & Bunnell 2003, Turner 2010). According to Ibert (2007: 108), a constructionist view of knowledge has resulted in the argument of place: knowledge is created in place, where people engage with and participate in practice (Wenger 1999: 131). Also, material and communicative micro-spaces are considered to be contexts. Altogether, these contexts are, for example, workplaces (Ettlinger 2003), laboratories (Knorr Cetina 1999) and temporary gatherings (Power & Jansson 2009).

Scholars have contributed to economic geography by treating the tacit-explicit continuum from a constructionist point of view (e.g. Howells 2002, Vallance 2011: 1099). For example, Gertler (2003) discusses tacit knowledge as being intertwined with context and culture. Therefore, its geographies cannot be studied apart from the context and culture. Faulconbridge (2006: 517) has been able to show that tacit knowledge can have global geographies, when knowledge is understood to be interpreted and contextual. Managerial practices cannot be "transferred", but they are shared and re-created in new locations. Also, going beyond buzz-and-pipelines within a practice framework has been on the agenda (e.g. Sunley *et al.* 2008). Moodysson (2008: 449,462) found that buzz does not necessarily exist in biotechnology collaborations. Instead, the knowledge creation in these cutting edge collaborations was embedded in global knowledge communities.

The approach in this thesis is constructionist-cognitive (table 2). It is not a distinct approach to explain human knowledgeability, but, rather, complements the constructionist approach. Compared to the rationalist knowledge of economic geography, the main difference of the constructionist-cognitive approach is the triangle. The rationalist approach represents a "tip of the iceberg" as it separates knowledge from people. Constructionist-cognitive knowledge is embedded in people and groups, who bind the corners of knowledge, processes and contexts into a triangle of knowledge creation. Another difference is the tacit-explicit continuum, where knowledge of the constructionist-cognitive approach exists. The rationalist approach tends to separate the tacit from the explicit. In addition, the space of knowledge is not only seen as material, but also communicative and cognitive in the constructionist-cognitive approach. Compared to the constructionist approach, the first complement is the level of study, which in constructionist-cognitive focuses on work groups, whereas the constructionist approach pays attention to wider compilations of people, for example, networks and communities. The second complement is the cognitive dimension, which includes the process of interpretation, mental maps, mental *ba* and cognitive

space. The cognitive dimension is rarely in the agenda of current constructionist nor rationalist approaches in economic geography. The constructionist-cognitive approach is a good way to step towards a more holistic approach to knowledge.

2.4.2 Academic knowledge and a micro approach in economic geography

Academic knowledge is studied within science and technology studies and knowledge management (e.g. Edwards *et al.* 2003: 49, Hasan *et al.* 2006, Lilleore & Hansen 2011), but not so much in economic geography. Although universities have been found to be essential for regional knowledge economies (e.g. Bramwell & Wolfe 2008, Etzkowitz & Leydersdorff 2000), the main interest of economic geography is a company, which is the key economic actor. Some economic geographical studies have focused on company-university collaborations (e.g. Bercovitz & Feldman 2010, Ponds *et al.* 2010) and biotechnological research (e.g. Cooke 2006, Feldman *et al.* 2006: 359–360, Mattsson 2007).

Universities and companies have differences as organizations. According to the Finnish Universities Act (558/2009: 2§), the most important missions of the universities are research and education, which is carried out in interaction with the surrounding society. Despite the recent turn towards entrepreunial universities, the end result of knowledge creation, for example, an article, is usually not a marketable item or service. University research values knowledge itself, whereas business organizations aim towards financial profits. Therefore, there is a central difference in what is considered to be (valuable) knowledge in universities and business organizations. This difference is reflected in the processes and contexts of knowledge creation, since these organizations are different lenses according to which the employees work.

Despite the differences, universities and businesses share a large amount of similarities related to knowledge creation. According to Thrift (2006: 23), academia cannot be thought "as an epistemologically privileged sphere" compared to business. The empirical setting of this thesis can, to some extent, be applied to business organizations. The bases on which some conclusions are drawn (see section 5 Conclusions and discussion) include four points. The first is the uniqueness of knowledge creation as such and the following need for further case studies. Even though knowledge creation would be empirically studied in companies, each company has its own organizational lens and unique combinations of employees and, therefore, drawing conclusions beyond the case

is never simple. However, several symmetries exist between business and academia. According to Thrift (2006: 23), both aim at creating knowledge and forming an organization to supports that aim. The importance of tacit knowledge, in the form of skills and practices, has increased in academia and business. The vocabularies of the academia and business are becoming closer and closer. A good example is the word "culture", as in organizational culture and epistemic culture.

Knowledge creating groups are the second feature common in university and company organizations. According to Thrift (2006: 23), in both organizations, knowledge is created in processes and contexts by individuals and groups. He adds geographical space to be essential for the activities of academia and business as the concentration of skilled people on the one hand and circulation of information and items on the other hand. Further similarities can be found inside the knowledge creating groups. The members communicate, aim to build a common understanding and knowledge creation is divided into projects that proceed step by step. I believe that at the group level, a large amount of features in those processes and contexts that the articles I–IV cover are not that different in companies.

The third point connecting university and business organizations is diversity at the group level. In internationalizing organizations, in other words both universities and companies, the groups increasingly consist of members with unique professional and cultural backgrounds. Exploiting and managing diversity is an important empirical study area in both business and university organizations (e.g. Ajmal 2009: 40, Fridholm 2010, Ibert 2010: 187).

The fourth point includes networks and clusters that connect the individuals and groups into wider knowledge creating entities. These entities connect universities, companies and governing bodies. In clusters and networks, universities are catalysts of innovation (Doutriaux 2003: 63) and are particularly important for science-based companies (Ponds *et al.* 2010: 233). The importance of academic knowledge for business innovations is expected to be improved in the future (Ingemansson 2010: 22). In this thesis, the technological groups, T-group, Tec1, Tec2 and Tec3 groups collaborate with companies. Their projects aim at products of which some are quite ready for commercial use and others require additional product development. These groups also connect the empirical part of this thesis to the business world.

In a study such as this thesis which adopts the constructionist-cognitive approach to knowledge and the empirical research follows processes, a micro approach is required. The micro approach focuses here on individuals and groups,

and is familiar in the fields of knowledge management and science and technology studies, but is much less applied in economic geography. The micro approach in economic geography is valuable for three reasons. First, it is required when opening the black box of an organization. The role of companies and universities as knowledge creating organizations is central to the economic success in a knowledge economy. Eventually, however, it is the innovations and services that are "produced", "sold" and "bought". They are embodiments of constantly ongoing knowledge creation processes. Indeed, as Amin and Thrift (2000: 8) conclude:

> "Without a feel for the processes and practices that sustain learning, there can be no proper theory of the firm and therefore also no proper understanding of the sources of economic competitiveness."

Second, micro activity by people has macro reflections in the economy, since all economic processes are socially embedded (Granovetter 1985). People innovate, gamble, choose an occupation — in other words, they make decisions that reflect the economy. Some of these decisions have major reflections: "small but smart moves can set big things in motion" (Hagel *et al.* 2010). A good example is the Oulu Technopolis cluster in Finland, a successful compilation of ICT firms in a very unfavourable location of Northern Finland. The statement by Mintzberg (1994: 26): "big strategies can grow from little ideas in strange places" describes this well. This cluster was created by a group of engineers, friends, with a lot of ideas and enough courage (Tervo 2004: 85–86). Studying economic decision making, according to Strauss (2009: 310):

> "means taking seriously what is shared among human beings (certain cognitive abilities, and cultural and social norms and practices) as well as the crucial role of the environment in framing, anchoring, and structuring behaviour."

Third, when the focus of the study is knowledge creating processes, we face a multilevel issue concerning how an individual and a group is linked to an organization and vice versa (Nooteboom 2000: 39–40). In this thesis, academia and the research projects are thought to form an organizational focus, which affects the ways of interaction and interpretation. Yet, individuals also act according to their own aims in career and life, are unaware of or do not want to participate in some organizational routines (Moodysson 2007: 43). Therefore, the "organizational" as a focus only reaches some of the individual (and knowledge

creating) activity, which is another reason to go inside organizations. Cognitive proximity is a good example of a concept which can be applied in a variety of scales (e.g. Nooteboom *et al.* 2007), as long as the multilevel issue is considered. Yet, this is not often the case (article III).

3 Methodology and empirical study

This section presents methodology, methods and cases. Following Kaplan (1964: 23), a method is defined as a research technique which enables creating justified (academic) knowledge. Further, they are divided as methods of collecting material and methods of analyzing material. Through methodology, then, methods are critically described and analyzed (Kaplan 1964: 23). In addition, positioning oneself as a researcher in relation to theory, field and empirical study is included in methodology. The positoning can be done in terms of ultimate presumptions (Ingeman & Björn 2009: 9).

The key epistemological and ontological presumptions of this thesis can be reviewed through the triangle of knowledge, process and context. First, I argue that knowledge is rooted in contextual cognition and practices of individuals and groups. Therefore, the explicit results of a research project, such as academic articles, are only a tip of the iceberg. Second, I believe that people construct knowing and being in the world interactively. Although interaction also takes place between people and the environment, the interaction between people is central here. Academia itself is organized through communicative actions such as publishing, referencing, attending conferences, collaborating, debating and lecturing. Third, I believe that knowledge is cumulative in the sense that an individual learns. Therefore, knowledge is a process. Fourth, I believe that knowledge processes can (only) be managed to some extent. By understanding knowledge processes, it is possible to suggest practical operations that can be done in groups, organizations and regions to manage the creation of novelty. However, at the same time, the organizations, groups and projects are unique, which should be noted when suggestions are done.

These presumptions have guided me to adopt a constructionist approach and ethnographic "attitude", which I have been applied in the case study strategy. According to the constructionist approach, reality is understood to be socially constructed. Social reality is externalized and produced in human activity and experienced as an objective as it affects human life and cannot be "wished away". Humans are socialized in the world when produced reality becomes internalized (Berger & Luckmann 1967: 60–61). Applied to the academic world, it means that the whole process of creating something that can be called knowledge is done within a social "reality". Apostrophes denote that a physical world exists out there which is separate of us, under attempts to be known better by scientists. However, our interpretations of that reality are social. Social reality plays a central part, for

example, when researchers decide what they study and how they create knowledge concerning that. According to Cunliffe (2008: 125–126), in constructionist-based research, three underlying themes of assumptions should be raised. The first is the nature of a social reality. In this thesis, the social reality of knowledge creation is understood to be both subjective and intersubjective. Even though people create knowledge with others within the system of (academic) institutions (for instance, universities and academies) and (academic) rules of knowledge creation, they still interpret knowledge subjectively. The second is the process of socially constructed reality. In this thesis, it is considered as a cognitive process of mental mapping that is done in relation to others and within the social constructed reality. The third is epistemological interests, which, in this thesis, lay at the micro-level of a group.

Ethnography has a variety of definitions from living and breathing what is studied to trying to understand the phenomenon from the point of view of the people being studied (Armstrong 2008: 54–55, Fetterman 2010: 1). Fieldwork and observation, usually participant observation, are central in ethnography. I have spent time in the corridors and I have observed meetings, courses, workshops and conferences. These events are no doubt essential for academic knowledge creation, but leave much of everyday work practices untouched, since I did not have an office among the study groups. In addition, I have not actively participated, for example, while observing. Although this approach is not at the heart of ethnography, my attitude towards the study phenomenon and people is in the sense that I have been trying to understand knowledge creation from the point of views of the members of the case groups.

3.1 Case study

A case study is a strategy for investigating processes in their context (Hartley 2004: 323, Yin 2003: 13). It allows the collection of many kinds of empirical materials for a period of time (Swanborn 2010: 2). Therefore, a case study enables a researcher to follow the knowledge creation process and consider its contextuality. Indeed, the process and context form the theoretical framework as well as the phrasing of questions in this thesis. In addition, a case study is a usable strategy when the theoretical refinement of a concept such as *ba* (article II) or cognitive proximity (article III) is unfinished (Yin 2003). To be more precise, an exploratory case study is the approach which is mainly used in this thesis,

which means that the fieldwork is performed without making explicit propositions beforehand (Yin 2003: 6,22).

The generalizability of the case study results is problematic, since the amount of cases is small. This research contains, altogether, seven research groups. However, through the systematic selection of cases, the generalizability from studied to unstudied cases can be improved (Gomm *et al.* 2000: 106–107). The selection here is performed according to the internationality of the Finnish multidisciplinary universities and the FiDiPro programme (see chapters 3.2 Case A... and 3.3 Case B..).

3.2 Case A: The University of Oulu

When the empirical study was conducted, the University of Oulu was the second largest multidisciplinary university after the University of Helsinki in Finland, measured both by the number of staff and students (KOTA 2011). Multidisciplinary universities include many academic disciplines and exclude, therefore, for example, technological universities. It was selected as a case in this research among Finnish multidisciplinary universities for two reasons. First, the relative amount of foreign employees has been high compared with the five largest multidisciplinary universities; those of Helsinki, Oulu, Turku, Tampere and Jyväskylä. For example, during the period from 2002 to 2006, the second largest relative amount of foreign employees can be found in the University of Oulu. There are more foreign employees only in the Åbo Akademi, which is a small university (about 1300 employees), where Swedish is the prior language and it is located in Turku. Second, analysis of the most recent general, internationalization and human resources strategies of the all multi-disciplinary universities in 2008 highlights the meaning of the University of Oulu as a strong internationalizing university, where internationalization pursues are considered (article II, see also article I).

The University of Oulu was established in 1958 and comprises six faculties: technology, science, humanities, medicine, education and economics and business administration. The faculties are completed by several interdisciplinary research institutes. The current focus areas of the university are (1) sciences and health, (2) information technology, (3) cultural identity and interaction and (4) environment, natural resources and materials. In 2007, the departments of the University of Oulu were rated by the research assessment exercise. This first rating was completed by international experts of each department's discipline. The average

quality of research in the faculties is five, except for the number four in the faculty of technology. The scale of the rating is from one to seven. The lowest number, one, means that virtually none of the publications produced in a certain unit exist in a fair international level. On the contrary, the highest number seven corresponds to the high international level of a majority of the unit's publications (Jaako & Ruskoaho 2008: 17). Number six was the highest number reached in the University of Oulu. This number was achieved in seven departments out of all the 57 departments (Jaako 2008). Therefore, the research in the University of Oulu strives to improve its international quality. The acts for this improvement include publications and the mobility of researchers, international collaboration, the organization of researchers into groups and enhancing the dedicated long-term work of the groups (Kinnunen 2009: 31).

The material includes a survey and interviews. The survey, collected in 2005, was sent to foreign employees of the University of Oulu, who either work or live in Oulu (N=160) (table 3). 67 replies were received, resulting in an answer percent of 41.9. The six-page survey included questions about the backgrounds of the respondents, as well as collaboration, communication and the SECI stages in knowledge creation. The survey was systematically analysed in the MSc thesis (Hautala 2006).

Table 3. Survey respondents among foreign employees of the University of Oulu.

Faculties	Foreign employees	Survey respondents
Technology	70	26
Science	52	27
Others	38	14
Total	160	67

In article I of this thesis, the survey is applied to answer research question Ib (How is knowledge shared and conversed about from the viewpoint of foreign employees in the University of Oulu?) together with the interview material of case A. The survey questions that were applied in article I include, first, unstructured questions that describe each of the SECI stages and ask the respondent to provide an example of that stage if (s)he thinks such a stage has happened in her or his work. These questions were the primary survey questions that were applied. Second, the survey included statements describing the preconditions of the SECI stages identified from the studies of Nonaka & Takeuchi (1995), Nonaka & Konno (1998) and survey questions based on the

aforementioned studies formulated by Bennett (2001: 194–195). These statements were ordinal variables and answered using a scale from 1 ("I totally disagree") to 5 ("I totally agree"), or using a scale varying from 1 ("never), 2 ("occasionally"), 3 ("monthly"), 4 ("weekly") to 5 ("daily"). These questions were the secondary survey questions that were applied.

The interviews were conducted during 2006–2007 with members of three international research groups. These groups were selected from the faculties of technology, science and humanities, broadly representing three realms of knowledge in academia (table 4). The groups had been working together for at least about a year and already had some approved working practices. Altogether, 12 interviews consisting of three interviews in the H- and S-groups and 6 interviews in the T-group took place. One interview lasted 30–60 minutes. The leader and at least one foreign researcher were interviewed from each group. The main themes covered the researcher's background, communication in the group, and the processes of knowledge creation. More detailed description about the interviews, the selection of the groups and the members can be found in articles I and II.

Table 4. Case research groups of the University of Oulu.

Faculty (group)	All members	Interviewees	
		Number	Titles (foreign*)
Humanities (H)	5	3	Project manager 1* Ph.D. researchers 1+1*
Technology (T)	8	6	Responsible director 1+1* Project manager 1 Research assistant 1+2*
Science (S)	20	3	Project manager 1 Senior researcher 1 Post-doc researcher 1*

The H-group applies a certain concept of text linguistics into new contexts. They exploit the concept as a descriptive concept and as a method to study societal phenomena. Their project has resulted in, for example, a doctoral thesis and an international conference that the H-group organized. The T-group develops an application for mobile phones in the field of computer science. They collaborate with firms. Their project ended in 2007 and resulted in nine international articles,

three new projects and two of the members starting their doctoral thesis. The S-group's leader had started the research programme on plants already in the 1980's. The S-group is continuing this endeavour. During 2007–2009, the members published 17 international articles and received major funding from the EU and the Finnish Academy.

3.3 Case B: The Finland Distinguished Professor programme

The Finland Distinguished Professor (FiDiPro) programme offers competitive funding for top researchers to conduct research projects in Finnish universities. The programme is targeted towards foreign researchers or Finnish researchers who have been working abroad for several years. The programme is funded by the Finnish Academy and Tekes and was launched in 2007. During the same year, twenty four FiDiPro professors began their projects in nine universities (FiDiPro 2011). Two of these universities were selected, the names of which are not revealed for reasons of confidentiality. The selection was done using two criteria. First, the universities were among the five largest in Finland, measured by the number of students and personnel in 2007. Second, the FiDiPro professors of the universities were willing to participate in the study. In addition, both of the selected universities invested in considerable effort in internationalizing research and teaching, as revealed in strategy analysis (see more in article II). In these two universities, six FiDiPro professors were awarded grants. All of these were contacted and all were willing to participate. However, only four of the projects started within the first eight months of 2007. The two projects were excluded from this study because including them would have drawn out the timeline of this thesis. In addition, attempts to encompass the knowledge creating processes of six groups would have probably been too much for one researcher. Each group started their work with three people, who participated in the study.

The key similarities of cases A and B are academic knowledge creation and internationality. The key differences are the leaders and the age of the groups. In case A, the leaders are Finnish or have been living in Finland for such a long time that they, for example, speak Finnish fluently. In case B, even though the leaders have collaborated directly or indirectly with the researchers of the recipient Finnish universities, they are coming to Finland for a longer period for the first time. Also, the age of the groups differ: in case A, the groups have been collaborating from several months to years, and had already formed a number of practices endorsing their knowledge creation. On the contrary, in case B, the

groups are starting their work or even being formed while collecting material. However, some of the members knew each other beforehand and had collaborated before.

The main materials include interviews, weekly diaries and observations and are presented in table 5 by each group: Science, Tec1, Tec2 and Tec3 groups. The background material includes photographs, university floor plans, power point presentations from conferences and lectures, a video from a course held by one of the FiDiPro professors, the Internet pages of the projects, articles that the group members have written and informal meetings every now and then with the members. This background material was not systematically analyzed for the thesis.

Table 5. The main materials of case B (Hautala 2011b: 609, published by permission of Emerald Group Publishing Limited).

Group	Diaries	Interviews (min)	Group-interviews (min)	Observed events
Science	40	6 (411)	1 (29)	conference, two weekly meetings
P	0	2 (99, 43)		
R1	9	2 (85, 73)	x	
R2	31	2 (47, 64)	x	
Tec1	26	5 (230)	1 (40)	workshop, normal working situation of
P	0	1 (15*)		R1 and R2
R1	16	2 (82, 50)	x	
R2	10	2 (65, 18)	x	
Tec2	11	6 (323)		workshop
P	0	2 (72, 40)		
R1	2	2 (53, 48)		
R2	9	2 (71, 39)		
Tec3	43	6 (370)		course, conference
P	5	2 (50, 50)		
R1	8	2 (93, 96)		
R2	30	2 (39, 42)		

* continued with a discussion that was not recorded

The collection of the material proceeded in three phases. The first phase included instructions on the weekly diary, a preliminary e-mail questionnaire and recorded one-on-one theme interviews. The diary instructions were written on four power point slides that were discussed with the interviewee. The main precept was to

write about the most important event, idea or moment of the week that relates to the interviewees' work on the FiDiPro project. That event, idea or moment could either improve or hinder work. The style of the writing was encouraged to be free, but lists should be avoided. I encouraged writing about how working feels and provided a few completed diaries as examples. The diary was sent every Friday morning as an e-mail for the interviewees. It was a template consisting of two parts and additional questions. The first part was about the progress (or setbacks) of the project, and the second part was about internationalization. International means, for example, communicating with people who possess different national backgrounds or another international activity that was discussed during the interview. The priority was to write about the progress (or setbacks), and if that piece of writing included internationalization, another part was left empty. In addition, the template included the following questions:

- Choose the correct alternative: the event helped my work / the event disturbed my work
- The exact time of the event
- The exact location of the event
- The names of the (key) people involved in the event

In the e-mail questionnaire, I asked preliminary questions about the FiDiPro project, such as the aims of the project and the aims of your own work in the project, and the FiDiPro project group, for example, if the members had collaborated before and for how long. This information was applied when designing the interview questions. The themes of the interviews contained professional and personal backgrounds, communication, internationality and the first impressions of the project and members. Discussions of the backgrounds were motivated by a lifeline. Interviewees were asked to draw a line or other suitable figure describing their lives from childhood to present. The interviewees also marked down the important events in their lives, especially those that had affected their choice of academic career.

The second phase was between the first and second interviews. The main materials which were collected were the weekly diaries and observations. In addition, I visited the group-members to "catch up" with them a few times. Events that the members attended varied from conferences to courses. The Science group also allowed me to observe their meetings, where I was a "complete observer" who did not ask questions (Burgess 1987: 82). An observation study by Iedema *et al.* (2006: 1115) was applied when a matrix for

meetings was designed. The matrix includes topic, turn-taking, interruptions, (dis)agreeing and language in discussion, as well as being silent. However, I otherwise adopted a role of "observer-as-participant", and asked the interviewees and other participants some questions in conferences, workshops and courses (Burgess 1987: 81–82). I contacted the organizers beforehand, explained my researcher status and received access to materials and sessions. Communication, such as giving a presentation, lecturing, arguing, joking and moving in relation to other people (for example, deciding where to sit), was the main focus of my observation. At the time of the observed events, some of the professors had employed more researchers on the groups. During the observation, I also held discussions with the new members, as well as other people that had been mentioned in the interviews and other discussions. The discussions were carefully written down but not recorded. Observations concentrated on the interviewees and other group members. Usually, during this period, the communication with the interviewees deepened as trust was developed between us. Altogether, about 200 A5 pages of field notes were taken.

The third phase consists of secondary interviews and it ended with the writing of the weekly diaries. For the interviews, I summarized the diaries into

- time-axis, including the progress
- floorplans of the universities where the locations of the diaries were marked
- a list of names

The recorded interviews started with a discussion based on the diaries. The interviewees checked my summaries and specified them if needed. The themes of our conversation were the progress and setbacks of work, learning, group-dynamics and research work in general. Progress was compared to the aims expressed in the questionnaires which were collected in the first phase. Conversation about the academic community was motivated by a task of illustrating social networks on the basis of a list of names collected from the diaries. The interviewee put her/his name in the middle of the paper and started to sketch other names related closely to the FiDiPro project around it. All of the names mentioned in the diaries were covered and additional names were added if needed. The centrality of the people was marked, if the interviewee collaborated with that person a great deal or had met other important persons through someone else. The last theme was the material and social working environment and it included a floorplan task. I showed the floorplan where the offices of the FiDiPro members were marked, as well as other places mentioned in the diaries. The

interviewees marked down other places which they deemed to be important for their work, and wrote out the routes what that they normally use during the day. The interviewee then explained the routes and places and attached memories and feelings. The Tec1 professor was very busy and only gave one short interview. The interview was followed by quite a wide discussion that was not recorded, and I also had discussions with the professor during the observation. Nevertheless, this degrades the material which was collected from the Tec1 group and restricts some of the conclusions drawn.

The researchers of the Science and Tec1 group collaborated on a daily basis. The Tec1 group members shared an office and even a desk. Therefore, they were also interviewed as a group, which was recorded. The topics covered the academic community and group dynamics.

Three of the groups are technological (Tec1, Tec2 and Tec3) and one is scientific (Science). Next, a brief introduction of the groups is provided including background information (tables 6 and 7), main challenges that the groups confronted and cooperation practices they developed.

Table 6. The FiDiPro groups.

Group	Period	Members (2007)	Members (2010)	Task	Achievements by 2010
Science	2007–2011	3	7	Basic research	Three new methods, four articles
Tec1	2007–2010	3	6	Applied research: a software application that can be used in academia and business	Software database, four articles (two PhDs completed by 2012)
Tec2	2007–2011	3	3*	To enhance research, education and build a laboratory	Laboratory in active research use, four articles
Tec3	2007–2011	3	5	Applied research: the development of a technological application	Research problems for all members defined, publications

* the amount is not stable, since the researchers receive funding from different sources

Table 7. The FiDiPro interviewees.

Group	Interviewee	Abbreviation	Cultural backgrounds	Professional backgrounds
Science	Professor	P	non-Finnish	sub-field a
	Senior researcher	R1	Finnish	sub-field b
	Post doc researcher	R2	Finnish	sub-field b
Tec1	Professor	P	non-Finnish	application-oriented
	PhD-student	R1	Finnish	theory-oriented
	Master student	R2	Finnish	not yet specialized
Tec2	Professor	P	non-Finnish	academically oriented
	Senior researcher	R1	Finnish	oriented to produce solutions for firms
	PhD-student	R2	Finnish, but working in the same country as P	academically oriented
Tec3	Professor	P	non-Finnish, sharing their nationality of birth with R1	sub-field a
	PhD-student (advanced)	R1	non-Finnish, sharing their nationality of birth with P	sub-field b
	PhD-student (beginner)	R2	Finnish	sub-field a

The *Science group* operates on basic research. The researchers were already members in the same research group and were working in the department of a Finnish university. However, they had not met the FiDiPro professor. The FiDiPro professor had been collaborating before with some of the professors at the Finnish university. The challenge for the Science group was the members' different sub-fields. Although all shared the discipline, R1 and R2 did not have experience on the sub-field in which P and the FiDiPro project were operating. P's strategy to overcome this challenge was face-to-face cooperation, and he spent quite long periods (2–5 months) in Finland. He called the first six months a "training stage". The group members developed a spontaneous way of communicating that combined both more formal channels, such as weekly meeting and international workshop that the group arranged successfully twice in Finland, and informal channels, as they went skiing, had lunch and visited each others' offices during the workday.

The *Tec1 group* is performing applied research. Their project develops a software application that can be used both in academia and business. None of the

members had seen each other before the project, and R1 had not worked in a Finnish university before. The FiDiPro professor had been collaborating before with some of the professors in a Finnish university. The main challenge for the Tec1 members was to combine the different interests of the professor and researchers. They came up with a solution that the researchers started the project by forming a software example. After that, new employees were hired to develop the project further. The researchers worked face-to-face daily, since they shared an office and even a desk. Since the R2 was a master student, he needed help from R1 to accomplish his tasks. They formed a master-apprenticelike relationship. The professor visited Finland for periods of days or weeks at a time. During these visits, the group had meetings. When the professor was abroad, they communicated by e-mail. The group members collaborated closely with a professor of the department of the Finnish university who was not officially in the FiDiPro project. This professor had a mediating role as he supervised the researchers while the FiDiPro professor was not in Finland.

The *Tec2 group's* project aims at enhancing the quality of the research conducted in their technological field in the Finnish university. Two steps were planned to be taken. The first was to enhance the education given in their technological field in the Finnish university. The second was to build a new technological laboratory for the Finnish university. The FiDiPro professor had been collaborating with a company located in the same Finnish city as the university. Through that collaboration, he had met some of the researchers in the Finnish university, one of them being R1. R2 had studied in the Finnish university and moved later to the FiDiPro professor's research group to complete her PhD. Therefore, the FiDiPro professor was already her supervisor. The main challenge of the Tec2 group was a lack of the funding that was needed for the laboratory. Therefore, the first year of the project was spent collecting funding, purchasing equipment and building the laboratory to enable actual knowledge creation. Therefore, R1 also did not attend the project at this period as much as was planned. The professor and R2 worked in the same research group before the FiDiPro project, and they lived in a foreign country. They visited Finland for several weeks at a time. The main focus of the visits was the preparation of funding applications, meeting possible sponsors and building the laboratory. R1 did not usually attend the meetings.

The *Tec3 group* operates on applied research. Their project develops technological applications. The FiDiPro professor had been collaborating with some of the professors in the Finnish university, but not with R1 and R2. R1 and

R2 had been working in the same project before the FiDiPro project. However, that particular project did not include much collaboration between R1 and R2. The collaboration in the Tec3 project is organized differently than in the other FiDiPro groups. The Tec3 project includes two separate projects and there is no collaboration between R1 and R2. The first project was an article that R1 and FiDiPro professor wrote together. The second project is R2's doctoral thesis that the FiDiPro professor supervises. Both of these projects contribute to the aim of the Tec3 project. The main challenge of the Tec3 professor was to find the right employees, which took more time than planned, more than six months. The FiDiPro professor spent quite long periods (from several weeks to a few months) in Finland. During the stays, face-to-face meetings were the main method of communication, otherwise it was by e-mail. Both of the researchers visited the FiDiPro professor's home university separately, and R2 worked there for one semester. This period took place after the collection of the material of this thesis was done.

Most of the members in both cases, A and B, were from individualist cultures and were used to quite short power distances (Hofstede 2001). During the research, it became clear that academic culture was more visible and important in the groups' work than their national cultures, which was discussed in the interviews and mentioned in the diaries. This is in line with a study by Magnier-Watanabe & Senoo (2010: 214), who conclude that the effect of organizational characteristics outruns those of national cultures in knowledge management practices. Even though cultural diversity exists in the background, it still is part of the groups and affects their work, at least indirectly. Some of the group members, especially the FiDiPro professors and also other FiDiPro group members, had lived in two or more countries for several years and even had two nationalities. Some of these were also able to discuss their work in three or more languages. They had been working in several groups and collaborations including members of different nationalities. These members were very aware of the cultural dynamics, which was also reflected in their actions. For instance, they knew what kinds of discussion topics were good and what to avoid when getting to know new people, how to achieve equality in multinational groups, what kinds of rules should be set up for a multinational group and how to make sure that everyone has understood their working duties. When I interviewed and observed these members, I noticed that they had a very clear manner of speaking and gesticulating. For instance, when they guided me within the university and conference locations, I had no problems in understanding where we were heading

and to which door we would go next. It was very easy to talk, walk and have lunch and coffee with them right from the very beginning.

Varying cultural backgrounds, for example, spice up the non-work-related conversations because the members were usually eager to learn about each others' cultures. In this thesis, the "cultural background" therefore refers to the local characteristics of the academic knowledge creating contexts and processes that the members have been working in. Academic knowledge is affected by the localities of its creation (Jöns *et al.* 2010: ix). "Professional background", then, refers to, for instance, research areas and a career within academia. What is salient here is that there is diversity of these aspects within groups that is exploited and managed in knowledge creation, not going into the details of these differences. All of the groups communicated in English and in Finnish or using another language which was common to the members. The selection of language varied situationally: if only Finns were involved in discussions, it was natural for them to speak Finnish. The interviews were done in Finnish with the Finns and in English with the members from other nationalities. The interviewees were accustomed to using English and, therefore, no language issues were noticed in the groups. The meaning of language in knowledge creation is discussed further in Jauhiainen & Hautala (2011).

3.4 The methods of analysis

The main methods of analysis are qualitative, including content analysis, discourse analysis and mental mapping. These methods are applied to the interviews and diaries as explained in this chapter. The secondary methods of analysis include quantitative cross-tabulation and Pearsons' correlation that were applied to the survey. Cross-tabulation is interpreted with χ^2-test and Exact P-value. An exact P-value is needed when the amount of answers is small (Mehta & Patel 1996: 1).

3.4.1 Content analysis

Qualitative content analysis is a research method that is applied in a variety of ways, usually based on deductive or inductive analysis (Elo & Kyngäs 2007). The definition of qualitative content analysis, according to Hsieh & Shannon (2005: 1278) is

> "a research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns."

Text has both a manifest and latent content (Babbie 1992: 312). Whereas, manifest content can be read as words and sentences, latent content is the meaning that can only be found behind words and sentences. Content is reached when text (e.g. speech, article) is summarized regarding the context of the text's creation (e.g. interview) (Krippendorff 2004: xix), the text's latent meaning and research questions.

Content analysis was selected as an analysis method as a result of its flexibility (White & Marsh 2006). It can be combined with a variety of theoretical frameworks, both with inductive and deductive reasoning. In this thesis, both deductive, or directed, content analysis and inductive content analysis are applied. Content analysis is applied in all articles of this thesis, either as a preparatory analysis method followed by discourse analysis or mental mapping, or the main analysis method. I have pursued also revealing the latent content by paying attention to, for example, sighs, laughs, gestures and changing positions. On the other hand, the variety of ways to apply content analysis is one of the downsides of the method. As a consequence, the analysis process may become vague. To prevent this, I have aimed to carefully unfold the analysis process. Next, each of the applied content analysis is justified and described according to the two main stages of analysis: preparation and organization (see also Elo & Kyngäs 2007).

Directed content analysis is suitable in situations where the researcher aims to refine a theory through applying it into a new context (Hsieh & Shannon 2005: 1281−1283). The theoretical framework included socialization, externalization, combination and internalization, according to the SECI model, which was applied into academic knowledge creation. Previously, the SECI model applications have concentrated on industries and mainly technological knowledge creation. Directed content analysis was applied both to the unstructured survey answers and interviews. During the preparation stage, the interviews were translated word-for-word into text. Altogether, the interviews of Case A included 125 A4 pages of text. During the organization stage, those text parts referring to knowledge and its refinement were selected and organized tentatively into SECI categories. "Tentatively" means being aware of the possibility that the text does not fit the category, when either the category definitions were adjusted or new code was created. A more detailed description of the process can be found in article I.

Inductive content analysis is suitable when the theoretical refinement of a concept is on the process, such as *ba* in article II or cognitive proximity in article III, or when there not many empirical studies have been done with a certain framework, such as space-time in article IV (Hsieh & Shannon 2005: 1279). The codes and categories are derived from the material. However, the coding is not disengaged from the theoretical framework, which is at the background of the analysis process. During the preparation stage, interviews were transformed into text, word-for-word. Altogether, interviews and diaries of Case B included 716 A4 pages of text. The QSR NVivo 8 -program was applied during the organizing stage, in which the notion of time was coded through words (e.g. week, spring, day) and through content that expressed time (e.g. progress, periods). The spatiality manifested in these selected parts of text was then interpreted. A more detailed description of the process can be found in article IV.

3.4.2 Discourse analysis

Discourse analysis was applied to reveal group discourses of knowledge creation and draw some conclusions about the context (*ba*) of knowledge creation. Grasping discourse is a challenge and often material remains under-analysed. Therefore, any discourse analyst must be able to go beyond written words and give evidence on their arguments (Antaki *et al.* 2003). To avoid this, I have included an appendix into article II that explains the categories, provides examples of the quotations and conclusions drawn.

Discourse analysis was prepared through inductive content analysis. The interviews were transcribed word-for-word into text, where latent content, such as breaks, sighs, quiet or loud volumes and shifts in positions, was also marked. The organization stage of the content analysis first included arranging the text into parts, or the topics of talk with the QSR NVivo 8 -program. Second, the main words and all the analogies were coded from each part, and these codes were collected throughout the text. Third, the codes were organized into 30 categories, from which the key words describing each group's knowledge creation, as well as all the analogies, were selected. The theoretical framework was guiding the selection at the background.

Identifying discourses was the next stage. Questions which directed the finding of discourses were posed and answered through the whole text. The definition of discourse guided the questions (see the definition in chapter 2.2 Academic knowledge..). The role of concepts, statements and expressions in

forming a way of talking about research in a group was accentuated. Through answering the questions, descriptive examples were identified and gathered as a 76-paged booklet that was the final corpus of interpreting the discourses. A more detailed explanation of the analysis process can be found in article II.

3.4.3 Mental mapping

Mental mapping is applied in this study to construct personal FiDiPro project related knowledge bases (mental maps). The underlying idea is that words, thinking and knowledge creating action are related. A mental map presents knowledge as interrelated concepts, statements and thinking patterns (mental models), therefore, capturing some of the comprehensive, contextual and tacit nature of knowledge. When studying cognitive structures of people facing complex issues, mental mapping is a valuable method (Eden 2004, Huff 1990: 406). However, the method is laborious and the researcher influences the map, for example, through selecting interview themes and, therefore, focusing the vocabulary that the interviewees use (Eden 2004, Johnson-Laird 1983). I have minimized my influence by following the steps of mapping technique set by Calori *et al.* (1994), Carley (1997), Eden and Ackermann (2004) and McComb (2007) in their studies. These steps are, first, selecting the content of the maps and second, outlining the structure of the content. The more detailed contents of the rules are explained next.

First, the key concepts and statements are identified from the material, in this study with the inductive content analysis. Concept here is "regularity in events or objects designated by some label" (Novak & Gowin 1986: 4). It can be a single word (research), a composite word (academic research) or a more complex phrase (academic and qualitative research) (Carley 1997: 538). A statement is an ideational entity, including at least two concepts and their relationship (Carley 1997: 538). "Key" concept or statement means that, either, it is greatly used by the interviewee, or s/he emphasizes it for example by a tone of a voice. The QSR NVivo8 program was applied, and, in total, 521 concepts or statements were coded. From these 521, the main concepts or statements related to the FiDiPro project were identified. 26 concepts or statements were selected per interviewee and were the foundation for the mental maps.

During the second stage, the actual mental mapping method is applied to construct the maps — one per interviewee. The Decision Explorer program was applied (see also Eden & Ackermann 2004). The location of concepts and

statements in the map, as well as links between the concepts and statements are the main features of mental map structure (Eden 2004). The main (first order) concepts and statements were situated on the map. Then, each of the first order concepts and statements were reviewed in the material and further (second order) concepts and statements were added. These are attributes that further reveal how an interviewee understands the key concepts and statements and the complexity of the FiDiPro project. For instance, "science" might include concepts such as "chemistry" and "biology". Expressions, such as "is part of" or "belongs to", are used to trace the hierarchy. All of the concepts and statements include the dates of the interviews and diaries. Links between concepts and statements were identified from the text. Each map consists of about 170 nodes. A further explanation of the interpretation of the mental maps can be found in article III.

4 A review of the results

Academic knowledge creation in international research groups is indeed intertwined with its creation processes and contexts. The articles show that both process dimension (articles I–IV) and cognitive dimension (articles III and IV) are important for understanding knowledge creation. The results of the groups, internationally considered academic knowledge, are created in complex and group-specific processes, where interaction (articles I and II) and interpretation (articles III and IV) blend. Field-specific knowledges evolve in different discourses (article II). The creation processes and knowledges take place and form in multiple arenas and space-times. The arenas set both building blocks for knowledge creating discourses and are re-created in communication (article II). In fact, knowledge creation itself is a spatio-temporal process and a series of both unique and shared interpretations of context lead to knowledge (article IV). This section poses and discusses the central observations from the articles by answering the second level research questions.

4.1 The complex process of interactive knowledge continuum

Knowledge creation is a complex process including interactive conversions of knowledge in a tacit-explicit knowledge continuum. The complexity of the knowledge creation process is shown in the results of Case A (article I) (see Ic). The progress is unique and includes loops, simultaneous stages and skips. Another central observation is viewing knowledge as a continuum of, on the one hand, a never-ending process, and, on the other hand, a tacit-explicit continuum (see Ia–Ic). It is the interaction that keeps knowledge continuing and conversing to include more tacit or more explicit elements. Utilization, conversion and sharing are intertwined, as knowledge (existing in the taci-explicit continuum) is conversed through sharing and utilizing. Research questions are answered in brief:

Ia. *What kind of knowledge do the selected research groups utilize?*

Tacit and explicit elements are combined in the knowledge of the research groups. Tacit knowledge is the "sieve" through which explicit knowledge is created, and, therefore, their examination as separate extensions of knowledge is not reasonable. Instead, the groups utilize the social potentiality of the researchers to work as a group, the experience of following research procedures and academic framework

justifying the work, each of these include tacit and explicit elements. However, the degree of tacitness of the utilized knowledge varies.

Ib. *How is knowledge shared and conversed about from the viewpoint of foreign employees in the University of Oulu?*

Knowledge creating activities, such as discussions, e-mails and reading have varying tendencies to converse knowledge along the tacit-explicit continuum when it becomes either more sharable (explicit) in the group of more interpreted (tacit) by the individuals. Face-to-face communication enabled tacit knowledge to become shared. At the same time, it was diversified through varying views. Knowledge was externalized through tacit knowledge. The international networks of the researchers played a key role when existing knowledge is combined. Knowledge was internalized when researchers interpreted it in the context of their own field and experience. Despite some separate mentions, a majority of the survey respondents did not report on difficulties in sharing and conversing knowledge in English in their research groups and the departments of the University of Oulu.

Ic. *How is knowledge created and refined in the selected research groups?*

The SECI stages and steps taken in the groups to create knowledge did not correspond. The knowledge conversions of sharing (S) and explaining tacit (E), combining explicit knowledges (C) and internalizing explicit (I) give rhythm to knowledge creation (SECI). The steps of knowledge creation in the groups included sharing tacit knowledge, planning and justifying the research, collecting and analyzing the material and publishing the results. One step forward in knowledge creation might involve several stages in different orders, skip some stages or include them simultaneously and create loops between the stages (article I: 137). In addition, the process is group-specific.

This article has affected the definition of knowledge in this thesis. Both tacit and explicit elements are included in all the knowledge, which was transferred to the knowledge definitions of other articles of this thesis. Their clear division is not possible, but it is essential to acknowledge the existence of tacitness. Although this conclusion is not new (see e.g. Leonard & Sensiper 1998: 113, Polanyi 1983), it is relevant since tacit and explicit are still often quite strictly divided in research (see section 2 Academic knowledge..). This article also challenges the "clarity" of the SECI model's knowledge conversion. The SECI model channels thought that all knowledge can be explicated. If this thought is

approved, the collective tacit knowledge and much of "being a researcher in academic community" is ignored. After all, that is a strong form of tacit knowing and central element in knowledge creation (Collins 2010).

4.2 The multiple *ba*s of multiple knowledges

According to the main finding of study article II, knowledge itself is a central element of context, which accentuates the intertwinedness of knowledge, processes and contexts. Multiple knowledges (for example, humanist, scientific and technological) are created with multiple interactions (here mainly discourses) and within multiple *ba*s, underpinning the construction of those discourses. The research questions and answers are:

> IIa. *In what kind of ba (here as a virtual, physical and mental context) do the research groups create knowledge?*

Knowledge is created in different combinations of physical, virtual and mental *ba*s. The office layout and usage of common workspaces are important in physical *ba*. The groups use a variety of applications in virtual *ba*, such as wiki, e-mails, docushare and web-pages. Mental *ba* consists of a group's way to ideate and connect themselves into their group and research community. All of these extensions of *ba* promote the creation of certain knowledge with a certain discourse. Even though virtual *ba* is important for the groups, its role in relation to knowledge creating discourses was smaller than, for instance, the role of physical *ba*. The research groups of case A all work in the same department and geographical location, which is an important reason for this: they communicate face-to-face a great deal.

The H-group's discourse is named as social and conceptual closeness. They create abstract humanist knowledge with profound conversations and a deep common understanding, which is reflected in their physical *ba*. The H-group members' offices are located side-by-side and they always keep their doors open to enable frequent drop-ins. The T-group creates knowledge with "human trust and technical clockwork"-discourse. Their project, just as the product they aim to create, resembles a clockwork mechanism. The project is divided into tasks that correspond to parts of the product, and each task is conducted by groups of researchers. The members trust each others' know-how, enabling the mechanism to work. The S-group's discourse is called "autonomous researchers' part of a global scientific community". Scientific knowledge is accurate, and professionals

understand and interpret it quite similarly without the clarification of philosophical backgrounds.

IIb. *What does ba (here as an arena of discourse) consist of in the research groups?*

Ba consists of three elements. The first is knowledge type. Humanist, technological and scientific knowledge that the research groups create, are different philosophically, epistemologically and empirically. The social practices that are linked to the ways to create these types of knowledge differ as well. The main difference is the closeness of the group-members. No such personal closeness is required between the T- and S-group members as in the H-group. The H-group deals with very abstract knowledge that is created with shared interpretations and vivid language, whereas scientific and technological knowledge is more accurate and straight-forward. The second element of *ba* is individual characteristics. Each group has produced a picture of an ideal member for the group, and when new group-members are selected according to this picture, the group-discourses continue quite unchallenged. The third element is structural factors related to administrative responsibilities framed by the university as an organization, research funding and collaboration, for example, with firms.

This article provided two important conclusions that have affected the later work of this thesis. First, different kinds of knowledges (humanist, scientific and technological) require different kinds of communication to be created. Not all groups need personal relations for knowledge creation. The ideal communication is a result of many elements, such as knowledge, people and project administration practices. This observation has guided the collection of FiDiPro case study material. Second, even though *ba* takes an important step towards understanding the context of knowledge creation, it has weaknesses. First of all, it is not very clear what mental *ba* is. The "mental" context of knowledge creation is evolved further in this thesis as cognitive space (articles III and IV). Second of all, the division of virtual and physical *ba*s can be challenged. The reason for the division is face-to-face communication which enables the sharing of tacit knowledge: in shared physical *ba*, tacit knowledge can also be shared, which is not necessarily true in virtual *ba*. Nevertheless, (virtual) video calls are a common communication channel today and, theoretically, enable the sharing of tacit knowledge. Another viewpoint to challenge virtual/physical division is interaction with devices to create knowledge. Researchers use computer software, laboratory

devices, chalkboard and paper to test and express their ideas. Whether that particular device is "virtual" or not is not (always) central, but how it is used and how it is part of a knowledge creation process. The space-times of knowledge creation presented in the fourth article are based on these observations.

4.3 Towards the cognitive friction of complex interpretations

According to article III, the most fertile ground for knowledge creation is on the way towards cognitive proximity by mental map content, while maintaining cognitive distance by the mental map structure. This middle ground of complex individual interpretations but a common understanding about the project creates cognitive friction. Cognitive proximity dynamics in mental maps include many directions to go towards: cognitively more proximate by content, cognitively more proximate by structure, cognitively more distant by content, cognitively more distant by structure and maintaining the distance either by content, by structure or by both. However, not all of these were captured in this study (e.g. developing distance). To sum up, the research questions and their answers are:

> IIIa. *How do the research group members become cognitively more proximate or maintain their distance?*

In Science, Tec1 and Tec3 groups, altogether in three of the four studied groups, some members became cognitively more proximate. Becoming cognitively more proximate mainly took place through the content of the mental models. Cognitive proximity is mainly received through (face-to-face) collaboration inside a group within a suitable task that allows the forming of a common view. Only the researchers in the Tec1 group also became cognitively more proximate by the structure of their mental models. This was due to their close "master–apprentice-like" cooperation relationship.

Despite the Tec1 researchers, all the members of the groups maintained their cognitive distance existing in the structure of the mental models. Cognitive distance is maintained when the members cooperate with others outside the group, they are able to apply individual views in the task and employ new members to the group.

IIIb. *During what cognitive proximity or distance are the results in a study-period achieved?*

Six out of eight explicit results, including publications, the results of calculations and software, were created in the groups during cognitive friction. Cognitive friction includes becoming cognitively more proximate by content, but maintaining cognitive distance by the structure of the mental models. It allows creative results since members have a common understanding about the project through similarities in the knowledge base content, but also unique thinking and a diversity in the knowledge base structure.

The findings develop the theory of cognitive proximity and suggest some implications for management. It is argued that in addition to studying the cognitive proximity of companies, which is mostly the case, researchers should also concentrate on the level of collaboration and groups. Cognitive proximity dynamics are shown by comparing the mental maps of collaborative individuals. The dynamics might not directly correspond to the cultural or professional backgrounds of people, let alone companies. Indeed, knowledge is not created by "organizations", but by people, and even though two firms may have the optimal cognitive distance, knowledge creation depends on the cooperation of their employees. The challenges of the main approaches to knowledge in economic geography were realized in this article: especially the centrality of rationalist knowledge in economic geography and lack of attention paid to the process and cognitive dimensions. From a cognitive proximity point of view, the "box of organization" indeed seems to be black and covered with multilevel issue. Including the cognitive and process dimensions has been shown to allow useful insights in the attempt to understand organizations.

4.4 Knowledge becoming known in space-times

Article IV reveals knowledge creation to be a spatio-temporal process. The FiDiPro groups aim to create distinguished knowledge and a characteristic of this aim is to go beyond the known. It is possible in space-times, since they enable the combinations of object, communicative and cognitive spaces and linear and relational times. For example, the funding, software, results and methods of the object spaces that are created at different points in linear time, become combined. The objects are applied to analyze and combine the knowledge and ideas that arise from the interaction are shared with other group members in communicative

space. Depending on how the work progresses, times feel as if they are flowing, hectic or disrupted. The interactions, results of analysis and times are interpreted in cognitive space and the current time with certain knowledge created in an epistemic community. Objects, interactions and interpretations progress through people who learn. Skilled individuals and research groups make these combinations, which become reflected in their work and projects. Therefore, knowledge is a spatio-temporal process when knowledge becomes known.

IVa. *What types of combinations space and time exist in the knowledge creation processes?*

Three sets of space-times are intertwined in the research work. The first is the time-space of stages. Linear time has a central role here, since the researchers interpret the progress of their project by sequencing it into stages. These stages are the beginning, settling, preliminary results, accurate results and the widening of the project. Being there, together in object, communicative and cognitive space, fosters the progress of knowledge.

Flows and disruptions of experienced time fluctuate in the second space-time. Living and working in this fluctuation is the key to creating knowledge that is distinguished. The researchers experience time flowing in the background when involved in work that feels rewarding and important. They also feel that time is disrupted or slow, when confronted by challenges or problems at work. The cognitive space has an interesting role here. The learning of new skills has often been associated with disrupted time, but has also enabled the group members to become cognitively more proximate and achieve flowing time. Slow times were sometimes experienced when the members had (too much) cognitive distance or the cognitive space was too narrow for the project.

In the third space-time, the analytical categories of space and time are inseparable. Therefore, this spacetime of network is written without a hyphen. The building blocks of a knowledge network are nodes, for example, people, articles and software. Meaningful combinations of the nodes are connected into bundles that are needed, for example, to form a research project. Knowledge travels with people along the bundles and form paths that, for example, a research project takes in aiming at something that is not-yet-known. Knowledge in spacetime is becoming.

IVb. *How are these combinations of space and time related to the knowledge creation of individual researchers and research groups?*

The space-times exist at the level of both researchers and research groups. On the one hand, researchers have unique interpretations of the space and time that they are working in, and, on the other hand, the interpretations are sometimes quite similar and the group creates knowledge in shared space-time. All the FiDiPro groups had periods in linear time when they shared space-time.

The space-times are related to the knowledge creation of the FiDiPro groups and researchers in three ways. First, different aspects of knowledge are brought out by different space-times. Knowledge is a progress in the time-space of stages. Through passion and pushing, researchers create knowledge that is distinguished in the space-time of flows and disruptions. Knowledge is becoming and networked in the spacetime of a knowledge network. Second, space-times perform as shared arenas that enable the group members to be there for each other, experience the project as being collectively shared and felt and go beyond the known as a group. Third, space-times enable the creation of explicit results. Space-times not only provide objects to apply, but are also shared arenas for groups. These shared arenas are central when creating explicit results: seven out of eight explicit results of the FiDiPro groups were created in shared space-times. In addition, the creation of explicit results preceded the working through "hard times" of a slow and unsecure time, which often guided the focus of individuals into the essential and consolidated the groups.

5 Conclusions and discussion

The current thesis explores academic knowledge creation in international research groups within a theoretical framework that considers knowledge intertwined with the processes and spatio-temporal contexts. This section begins by answering the first level research questions that are formulated through the gaps identified in the (academic) knowledge creation literature. Therefore, the empirical contribution of the thesis is presented here. The literature in focus includes the fields of knowledge management, economic geography and science and technology studies. Second, the theoretical contribution of this thesis is discussed. The main theory in each article is taken forward: the SECI model (Nonaka & Takeuchi 1995) in the article I, *ba* (Nonaka & Konno 1998) in the article II, cognitive proximity (Nooteboom 1992, Nooteboom *et al.* 2007) in the article III and space-time (e.g. Dodgshon 2008) in the article IV. Third, according to the findings, a few further points are raised for discussion and deficiencies of the thesis are contemplated. Fourth, future research suggestions are discussed under the topic "Geographies of organizations".

The first gap in current (academic) knowledge creation literature derives from the uniqueness of knowledge creation in groups, organizations and fields. Therefore, there is need for further case study research, especially in international and geographically distributed groups (e.g. Bosch-Sijtsema *et al.* 2011: 276–277, Nam *et al.* 2009: 781). These are addressed as the selection of case study strategy and the selection of the project groups. An empirical study follows two cases: the University of Oulu and, especially, its three international humanist, scientific and technological groups (Case A), and the four FiDiPro groups built around distinguished international professors that start new projects in Finnish universities (Case B). The FiDiPro groups are temporally geographically dispersed as the leaders, the FiDiPro professors, move between the Finnish and their home universities. These groups operate in the fields of technology and science. Materials consist of interviews, diaries, observations and surveys for foreign employees of the University of Oulu. The main methods include mental mapping, discourse analysis and content analysis.

The second and third gaps exist in the knowledge creation processes: more detailed research is needed about the interaction (second gap, e.g. Raes *et al.* 2011: 102) and cognitive (third gap, e.g. Harquail & King 2010: 1619) processes. The diversity and cognitive dimension should be linked (Kearney *et al.* 2009: 581). Within the studies on academic research, early phases of knowledge

creation (e.g. Evans 2010: 760) and the evolution of collaboration (e.g. Sundberg 2010: 37) should be in focus. These studies are needed at the levels of an individual and group, which, especially in economic geography, are often bypassed as the focus is on "organization", "industry" or "region" (article III). Even though economic geographers have identified the black box of organization (e.g. Boschma & Frenken 2006: 277–278) it is still rare to go inside organizations to follow processes, individuals and groups. Therefore, the process dimension of following processes in time is also called for. The levels of a group and individual are focused on in the thesis and applied as a link bringing the corners of knowledge, processes and contexts into a triangle of knowledge creation.

These two gaps are formulated into the first level research question A. Cognitive dimension is included as interpretation process, mental maps, mental *ba* and cognitive space. An individual has a mental map of the concepts and their relations. When individuals interact with other people or their surroundings, they place the messages into the mental map, or in other words, interpret the interaction. In these maps, knowledge is organized as representations of the world called mental models that guide behaviour and offer action plans (Johnson-Laird 1983). In article III, cognitive dimension is linked to the diversity of the FiDiPro members' knowledge bases. The process dimension is included as the empirical material is collected by following the knowledge creation processes. The FiDiPro case focuses on the early stages of knowledge creation.

Research question A asks, *what are the appropriate processes of interaction and interpretation of knowledge creation like in international research groups?* The appropriate interaction and interpretation processes are found to be unique to groups, different kinds of knowledge, projects and administrative practices (articles I, II and III). However, based on general similarities in the groups, three aspects of appropriate interaction and interpretation processes are identified. According to the first aspect, appropriate interaction and interpretation processes are intertwined. They form a series of actions and reactions of interacting and interpreting in a group such as explaining and understanding or reading and applying. The members of a group need to be able to explain their views to others, in such a way that others can interpret knowledge. These actions and reactions further create knowledge, like building a ladder, and set it to different viewpoints, since knowledge becomes rooted in the various mental maps of the group members. These actions also constantly alter knowledge along the tacit-explicit and never-ending continuum. By interpreting and interacting, the individuals sense cognitive proximities and distances between the members of a

group. With the help of a group leader, too wide distances can be bridged, for example, by forming suitable collaboration pairs or tasks inside the group.

The second aspect of appropriate interaction and interpretation processes is that they are contextual. The interactions require (shared) place, space and time. Researchers, for example, interact with and apply their surroundings in interactions with other people. They can enrichen communication by showing, forming analogies and moving. All of this is derived from their context. In addition, interpretation or organizing pieces of knowledge into personal mental maps takes place in cognitive space.

According to the third aspect, appropriate interaction and interpretation processes bind the members and groups into a wider international epistemic community. The common rules of knowledge creation, language, collaboration practices and awareness of what is known and by whom, are derived from epistemic communities. Being engaged into these common practices helps the researchers to organize knowledge creation in new groups and collaborations.

The fourth gap in current (academic) knowledge creation literature is in the context of knowledge creation, which is often not understood much more than material (e.g. Sismondo 2010: 11). The research question B therefore asks, *what are the central contexts of knowledge creation in international research groups?* Derived mainly from articles II and IV, three central spatio-temporal contexts of knowledge creation are summed up. These three are only analytically separable, not in the knowledge creating work in which they become intertwined. These contexts form arenas, times and spaces of knowledge creation. The first is context enabling communication between people. It is based on common rules of what is knowledge and how (and by whom) it can be created. In academia, this context includes communication channels, such as Internet journals, e-mail lists and temporal clusters like conferences. At the group level, the context is the form of rules about when, how and what to communicate that are manifested, for example, as weekly meetings and in common lunches.

The second is context enabling understanding. In this cognitive space or mental arena, different views can be combined through shared concepts or skills, for example. The group members learn to step each other's contexts and to explain their ideas in a way the others can understand and the group can progress in their knowledge creation. Through more versatile explanations and connections to multiple personal contexts, the possibilities to alter knowledge in the tacit-explicit continuum increase. Knowledge itself becomes multiple. Through these contexts, even surprising combinations of people, due to their different cultural

and professional backgrounds, can be brought together. This can be possible with innovative concepts and common research aims, for instance.

The third is context locating people and mixing life and work. People derive inspiration and socialize into culture from the places where they work and live. Even distinguished researchers do not only work, but have hobbies, friends and family, as well as memories and associations along their life lines that bring out landscapes, buildings, scents, atmospheres and feelings. Since there are no two people with exactly the same backgrounds, the practices of working and thinking between people differ. People are unique and, therefore, groups have diversity. It is the people that create knowledge, and diversity, for example, cognitive proximity, reflects to work through groups and collaborations.

The research question C asks, *how are the processes and contexts of knowledge creation related to the explicit results achieved in international research groups?* The answer provides a more detailed view on how the processes and context relate to actual explicit results, which are important for the groups and epistemic communities to progress knowledge. This is also a relevant research question for work groups in business organizations, since it is the explicit marketable results that make companies (and regions) competitive. Case B provides detailed material about the progress of the FiDiPro projects, including the time when explicit results are achieved. Case A is applied here to consider the research question on a more general level.

The processes of interaction and interpretation are related to explicit results in two ways. First of all, the processes are tools to create knowledge. Group discourses promote the creation of different kinds of knowledges and different ways to organize work in a group (article II). Explicit results are not created in a void, but their paths can be followed in time and these paths are always created in the processes engendered by people who work and live in wider communities, such as groups or epistemic communities (articles I, II, IV). Second of all, the processes are tools to form good groups. Interaction and interpretation raise the awareness of the members' differences and similarities and help the groups to harness diversity in creating novelty. A group that has a chance to discover the novel has members with enough common understanding and enough diversity in their individual views. Through interaction and interpretation, the groups become aware of the interests, personalities, similarities and differences of the knowledge bases of the members. They can also exploit this through cognitive friction of a similar knowledge base content, but a unique knowledge base structure, in which six of the eight explicit results of the FiDiPro groups were created (article III).

There are four main ways to connect the contexts of knowledge creation, or arenas, times and spaces, into the achieved explicit results of the groups. First, the context provides building pieces for knowledge creating processes. As shown in article II, the building blocks that form the arenas of knowledge creation, are also applied in the group discourses.

Second, context "makes sense". In other words, information is transformed into knowledge in the context, since the context allows people to interpret and add meaning to messages through forming mental maps (article III). In addition, in context, knowledge further evolves to be known, as researchers and research groups identify what is not yet known and build contexts out of the objective, communicative and cognitive spaces that enable them to step beyond what is known. This activity widens the entire knowledge network of an international epistemic community (article IV).

Third, contexts provide times, arenas and spaces for the members of a group to build shared experiences and a common understanding. Throughout all the articles (I–IV), sharing and common understanding were repeated themes that the members suggested the group needs for the creation of explicit results. The members are "tuned in to the same broadcast" (Bathelt *et al.* 2004: 46) through discussions, collaborative tasks, skiing trips and conference travels. In the studied groups, academia as a practice-setting organization was the collective system of broadcasting. For "tuning in", it seems to be important to work in the same geographical location, in other words, face-to-face, at least temporally and stay together long enough. In the FiDiPro groups, it was important to spend quite a long time together (from weeks to months) in the beginning to learn to know each other and set the basis for working as a group. According to the more detailed observation of the article IV, shared contexts enable international and temporally dispersed groups to work as an organized group. Collaborative explicit results were mostly created when the collaborating members shared space-times, in other words, when they experienced time (as flowing, disrupted or slow) and space-time (as stages, flows/disruptions or network) similarly. With regards to a certain project, these shared contexts keep the members "tuned in" for some time, even though they work in different organizations and countries. It is possible that shared contexts also enable the sharing of tacit forms of knowledge along the tacit-explicit continuum without face-to-face contact (see also Faulconbridge 2006: 517).

Fourth, contexts bring out the multiplicity of knowledge as progression, distinguished and becoming (article IV). In the time-space of stages, knowledge is

continuously built forward at every stage. Therefore, knowledge is a progression. The finishing touch that makes knowledge internationally novel and distinguished is given in the space-time of flows and disruptions. Top researchers have a passion for their work and they push themselves and their groups towards improved results. The best ideas, methods, researchers and collaborations are combined in the spacetime of a knowledge network. These combinations, or bundles, are steps in the path towards becoming knowledge in the epistemic community. The contexts of knowledge creation enable the creation of explicit results.

The fifth, epistemological gap in (academic) knowledge creation research calls for a deeper understanding of knowledge. This is visible in particular in the fields of knowledge management and economic geography, where much of the approaches to knowledge are based on rationalist understanding. Rationalist knowledge is seen as an object extracted from people and often studied with surveys or statistics (e.g. Jakubik 2011, see chapter 2.4.1 Approaches to knowledge…). In addition, rationalist knowledge is mainly explicit, but if the tacit dimension is acknowledged, these two are often divided. Then, tacit is shared face to face, while explicit can be shared from a distance (e.g. Asheim & Isaksen 2002). The approach to knowledge in this thesis is constructionist-cognitive, which in short means that knowledge is thought to be created in interaction and something becomes knowledge when interpreted. The applied theoretical framework sees knowledge creation as a triangle where knowledge, creation processes and creation contexts are intertwined in the work of people and groups. Knowledge exists in tacit-explicit continuum.

Under the epistemological gap, more specific challenges for the development of theories are identified and answered in articles I–IV of this thesis. Article I considers the SECI model of creating knowledge in interaction by the stages of socialization, externalization, combination and internalization (Nonaka & Takeuchi 1995), which has not been studied much in the knowledge creation of research groups. According to the main results, both knowledge and its creation are more complex than the model appears to claim. Knowledge exists in a tacit-explicit continuum where no pure tacit or explicit manifestations of knowledge exist. Socializing, externalizing, combining and internalizing place knowledge along the tacit-explicit continuum. Even though such SECI stages do take place in the work of international research groups, the order of the stages is complex and the progress in knowledge creation is group specific. These should be considered when the SECI model is applied.

In article II, the main theoretical focus is on *ba* (Nonaka & Konno 1998). Previously, *ba* has not been studied much in research work. In addition, this is one of the earliest studies linking *ba* with discourse and studying *ba* through discourse analysis. According to the results, specific knowledge creating discourses are formulated in the groups, and these discourses reveal aspects of *ba*. More detailed knowledge is provided about what *ba* consists of. For example, it is found, that knowledge itself is the main characteristic of *ba*, and different knowledge is created in corresponding discursive arenas. Furthermore, in the literature review of the article, it is concluded that *ba* is defined quite vaguely. As a conclusion, a more detailed definition of *ba* is suggested (article II: 13).

Article III focuses on the theory of cognitive proximity and contributes to it in following ways. The study is one of the earliest attempts to study cognitive proximity as a process. In addition, cognitive proximity has not been studied much in groups and even less in research groups. Therefore, answering the research questions IIIa–IIIb provides novel knowledge with mental mapping analysis about how group members become cognitively more proximate and how they maintain a cognitive distance. This is done by combining the theories of mental models and cognitive proximity. The study also adds the concept of cognitive friction as the ideal ground for knowledge creation into the theory of cognitive proximity. In the review of previous research on cognitive proximity, two further challenges are identified and answered in the study. First, the definitions of cognitive proximity are often quite vague, mostly due to unclear definitions of knowledge bases. In this study, a knowledge base is defined as a mental map. Second, most studies do not consider the multilevel issue profoundly enough. The multilevel issue refers to problems arising from applying the concept of cognitive proximity, which relates to individual cognition, to wider levels of organizations and regions (Nooteboom 2000: 39–40). Considering the multilevel issue means considering how individual cognition can be linked to an organization, for instance. In the study, it showed how individual cognition relates to groups through shared mental models. In addition, it is considered how individual cognition could be further related to organizations. Organizations, such as academia, form an organizational focus that guides the interest and mental mapping of the individuals and the knowledge creation of the groups.

Article IV considers the space-times of knowledge creation. In current research, different approaches to space bear different understandings of knowledge. Usually, space is mostly understood as a material and time linear. These support knowledge whose spatiality narrows down to movements on a

geographical surface and time to years or dates. Even though each of the main approaches brings out important aspects of knowledge, none of them can solely be applied to study complex knowledge creation. In addition, the approaches do not appreciate the potentiality of space as a concept to contribute knowledge creation research. It is suggested in the article that the various combinations of object, communicative and cognitive spaces and linear and relational times that are identified in the knowledge creation of the FiDiPro research groups, could be applied in future research. These combinations support knowledge as being multiple, individually interpreted and collectively created. Within these space-times, dynamic geographical, cognitive and temporal proximities can form tensions (Ibert 2010: 187) of travelling and staying, becoming cognitively more proximate and maintaining cognitive distance and working through disrupted and slow times to reach a flowing time. These tensions can foster the achievement of contested and novel results.

To sum up, this thesis suggests knowledge to be, first of all, a spatio-temporal process. Spaces and times become intertwined by people and groups through knowledge creating processes. It is not the "organization" that creates knowledge, but people that are often formed into work groups. Organization is rather an important framework of what knowledge is and what kind of processes, spaces and times can be applied in its creation. Therefore, the overall theoretical framework and findings of this thesis offer insights on how the black box of an organization could be approached: through individuals and groups. Second of all, knowledge is complex and knowledge creation is uncertain and even chaotic. Complexity is in the processes, contexts and multiple knowledges. Knowledge is not either tacit or explicit, but all knowledge includes both elements in the continuum. Complexity means that the corners of the triangle (knowledge, processes and contexts) relate but cannot be simply added up, knowledge creation occurs, but not only in linear time and cannot be located simply with coordinates (Mol & Law 2006: 1). Third of all, cognitive and process dimensions are salient to include in knowledge creation studies. Knowledge progresses in the epistemic community and in projects. Information becomes knowledge if it can be interpreted: not everyone can understand a scientific article about chemistry, and not any combination of individuals can form good groups with a common understanding.

Such knowledge cannot be simplified into a formula and should not be tamed too much — neither by the rationalist understanding of knowledge, tacit/explicit dichotomies, ignoring the cognitive dimension nor strict models of knowledge

creation processes. It can be risky to understand knowledge as an object that can be extracted from people — as the "tip of an iceberg" — not only in theory, but also in managing practice. A good example is the current challenges in internationalizing universities. In the contemporary academic world, universities are more and more international, entrepreunial and involved in mutual competition, where universities, groups and researchers are ranked and evaluated constantly. In Finland, a chain of activity, from emphasizing the internationalization in the strategies of the universities, employing foreign researchers and bringing distinguished professors to Finland through a FiDiPro programme resulted in a reform of the whole university system. From the beginning of 2010, the Finnish universities are no longer governmental units, but independent legal entities of either public corporations or foundations who actively collect funding.

This reform included the founding of the Aalto University, a merger of the Helsinki School of Economics, Helsinki University of Technology and the University of Art and Design Helsinki. According to Aula & Tienari (2011: 11,16), the Finnish university reform, as well as forming the Aalto University, was framed by a market-oriented economic discourse. The discourse has many features of the rationalist approach to knowledge. The underlying idea behind Aalto is to form a world class university in Finland, by combining units that in theory could benefit each other and achieve novelty together, since the merger includes fields which could develop cross disciplinary projects, in other words, are cognitively quite proximate. However, as shown in this thesis, whether the collaboration is successful or not is a matter of the people, or actors who perform within groups and epistemic communities, and their ability to reach cognitive friction in groups and communities. The requirements in competing universities risk knowledge to be simplified to be an explicit and economic product, which is possible to produce by combining convenient researchers, fields or universities, or bringing top experts from abroad. Managing such rationalist knowledge (or information) is not enough as the products are not created from a void, but in processes by people and groups. Managing knowledge is managing people and their cooperation.

The findings of this thesis provide ground for further discussion on knowledge creation. The geography of presence or "being there" has been of interest by several scholars (e.g. Gertler 2003, Lombard & Ditton 1997) and the topic is important in international universities where the members of knowledge creating groups often locate in different organizations and countries. Studies have

concluded that "being" physically "there" in the same location with other people is important for tacit knowledge to be shared and knowledge to be created. However, more is required to create a feeling of "being there" than physical presence. "There" is not only proximity in object space, but also communicative and cognitive space. Indeed, being there can also be spotted as being there on a (somewhat) shared mental map. Being there is "now", not only in linear time but also relational, sharing the anxiety of a disrupted, slow and uncertain progress towards the not-yet-known. In fact, seeing glimpses of shared contexts, or shared "theres", I believe that it is possible that they can be mediums to share tacit knowledge regardless of the long geographical distance.

Developing further the idea that shared contexts enhance the possibilities to share tacit knowledge in groups whose members are geographically (temporally) dispersed, a question about the existence of cognitive clusters is raised. Cluster theory emphasizes tacit and explicit forms of knowledge and especially tacit knowledge being shared mainly face-to-face, which is one explanation why clusters have formed (e.g. Maskell & Malmberg 1999). Concepts, ideas, theories and research aim to connect people from different geographical locations and epistemic fields into cognitive clusters. Borrowing Porter's (2000: 254) definition, a cognitive cluster can be a cognitively proximate group of people, such as a group of researchers in the same epistemic field. In addition, a cognitive cluster can be a cognitively proximate group of concepts, ideas, theories and research aims that connect people, whose cognitive distance of mental maps due to different backgrounds can be long. However, they can find cognitive friction in the cluster of thoughts.

There are three weaknesses in this thesis. The first is empirical: the main material of the thesis only consists of seven research groups. This is the usual critique presented for case studies. However, knowledge creation is unique in groups, which is why additional case studies are called for. Answering the research questions set for this thesis and operating on a theoretical framework of a triangle of knowledge creation, the material of the processes and groups are needed. Collecting deep and vast material means that the amount of groups remains small. The second weakness is methodological. I believe that this thesis would have benefited on ethnography as more than just an attitude. Ethnography was not taken further due to a lack of time and possibilities. Organizing such a study would require a research group rather than one researcher. In addition, in particular, the technological groups could not provide permission to attend the meetings due to their collaborations with business organizations that consisted of

confidential information. However, the collected empirical material is wide and in-depth enough to contribute to knowledge creation research.

The third weakness relates to interdisciplinarity. Not all of the central research fields are covered equally. For instance, the theoretical focus is on knowledge management and economic geography, while science and technology studies has a smaller role. Neither can this thesis thoroughly contribute to any single field. Even though the micro level, qualitative, cognitive and process approach is attempted to be justified among economic geography, it still lacks some salient features. At worst, one might conclude, both geography and economy. However, geography is included, for example, through the concept of space-time and cognitive proximity/distance, through considering a human-environment relation as a knowledge creation in context and through the internationality of the case groups. Even though university research usually does not create products for the economy, knowledge creation as an activity precedes and develops the products. In addition, the first level research question C, aiming to connect the processes and contexts to explicit results, is formulated to also provide ideas for business organizations. Therefore, a connection to the (knowledge) economy exists. Yet, I acknowledge that linking people and processes to the economy (e.g. Sunley 2008) is one of the problems of the micro approach and this thesis could have been developed to this direction by considering the further adoption and application of the articles, methods, laboratory and products created by the case groups. However, a researcher who follows processes cannot know whether those processes will end up in (valuable) knowledge or not and within what time frame.

The promising routes for future research are discussed under the suggestion to study the geographies of organizations. This suggestion has three dimensions. First, organizations, especially international, have geographies. Geography as a location, as a concept of space and as multidimensional proximities could contribute more to the fields of knowledge management and science and technology studies (see especially articles III and IV). Moreover, the international and multicultural dynamics of knowledge creation deserve greater attention in relation to the creation processes and contexts. It would be interesting to know, which international groups and collaborations, achieve a multicultural attitude in exploiting their cultural diversity in work and why. Some of these groups remain international, drawing creativity mainly from other kinds of diversities. Academic culture, as the framework of common understanding, was identified in this thesis to be more important than the cultural similarities and differences (see chapter 3.3

Case B..). This notion itself is interesting for considering the cultural dynamics further. In addition, the notion raises questions about whether the cultural diversity is more visible in groups that do not share such a common framework, whether the development of a group into becoming multicultural requires more time than was possible to include in this thesis, or whether the relation of cultural diversity and knowledge creation remains very tacit and would, therefore, require intensive ethnographic fieldwork.

Following two understandings of organizations, two more dimensions on geographies of organizations exist. The second views organization as a rule and a routine based entity, allowing people to create knowledge in groups (Strati 2000). Universities and companies are examples of these kinds of organizations. This route follows the endeavour to open the black box of an organization. It requires stepping inside organizations and studying complex knowledge processes "here" and "now" as they exist with the (qualitative) approach which provides a voice for people and processes.

However, the boundaries of organizations are not the boundaries of knowledge. Therefore, the second route follows the conceptual shift from an organization to organizing (e.g. Czarniawska 2008, Jakubik 2011, Steyaert & Van Looy 2010). Organizing is a wider framework of practicing knowledge (Whitley 2006: 1154–1155). This includes generally approved definitions of what is knowledge in a particular field and industry, which extends outside the boundaries of companies and universities. The geographies of organizing would therefore allow stepping beyond "scale thinking" and see people, groups and organizations as parts of networks (Brenner *et al.* 2011: 113–114). This enables another important study area: the geographies of cognition. It would be interesting to study further what kind of geographies cognition has in international, dispersed and temporal groups and networks, and, especially, whether cognitive clusters exist.

This route is particularly important, since it enables a researcher to travel with knowledge. It is acknowledged here that along its path, knowledge can take different forms and fluctuate between being information and knowledge. For example, knowledge starts by being an idea that a person with a certain background, in suitable collaboration and in a particular space-time can create. Eventually, knowledge can evolve into a product and be distributed around the globe. It is information, while lying unread in a journal, but can be re-created as knowledge in the practices of thinking, discussing and applying. Along its life path, knowledge as information is an object that can spill over and be transferred.

Important results about the knowledge creation process can be brought out if the empirical study catches the moments when information becomes knowledge and knowledge information and considers how this fluctuation is created. The approach to knowledge in geographies of organizing is reminiscence of a generative dance between knowledge and knowing suggested by Cook & Brown (1999). However, I do not think we should or need to mix rationalist and constructivist thinking. Yet, we should realize that knowledge is a process that takes both manifestations of activity and products (information). This view would allow the combining of the micro level of processes to the macro level of the economy.

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Appendix 1 Errata

Article III contains two errors:

1. On page 607, it is stated that "The first 16 professors began their projects in 2007 in nine Finnish universities." It should be that "The first 24 professors began their projects in 2007 in nine Finnish universities.
2. The Figure 6 on page 617 should be the following:

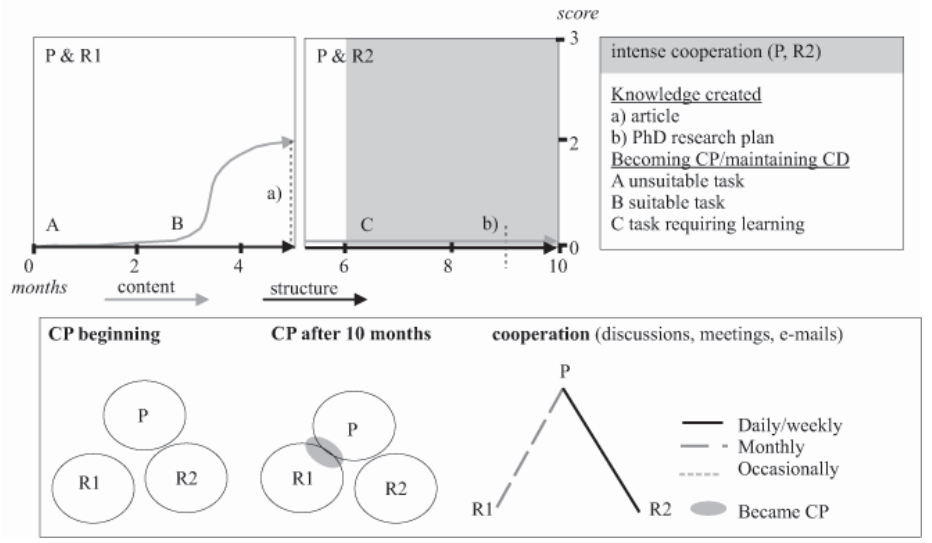

Fig. 6. CP process in the Tec3 Group (Hautala 2011b: 617, published by permission of Emerald Group Publishing Limited).

Original publications

I Hautala J (2008) Internationalization of knowledge creation at the university. The case of the University of Oulu, Finland. In Ylinenpää H (ed) Proceedings. 2nd Conference on Nordic Innovation Research, December 3–4 2007; Luleå University of Technology: 126–142.

II Hautala J (2011a) International academic knowledge creation and *ba*. A case study from Finland. Knowledge Management Research and Practice 9(1): 4–16.

III Hautala J (2011b) Cognitive proximity in international research groups. Journal of Knowledge Management 15(4): 601–624.

IV Hautala J & Jauhiainen J S (2011) Spatio-temporal processes of knowledge creation. Manuscript.

Original publications are not included in the electronic version of the dissertation.

568. Leppälä, Johanna (2011) The genetic basis of incipient speciation in *Arabidopsis lyrata*

569. Kivelä, Sami, Mikael (2011) Evolution of insect life histories in relation to time constraints in seasonal environments : polymorphism and clinal variation

570. Kaartinen, Salla (2011) Space use and habitat selection of the wolf (*Canis lupus*) in human-altered environment in Finland

571. Hilli, Sari (2011) Carbon fractions and stocks in organic layers in boreal forest soils—impacts of climatic and nutritional conditions

572. Jokipii-Lukkari, Soile (2011) Endogenous haemoglobins and heterologous *Vitreoscilla* haemoglobin in hybrid aspen

573. Vuosku, Jaana (2011) A matter of life and death - polyamine metabolism during zygotic embryogenesis of pine

574. Petsalo, Aleksanteri (2011) Development of LC/MS techniques for plant and drug metabolism studies

575. Leppälä, Mirva (2011) Successional changes in vegetation and carbon dynamics during boreal mire development

576. Huotari, Noora (2011) Recycling of wood- and peat-ash – a successful way to establish full plant cover and dense birch stand on a cut-away peatland

577. Alahuhta, Janne (2011) Patterns of aquatic macrophytes in the boreal region: implications for spatial scale issues and ecological assessment

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582. Haataja, Tatu (2011) Peroxisomal multifunctional enzyme type 2 (MFE-2) : the catalytic domains work as independent units

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